PRIDE Project in Development and the Environment

Comparing Environmental Health Risks in Cairo, Egypt

Volume One

September 1994

Submitted to:
USAID/Egypt
Submitted by:
PRIDE

USAID Contract Number:
ANE-0178-Q-00-1047-00
USAID Project Number:
398-0365

Sponsored by:
USAID/NE/DR/ENR
Implemented by:
Chemonics International
and its associates

2000 M Street, NW, Suite 200, Washington, DC 20036
Telephone: (202) 331-1860 • Fax: (202) 331-1871

The objective of the Project in Development and the Environment (PRIDE) is to help the U.S. Agency for International Development (AID) design and implement programs that foster the agency's environmental and natural resources strategy for sustainable economic growth in the Near East and Eastern Europe.

PRIDE provides AID and participating countries with advisory assistance, training, and information services in four program areas: (1) strategic planning, (2) environmental policy analysis, (3) private sector initiatives, and (4) environmental information, education, communication, and institutional strengthening.

The project is being implemented by a consortium selected through open competition in 1991. Chemonics International is the prime contractor; subcontractors include RCG/Hagler, Bailly, Inc.; Science Applications International Corporation; Capital Systems Group, Inc.; Environomics, Inc.; Industrial Economics, Inc.; Lincoln University; and Resource Management International, Inc. In addition, AID has entered into a cooperative agreement with the World Environment Center to support implementation of PRIDE.

Comparing Environmental Health Risks in Cairo, Egypt

Volume One

by

Stuart Sessions
Mike Gaffen
Susan Moore
Rebecca Efroymson (USAID)
Fatma El-Gohary
Mahmoud Nasralla
Amin El Gamal
Ahmed Abdel Gawaad

September 1994

PREFACE AND ACKNOWLEDGEMENTS

This report summarizes the findings of a project conducted in 1993 and 1994 for the U.S. Agency for International Development (USAID) mission in Egypt. The project assesses and ranks health risks from environmental problems in Greater Cairo. It represents the first application of comparative risk analysis (CRA) techniques in the Near East. It is hoped that the study results will prove useful in establishing environmental priorities in Cairo. If so, further CRA work may be conducted in Egypt and the region.

Many people contributed to this project. It was conducted under the auspices of the Project in Development and the Environment (PRIDE), a USAID project operated by Chemonics International and its associates. Stuart Sessions (Environomics, Inc.) was the team leader and primary author of this report. The other U.S.-based team members were Michael Gaffen (Chemonics, Inc.), Susan Moore (SAIC, Inc.) and Rebecca Efroymson (USAID/Washington). Four Egyptian consultants contributed background studies, advice, and guidance in their fields of expertise: Dr. Mahmoud Nasralla (air pollution), Dr. Fatma El-Gohary (water pollution), Dr. Amin El Gamal (public health), and Dr. Ahmed Abdel Gawaad (food and toxic substances).

The Egyptian Environmental Affairs Agency cooperated and provided important guidance and assistance. We appreciate the assistance of Salah Hafez, chairman, Dr. Tarek Genena, director of the Technical Cooperation Office, and their staff. Other Egyptian government agencies provided help, notably the National Research Center, the Nutrition Institute, and the Cairo Water Authority.

Several individuals and firms contributed to an air pollution sampling effort for the project. The Foxboro Company provided a portable ambient air analyzer through its Cairo office, Osman A. Azzam & Co. Dr. Azzam and Dr. Mahmoud Hewehy of Ain Shams University lent the machine and assisted in the sampling and data interpretation. Ramses Khalil of Bechtel Corp.'s ECEP project arranged for the sampling. Dr. Ahmed Gaber of Chemonics/Egypt made important intellectual contributions, and he and his staff greatly facilitated the team's field work in Cairo. Brad Firley of Abt Associates, Inc. provided an annex summarizing current knowledge about the health effects of lead. Kathryn Steucek of Environomics assisted extensively in research, data analysis, and report formatting.

USAID officials financed and directed the project. Dr. Richard Rhoda, director of the Environment Office at USAID/Egypt, conceived of the project and guided and encouraged the project team. Dr. Anne Patterson and Seifalla Hassanein provided helpful comments and assistance in the team's field work.

Many other persons rendered assistance, and the team is indebted to them even though we have not named them here. The views expressed in this report, however, are those of its authors and do not necessarily reflect those of USAID, the Government of Egypt, or others who have assisted in the project.

b

TABLE OF CONTENTS

c

EXECUTIVE SUMMARY

This report summarizes the results of a comparative risk analysis of environmental problems affecting Cairo, Egypt. Comparative risk analysis (CRA) is a systematic procedure for evaluating environmental problems affecting a geographic area and deciding what to do about them. CRA helps decision makers set priorities when problems are numerous and the resources to solve them simultaneously are insufficient.

CRA has been used extensively since 1986 to help set environmental priorities in the United States. It has been applied only recently in a small number of developing countries. As a result, this CRA in Cairo is somewhat limited and experimental. For example, the study assesses risks posed by environmental problems, but does not discuss how these risks might best be managed. In addition, it evaluates the health impacts of environmental problems but not their ecological or economic impacts.

The U.S. Agency for International Development (USAID) mission in Egypt contracted for this study and directed it. Although both USAID and the Government of Egypt (GOE) provided advice and data, the findings do not necessarily reflect the policies or judgments of either. The CRA was performed in 1993 and 1994 by a team of U.S. environmental experts and Egyptian consultants. The team's two objectives were to:

- Rank Cairo's environmental problems by the magnitude of adverse human health impacts they cause.
- Evaluate the feasibility and desirability of performing further, more intensive, comparative risk analysis in Egypt.

The team collected environmental data for Cairo and estimated health risks likely to result from different environmental problems. Each problem was then assigned to one of several categories ranging from higher to lower risk.

Most of this volume of the report discusses the methods and findings that led to the health risk ranking of Cairo's environmental problems. This ranking is shown in Table ES-1 on the following page. Volume Two is a technical appendix providing further details supporting project findings. Volume Three includes the background reports by Egyptian consultants.

Table ES-1: Relative Health Risks From Environmental Problems in Greater Cairo

Higher Risks:
- Particulate Matter Air Pollution
- Lead (in all media)
- Microbiological Diseases From Environmental Causes

Middle Risks:
- Microbial Food Contamination
- Ozone Air Pollution

Middle/Lower Risks:
- Sulfur Dioxide Air Pollution
- Carbon Monoxide Air Pollution
- Indoor Air Pollution
- Drinking Water Contamination by Chemicals
- Drinking Water Contamination by Microbiological Agents
- Solid and Hazardous Wastes

Lower Risks:
- Toxic Air Pollutants
- Other Water Pathways: Direct Contact, Irrigation, Fish Consumption

Uncertain Risks:
- Nitrogen Oxides Air Pollution
- Metals in Foods
- Pesticides in Foods (middle risk if available data are accurate; lesser risk if not)

Higher Risk Problems

Particulate matter. Particulate matter (PM) air pollution in Cairo exceeds health-based standards by a factor of 5 to 10, with levels in Cairo higher than in any of the world's largest cities. Other parameters relating to PM—dustfall and smoke—also far exceed recognized international standards. We estimate that reducing PM concentrations in Cairo to natural background levels might prevent 3,000 to 16,000 deaths and 90 million to 270 million days of restricted activity each year. (These are likely overestimates because of difficulties in extrapolating U.S. dose-response relationships to the extreme conditions in Cairo.) Industry is likely the major source of PM in Cairo.

Lead. Lead is widely present in food, water, and air in Cairo. The average lead level in the blood of Cairo men is about 30 micrograms per deciliter and slightly lower for women, both well above the levels in other large cities. Reducing blood lead in Cairo to U.S. levels would significantly improve the mental development of children (about 4.25 IQ points per child) and reduce infant mortality by 820 deaths per year and deaths from cardiovascular illness by 6,300-11,100 per year. (These are also likely overestimates.) Cairenes' exposure to lead comes mainly from food or water, though much of the lead probably enters the environment from highly leaded gasoline or lead smelters.

Microbiological disease. Microbiological diseases related to environmental conditions are common in Cairo, including diarrheal diseases, infectious hepatitis, typhoid fever, schistosomiasis, and many others. These diseases cause up to 10 percent of all deaths among the general population and 30 percent of deaths among young children. Environmental factors such as the quantity and quality of water supplies, disposal and treatment of excreta, solid waste collection, and food contamination significantly affect the transmission and persistence of these diseases. However, their incidence is related as much or more to non-environmental factors (e.g., malnutrition, inadequate health care and education, overcrowded housing, poor domestic hygiene) as to environmental ones.

The two most important environmental factors in controlling these diseases are:

- Providing sufficient quantities of water to residences to support washing and other sanitary practices.

- Providing toilets and sanitary sewers to remove human excrement from immediate human surroundings.

Other environmental improvements involving water quality, sewage treatment, solid waste collection, and food contamination are less important. A very large portion (relative to other large cities in developing nations) of Cairo is already provided with water and sewer service. We estimate that extending good water and sewer service to the unserved fraction of Cairo's population would reduce the days of diarrhea suffered by 6.1 million per year and prevent 1,700 to 5,500 deaths per year. Improving the reliability of service to those already served would add to these numbers.

Middle and Lower Risk Problems

Other air pollutants. Although levels in Cairo of several air pollutants often exceed health standards, they do not do so by as much as particulate matter (PM). Non-PM air pollutants also generally have less severe health effects and, at levels prevailing in Cairo, often affect only small, particularly sensitive groups (e.g., asthmatics). Among the other air pollutants, ozone appears likely to have the most significant health impacts and is probably responsible for several days per year of relatively mild adverse symptoms among much of Cairo's population. Monitoring data on ozone is very limited, so this assessment is uncertain.

Water contamination. Water pollution poses relatively low risks in Cairo for several reasons. First, the Nile arrives in the city reasonably clean and is a good source for drinking and irrigation. About 90 percent of the population is provided, in their homes, with piped public drinking water, which receives adequate disinfection at treatment plants. Contaminants entering the water distribution system can cause problems but, as noted above, water quality is of less concern in microbiological disease incidence than other factors. Finally, most of Cairo's domestic and industrial wastewater effluents are conveyed away to the north through drains. As a result, most risks from Cairo's water pollution are exported out of the city.

Solid waste and food contamination. Solid waste and environmental food contamination (contamination that occurs outside the home and is reasonably subject to governmental inspection and regulation) are also less important factors in transmission of microbiological diseases.

Finally, although the team did not intend to investigate occupational exposures, we found information suggesting that occupational exposure to toxic substances poses substantial health risks in Cairo.

There are many important uncertainties in the data and analysis underlying our ranking of health risks. These uncertainties stem from:

- Very limited data on sources and amounts of pollution in Cairo. No data were found for a few potentially important pollutants. Data for most pollutants were insufficient to provide a solid picture of temporal and spatial variability. Some data sets raised as yet unresolved questions about their reliability.

- Inadequate health statistics for Cairo, particularly on the incidence of diseases (morbidity and mortality) that might be environmentally related.

- Incomplete scientific understanding of cause-and-effect relationships between exposure to a pollutant and health. In general, we extrapolated relationships found through studies in the developed world to conditions in Cairo. For some pollutants, knowledge about effects is insufficient worldwide. Others required extrapolation to pollution levels above those prevailing where the findings were obtained.

The project team in many cases filled gaps in data and knowledge through professional judgment. Rankings therefore reflect this judgment as much or more than scientific analysis. Nevertheless, the team is confident of the placement of problems into broad groups posing higher, middle, and lower risks.

Ranking environmental problems according to their health risks does not dictate the priority that should be given to controlling each problem. Impacts beyond the scope of this study are also important—for example, impacts outside Cairo (e.g., water pollution downstream from Cairo) and ecological and economic impacts in addition to health effects. Furthermore, the ranking reflects the present risks posed by problems, taking into account the environmental protection measures that have already been implemented. Thus a problem might pose lower risks not because it is inherently less severe, but because control measures have been effective in addressing it. Maintaining these controls to keep risks to their current low levels may be important. An example of this could be the large investment in Cairo's water and sewer infrastructure. In general, decisions about environmental problems should address not only the magnitude of risks involved but also several other factors that were not addressed in this study. They include cost and technical feasibility of control measures, public opinion, political concerns, legal authority, and institutional issues.

The team believes CRA has provided important insights into the relative severity of environmental problems in Cairo that should prove useful to both the GOE and the donor community in establishing environmental priorities. Further CRA work in Egypt could focus on other geographic areas (perhaps rural regions, Alexandria, or the entire country) and additional types of risk (economic and/or ecological). It should include both risk assessment and risk management components. Depending on how a future CRA is structured, it could also have significant procedural benefits in strengthening working relationships and contributing to a shared sense of purpose among diverse public and private entities concerned with Egypt's environment.

SECTION I

INTRODUCTION

SECTION 1
INTRODUCTION

This report summarizes the results of a comparative risk analysis of the environmental problems affecting Cairo, Egypt. Comparative risk analysis (CRA) is a systematic procedure for evaluating environmental problems affecting a geographic area and deciding what to do about them. CRA helps decision makers set priorities when problems are numerous and resources for solving them simultaneously are insufficient.

A. Background

Since 1975, the U.S. Agency for International Development (USAID) and other donor agencies have provided substantial assistance to Egypt to facilitate economic development. Much of USAID's assistance has focused on measures to mitigate environmental impediments to economic development, particularly by establishing adequate water supply and wastewater collection and treatment facilities. Having made great progress on several large water-related environmental infrastructure projects, USAID and the Government of Egypt (GOE) are considering measures to address other environmental problems such as air pollution, misuse of pesticides, and industrial water pollution. Recent comprehensive planning efforts have addressed the full range of environmental problems in Egypt, supporting a large variety of proposed policy initiatives and project interventions.[1] In these planning efforts, groups of Egyptian, donor, and expatriate environmental experts have assembled data about Egyptian environmental problems and developed consensus programs for mitigating the problems.

This CRA does not duplicate previous planning efforts. Instead, it reviews information gathered in previous studies *to compare explicitly and systematically* the environmental problems facing the country. As an initial test of the CRA methodology in Egypt, this study involves a pilot analysis of environmental health risks in Greater Cairo. Which of Greater Cairo's environmental problems are the most serious in terms of their impact on the population's health? Comparing the seriousness of problems will provide policy makers with a more objective basis for setting priorities and help them focus their limited resources on the most important problems.

This study thus has two objectives:

- Perform a preliminary comparative environmental health risk assessment for Greater Cairo. This will enable a ranking of Cairo's environmental problems by the magnitude of their adverse impacts on human health.

- Evaluate the feasibility and desirability of performing further, more intensive, comparative risk analysis in Egypt. Further work could include areas of Egypt

[1] Two of the most important environmental planning efforts have been the joint GOE/World Bank work to develop the Environmental Action Plan (GOE, 1992) and the USAID/Egypt Country Program Strategy for Environment (USAID, 1992).

other than Cairo and assess economic or ecological damage from pollution as well as health impacts. It could also be performed largely by Egyptian experts rather than expatriates. Section IV will examine the utility of further CRA work and options for structuring it.

B. Project History

This CRA of Greater Cairo was carried out under contract with USAID/Egypt. The work was directed by Dr. Richard Rhoda, director of the mission's Office of the Environment. USAID requested the study to help develop future environmental assistance projects in Egypt, and to assess the likely value of further comparative risk work in Egypt.

The Government of Egypt provided advice regarding this study and much of the environmental data on which the study relies. Otherwise, the GOE has not been intensively involved in the study and has not formally reviewed or approved its conclusions. The study thus represents a product contracted for by USAID and does not necessarily reflect the policies or judgments of the GOE.

The study began in October 1993. A group of U.S. environmental experts worked in Cairo for six weeks to define the approach and collect data on environmental conditions and problems. Four Egyptian environmental experts were retained to assist in the study design and acquisition and interpretation of data. The Egyptian consultants advised U.S. team members on data acquisition, and each consultant wrote a summary paper on specific environmental conditions in Cairo and resulting health impacts. The team's process for acquiring environmental data for Cairo was wide-ranging, encompassing studies and data from Egyptian government agencies, USAID and other foreign donors, academics, scientific journals, international organizations such as the World Bank and World Health Organization, environmental consulting firms active in Cairo, and others.

Following data collection in Cairo, the U.S. team members returned home to analyze the data and develop the project report. The four Egyptian consultants' papers were incorporated into a draft report, which was circulated to USAID and interested parties in Egypt and the United States for review in 1994. Some of the U.S. team members returned to Cairo in February 1994 for discussions with the mission, the local consultants, and the GOE about project findings. This final version of the project report reflects the discussions and subsequent comments on the draft. During the summer of 1994, USAID/Egypt began studies to fill several key data gaps identified in the CRA. After completing these studies, the mission will decide whether to pursue further comparative risk work in Egypt.

C. Scope and Limitations of the Study

Comparative risk analysis is a technique used extensively in the United States since 1986 to help establish environmental priorities (USEPA, 1993). It has been used in other countries only recently. USAID has applied it in Bangkok, Thailand (USAID, 1990), and in Quito, Ecuador (USAID, 1993), and the EPA used it recently in several places in Eastern Europe (IEc, 1992 and ISC, 1993). Thus there is little experience in CRA techniques in developing countries, and even less subsequent experience in applying the findings of CRA studies to improve policy making in these countries.

As a result, the CRA in Cairo was somewhat limited and experimental. The project design concentrated on several aspects of CRA that could be performed quickly and successfully, leaving other elements for possible future consideration. The study was performed at moderate cost by a small project team and relied on existing data. The restrictions on the project scope affect how the results can be interpreted. This will be described in Section II. Despite the limitations, it is hoped that the project provides useful substantive findings about environmental problems in Cairo as well as information on the advisability of conducting a broader CRA in Egypt.

D. Organization of the Report

This report includes three volumes. In Volume One, the introductory section is followed by a section describing the CRA methodology as it has been applied in the past and here in Cairo. Several methodological choices were made for this study, and their implications are discussed. The third section presents the key findings of the project. It describes the environmental problems affecting Cairo, estimates the health risks they pose, and concludes with a ranking of the severity of the problems. The fourth section discusses options for further CRA work in Egypt.

Volume Two of the report contains technical appendices that support the project findings. It provides detail underlying the project findings summarized in Volume One. Individual sections summarize available data on each environmental problem in Cairo and explain the health risk estimates for each. Complete references are provided for the data sources and calculation methods used. For the sake of brevity, the references cited in Volume Two are not repeated in Volume One.

Volume Three of the report contains the background reports prepared for this project by four Egyptian consultants.

SECTION II

METHODOLOGY

SECTION II
METHODOLOGY

The main objective of this project is to rank environmental problems affecting Cairo by their severity. This section describes our approach to this ranking and how our methodological choices influence the ranking and interpretation of the results.

A. Overview of Approach

It is difficult to compare objectively the disparate environmental problems facing a city such as Cairo. Consider just two of Cairo's problems: air pollution from motor vehicles and untreated industrial wastewater discharges. Most pollutants associated with these two problems are different, the environmental media they affect are different, and their impacts are different. How can one find a common denominator for comparing them?

Several approaches can be used. Perhaps the most common is to compare the degree to which each problem violates national or international environmental standards. One might conclude, for example, that air pollution in Cairo is a more serious problem than surface water pollution because Egyptian and World Health Organization standards are often exceeded in Cairo for many air pollutants (e.g., particulate matter, sulfur dioxide, lead, nitrogen oxides), while water quality of the Nile through and below Cairo is typically better than national and international standards. Alternatively, one might judge relative severity by comparing amounts of pollutants emitted, their ambient concentrations, or the number of pollution sources out of compliance with pollution control requirements.

These approaches, however, all focus on intermediate impacts from environmental problems. In contrast, risk analysis deals with the ultimate impacts of the problems. Do people get sick? Are ecosystems harmed? Will economic losses occur? A basic premise of CRA is that environmental problems can best be judged by the degree to which they harm health, ecological quality, and economic well-being. Likewise, environmental management measures can best be judged by how much they reduce threats to these areas. The term "risk" in this sense encompasses the probability, magnitude, and severity of these ultimate impacts. CRA techniques are particularly useful in setting priorities because they:

- Address the impacts we ultimately care about.

- Provide a common denominator for comparing disparate environmental problems by using measures that are comparable across problems (how many people suffer illness or injury, amount of monetary damages) rather than non-comparable measures (different sources and pollutants).

Analysts often consider several varieties of risks. For example, risks from pollution in Cairo include:

- **Health risks.** Pulmonary disease among those exposed to high levels of air pollution; tetanus in children suffering cuts or wounds from materials in uncollected solid waste.

- **Ecological risks.** Deterioration in species diversity in Lake Manzala as a result of industrial and household sewage discharged into the Bahr-El-Baqar drain.

- **Welfare or economic risks.** Reduction in productivity of Nile water for downstream irrigation, fishing, water supply, and recreation due to pollution from Cairo; accelerated deterioration of stone surfaces of the Sphinx and other antiquities from acidic air pollution; direct medical costs and loss of productivity for those suffering pollution-related health problems.

In this project, we focus exclusively on human health risks. Data needs and techniques for evaluating ecological and welfare risks are different from those required for evaluating health risks; addressing them would require a significantly longer and more expensive project. In Section IV we discuss what might be involved in considering ecological and welfare risks in future CRA work in Egypt.

The range of adverse health effects from environmental problems is broad, including gastrointestinal disease (from pathogens in drinking water), angina pain (from carbon monoxide), learning disabilities (from exposure to lead), cancer (from chronic exposure to many toxic substances), and many others. Our approach to judging the relative importance of Cairo's environmental health problems is as follows:

- For each problem, estimate the number and severity of cases of disease or injury it is likely to cause. (For some pollutants, knowledge about health effects is not sufficient for this estimate. In such instances, we can only estimate the number of people exposed at levels above a threshold of concern.)

- Develop a summary judgment about the magnitude of health risks posed by each problem by estimating the incidence and severity of diseases and injuries and the quality, completeness, and biases of the underlying data.

- Rank the problems by the magnitude of their health risks.

In ranking the problems, we are careful to consider only risks associated with them. We do not consider factors such as the cost and technical feasibility of controlling each problem, public opinion, political support, or statutory mandates or institutional capabilities for dealing with each. These other factors may be of equal or greater importance than the magnitude of the problems in deciding what should be done about them. However, we believe it is critically important to separate the process of assessing risks from deciding how to manage them. Risk assessment is ideally a scientific and objective process performed by technical experts. Risk management, in contrast, is a judgmental process requiring public officials to balance a wide variety of concerns. Obtaining an objective assessment of the risks facing a community is a key precondition to managing those risks efficiently.

B. Environmental Problems Covered in the Study

We sought to analyze all environmental problems affecting the health of Greater Cairo residents. The list of problems to be covered is shown in Table II-1 below.

Table II-1: Environmental Problems Analyzed in the CRA

Air Pollution
- Sulfur dioxide, particulate matter, nitrogen oxides, carbon monoxide, ozone
- Other toxic chemicals
- Indoor air pollution

Water Pollution
- Effects through drinking water
- Effects through fish consumption, irrigation, and direct contact

Food Contamination
- Pesticides, metals, and microbiological agents

Solid and Hazardous Wastes

Lead (in all media)

Microbiological Diseases Relating to Environmental Factors
- Those stemming from deficiencies in environmental sanitation involving water supply and quality, human and solid waste disposal and treatment, and food hygiene

There are many different ways to draw up a list of environmental problems, and several aspects of our list deserve comment. Although lead is a pollutant found in air, water, and food, we discuss lead in all media as a separate problem to highlight preliminary information suggesting significant risks from lead. Similarly, microbiological diseases are treated as a single problem even though the agents causing them are often found in water, food, or solid waste. Note also that we do not consider all microbiological diseases to be an environmental problem (e.g., AIDS and measles are two diseases with minimal connection to environmental pollution), but only those with a clear link to traditional environmental sanitation concerns.

We do not cover several other problems typically considered environmental. These include:

- **Climate change and stratospheric ozone depletion.** These are global problems that cannot effectively be addressed by actions in Cairo or Egypt alone.

- **Noise.** We omit noise because data portraying the temporal and spatial variation in noise in Cairo are not available, and because we are unaware of any satisfactory way of quantitatively relating ambient noise to population health effects.

- **Occupational exposure to toxic substances.** Although this problem appears to pose significant risks, occupational exposure situations in Cairo are wide-ranging, and collecting data on a representative sample is beyond our means.

- **Radiation and accidental releases from industrial facilities** (e.g., Bhopal-like accidents). We omit these because of limitations on our project level of effort. Acquiring data on these problems would require investigating sources other than those we accessed for this project.

We also omit problems that do not relate primarily to pollution: malnutrition, food additives, occupational safety, traffic accidents, smoking, natural disasters, overcrowding, inadequate medical care, and high population growth. Several of these issues relate more to public or occupational health.

C. Specific Analytical Approach

Most environmental problems adversely affect human health through an identical series of steps (see Exhibit II-1):

- **A source generates pollutants.** Motor vehicles generate particulate matter, carbon monoxide, and other pollutants as fuels are burned. The amount of pollutants generated depends on characteristics of the source: type of vehicle, fuel used, etc.

- **Pollutants are emitted or discharged into the environment.** Technologies may reduce the amount of pollutants emitted or discharged. Engine tuning, catalytic converters, and other control measures can reduce emissions from motor vehicles.

- **Pollutants undergo chemical or physical processes in the environment, resulting in ambient concentrations.** Nitrogen oxides and hydrocarbons emitted by motor vehicles may react in the presence of sunlight over several hours to form ozone. Meteorological factors such as wind can cause ozone concentrations to peak some distance away from the source of the emissions.

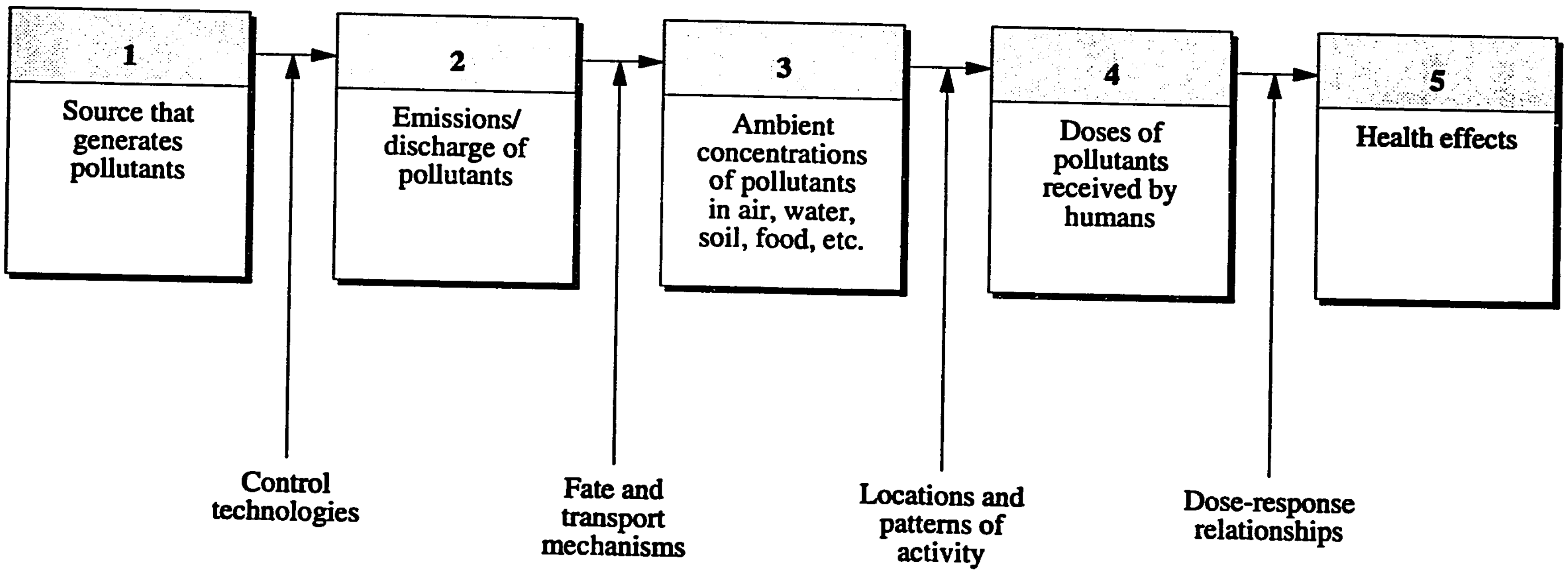
- **People are exposed to pollutants.** The degree of exposure depends on where people are located and how they interact with the environment. Exposure to ozone will be low if prevailing winds blow the ozone into a sparsely inhabited area. Exposure may also be low if people stay indoors when outdoor concentrations are high.

- **Exposure impacts health.** For many pollutants, clinical, epidemiological, and toxicological studies have provided an understanding of the adverse effects of exposure, as well as an underlying dose-response relationship. Such a relationship is a mathematical calculation of the probability that a person will suffer an adverse effect as a result of exposure to a given amount of pollutant.

In assessing environmental problems, we are most interested in obtaining data on the ultimate impacts of the problems (Level 5 in Exhibit II-1). Data at this fifth level can show how many cases of adverse health are caused by the problem. Unfortunately, accurate direct

8

Exhibit II-1: How Environmental Pollution Damages Human Health



measurements of health effects from environmental causes are rarely available, for several reasons:

- Available statistics are often inaccurate indicators of the underlying numbers of health effects. Mortality and morbidity figures from doctors, clinics, and hospitals are subject to large errors from under-reporting (many individuals do not seek treatment), misdiagnosis, insufficient specificity, and uncertain catchment areas (what geographic and socioeconomic groups go to the health care facility providing the data).

- Few diseases are attributable exclusively to environmental factors. For most diseases, pollution seems to be a relatively minor cause.[1] Incidence of most diseases is strongly influenced by genetics, diet, smoking, personal hygiene, quality of medical care, etc.

- Many diseases related to pollution appear only long after exposure. Current disease statistics, even if accurate, may reflect past problems; the impacts of today's problems may take years to show up.

Because of the lack of direct information at Level 5, we typically project likely health effects by estimating the dose of a pollutant to which people are exposed and then applying a dose-response relationship for that pollutant. In effect, we collect available data at the levels to the left in Exhibit II-1 and use models and other techniques to estimate quantities further to the right that have not been measured directly. Numerous uncertainties and sources of error are inherent in these two steps.

In the first step, uncertainties arise from shortcomings in monitored data in Cairo and difficulties in modeling exposures based on these data. We discuss the most important uncertainties in Volumes Two and Three of this report.

Uncertainties inherent in applying dose-response relationships are of a different sort. In this study we use methods and databases on health effects approved by the U.S. Environmental Protection Agency (EPA). However, there is scientific controversy about the choices EPA has made in its risk assessment procedures. Some of the most difficult issues involve extrapolating the effects of chemicals in high-dosage animal experiments to situations in which humans are exposed to low doses. Thorough discussions of uncertainties and suggestions about alternative health risk assessment procedures are available elsewhere (Finkel, 1990; OMB, 1990), and will not be repeated here. We have used EPA's methods, and our conclusions are thus subject to all of the associated uncertainties.

For a few environmental problems, our process is the reverse of the typical left-to-right progression in Exhibit II-1. Sanitation-related problems such as insufficient or unclean water, inadequate domestic sewerage and treatment, and uncollected solid waste are

---

[1] For example, only a small fraction of the incidence of cancer is attributable to environmental pollutants. The major preventable risk factors for cancer identified so far are tobacco, dietary imbalances, hormones, and chronic infections (Gold, 1993).

10

examples. For these problems, statistics on health effects (diarrheal diseases, typhoid) may be available, but dose-response functions are not. Risk analysis for these problems will involve a right-to-left progression in which disease statistics are collected and then adjusted to reflect the degree of under- or over-reporting and the contribution of non-environmental causes.

D. Methodological Choices and their Implications

Several limitations in project scope and methods were placed on this project, with the expectation that these limitations could be reconsidered in any future, more intensive project. The reader should understand these limitations, because they affect interpretation of the ranking of environmental problems in Cairo.

D1. Focus on Risk Assessment, Not Risk Management

The project concentrates on evaluating the relative severity of Cairo's environmental problems rather than designing solutions for them. Complete CRA projects often last about two years and include two major phases:

- Identifying, evaluating, and ranking the environmental problems facing a geographical area (risk assessment).
- Developing and analyzing cost-effective policy measures to mitigate the highest-priority environmental problems (risk management).

In this project we have completed only the risk assessment phase. The resulting ranking of Cairo's environmental problems does not dictate the priority that should be given to controlling each problem. Risk management should incorporate factors not analyzed in this project, including cost and technical feasibility, public opinion, implementation concerns, legal mandates, and institutional considerations.[2]

---

[2] The relationship between risk assessment and management has been an unsettled issue throughout the history of CRA. Several approaches have been taken in CRAs that included both a risk assessment and a risk management phase. At one extreme is the position that the proportion of the control program budget directed at environmental problems should exactly match the proportion of risk posed by each problem (Garetz, 1993). At the other extreme is the argument that allocation of control resources should depend primarily on the cost-effectiveness of risk reduction in the various program areas, and that the cost-effectiveness of available control measures bears no necessary relationship to the magnitude of risks in a program area. Somewhere in between is the position of the EPA group that supports much of the U.S. CRA activity—i.e., that a risk ranking provides an important starting point for considering priorities and risk reduction strategies. High-risk problems are a good place to look for risk reduction opportunities, and understanding the anatomy of risk that is gained in the risk assessment phase is critical to determining which risk reduction strategies will work best (USEPA, 1993).

On balance, we believe a general correlation is likely between environmental problems posing higher risks and the problems for which additional control efforts will prove most cost-effective. This is particularly so for problems that pose high risks and for which significant control efforts have not yet been implemented. We believe more control efforts should be directed at the more serious environmental problems.

D2. Focus on Residual Risks from Current Environmental Problems

We have estimated the risks that remain from current environmental problems despite the controls now in place. We focus on residual risks due to our interest in guiding additional steps to address problems. We assume current controls as the base and then ask what risks remain and what can be done to reduce them further. Several aspects of this approach are noteworthy:

- We do not assume that environmental controls in place are as effective as laws specify they should be. Noncompliance is widespread in Egypt.

- We estimate risks based on the current manifestation and magnitude of each problem, although we do present time trend information when available.

- Rankings based on residual risk need careful interpretation. A problem might pose low residual risks now for one of two reasons: (1) it has always posed low risks, or (2) it once posed higher risks, but a control program has reduced them and may be needed to keep them low.

D3. Thoroughness of Data Collection

This project involved a modest data collection effort in terms of person-hours. Because of time limitations, we have not exhausted relevant available environmental data pertaining to Cairo. No new sampling or monitoring was conducted to fill identified data gaps. Despite these limitations, we believe the collected and analyzed data are sufficient to allow confident conclusions about the relative severity of problems in Cairo. In Volumes Two and Three we discuss the major uncertainties and data gaps for each problem.

D4. Geographic Scope

This report focuses on Greater Cairo. Although the GOE and USAID are clearly concerned with the entire country, we limited data collection for this initial effort to a manageable scale and thus did not choose a broader scope. In contrast, a narrower focus on smaller geographic subdivisions (e.g., Cairo City alone or specific zones within the city) would not reflect the extensive movement of people and pollutants throughout the Greater Cairo metropolitan area. Thus, we analyze the environmental health risks faced by the residents of Greater Cairo regardless of the source of pollutants that give rise to the problems. This includes risks imported into Cairo (e.g., pesticide residues on food grown in the Nile Delta) and excludes risks exported from Cairo (e.g., downstream effects from Cairo's wastewater effluents).

D5. Variations in Risk Within Greater Cairo

Any choice of geographic scope for a CRA brings with it serious problems of aggregation if the study area comprises disparate zones. We rank environmental problems as they affect Greater Cairo as a whole. But Greater Cairo is a large area with widely varied conditions, including upper-income Zamalek, which has good sanitation services and little industrial pollution; industrial Helwan, which has serious problems from cement plants and metals factories; and many informal settlements, which have high disease rates due to poor water, sewer, and solid waste collection services. A ranking of health risks for an average individual would differ substantially across these areas.

We cannot respond in a fully satisfactory way to such variations. Available data are insufficient to show the concentrations of contaminants to which people are exposed at different times and places. Our only option is to use a rough average of environmental data collected for relatively few areas to characterize Cairo as a whole. To the extent the data allow, in discussing each environmental problem we will say what we can about variations in health risk across the metropolitan area.

In general, then, we focus on aggregate health risks rather than risks to individuals or sub-populations. In doing so we miss what is often a significant concern in environmental protection—intense risks to highly exposed individuals or groups. On the other hand, many analysts feel that broad environmental priority setting should be based on aggregate risks to the entire population (the greatest good for the greatest number), while high risks to unusually exposed individuals should be addressed through fine-tuning of individual control programs.

Choosing to focus primarily on population risks has implications for ranking environmental problems. A problem that is geographically widespread and thus affects many people (e.g., air pollution) will rank high. A problem that is localized (e.g., contamination around industrial solid waste dump sites), though it may affect a few people severely, will rank lower.

SECTION III

HEALTH RISKS FROM ENVIRONMENTAL PROBLEMS IN CAIRO

SECTION III
HEALTH RISKS FROM ENVIRONMENTAL PROBLEMS IN CAIRO

In this section we describe environmental problems affecting Greater Cairo and estimate the health risks each problem poses to residents of the metropolitan area. Following a discussion of each major problem, the problems are ranked by the severity of health risks they pose.

This section only summarizes findings on each environmental problem. More technical details may be found in Volume Two, including background on each problem, an explanation of how the health risk calculations were performed, and full references for the underlying data. In Volume Three are four background papers prepared by Egyptian consultants. These include papers on air and water pollution and two broader studies on the impact of environmental problems on public health.

A. Background on Cairo

Cairo is situated on the Nile River about 200 kilometers south of the Mediterranean Sea (Exhibit III-1 on the following page). Cairo is the capital and largest city in Egypt, and home to about one-fourth of the country's population. Greater Cairo extends along both sides of the Nile for about 30 kilometers. The populated area is bordered on the east by the Mokattam Hills, separating the city from the Eastern Desert that extends to the Suez Canal. To the west are the Abu-Rawash Hills and the Western Desert, which extends to the Libyan border. The Pyramids are at the edge of the Western Desert. Several kilometers north of the city the Nile divides into the Rosetta and Damietta Branches, forming the fertile Nile Delta. South of Cairo is a string of largely agricultural towns along the Nile.

Important settlements in and around Cairo have existed for more than 5,000 years. The population of the metropolitan area grew from 0.3 million in 1800 to 1.2 million by 1930. Following World War II the city grew more rapidly, as shown in Table III-1 below.

Table III-1: Greater Cairo Population (millions)

1960	4.432
1966	5.728
1976	7.280
1986	10.951
1990	11.486
2000 (projected)	16.621

Exhibit III-1

Cairo is now one of the 20 most populated metropolitan areas in the world and the largest city in Africa. The exact population of Greater Cairo is highly uncertain, partly because its geographic definition is inexact and partly because of numerous undercounted informal settlements and transients. Estimates of the population of Greater Cairo range from about 10 to 16 million people. For calculation purposes in this report, we assume a current population of 12 million.

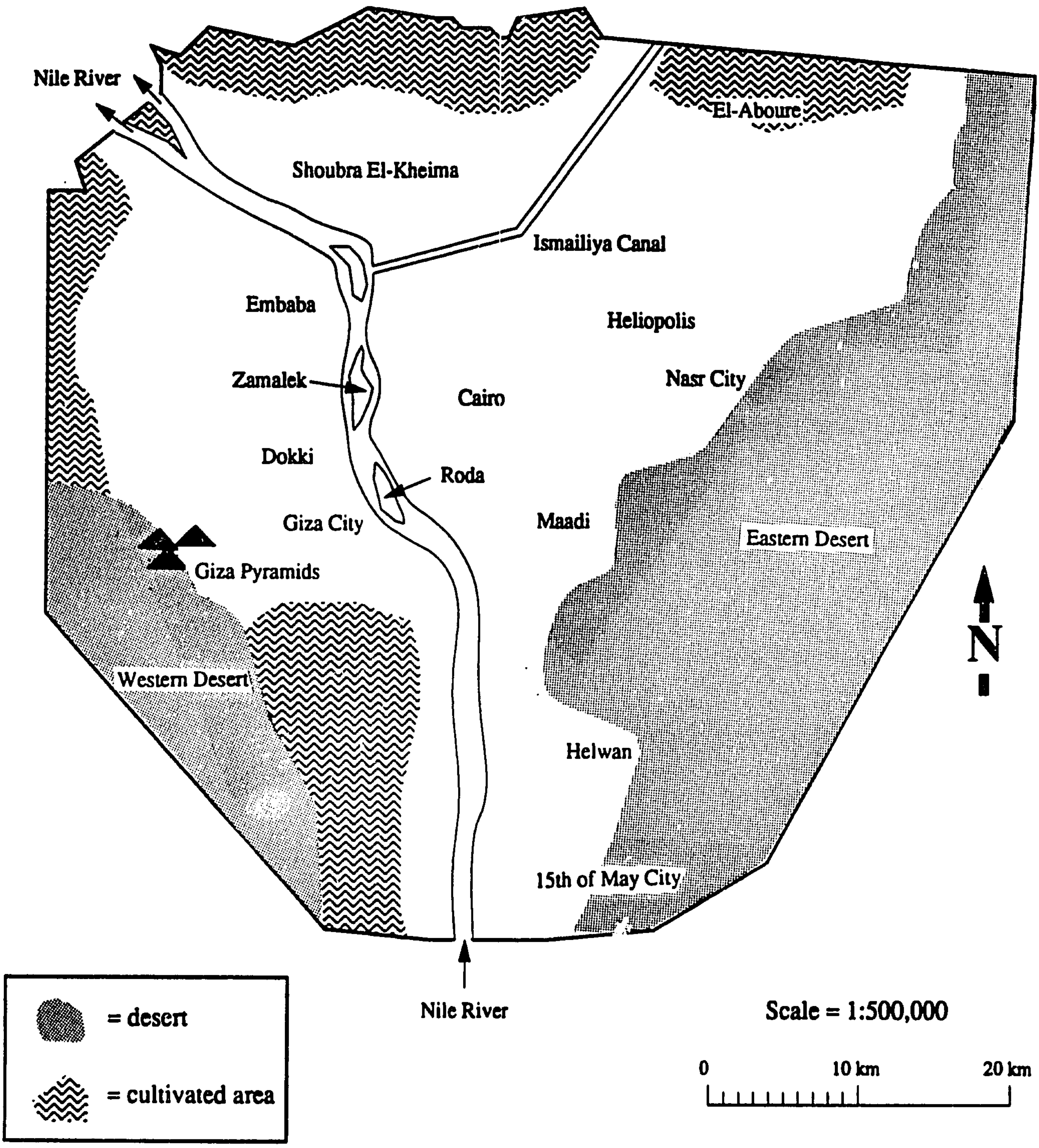
During the past decade, Cairo's population has grown by about 2.3 percent per year. Growth has been fastest outside the city center, in the areas west of the Nile and to the north in Shoubra El-Kheima. High population growth in Cairo is a result of Egypt's overall high rate of growth, accelerating migration from rural areas to the cities, and sharp improvements in nutrition and health (life expectancy in Egypt increased from 41 to 61 years between 1960 and 1990). The population of Greater Cairo is densely distributed in about 400 square kilometers of the Nile Valley between the two deserts. Average population density is about 30,000 per square kilometer, more than in Manhattan in New York City, despite the fact that the most crowded districts in Cairo have buildings seldom exceeding three or four stories. Housing is overcrowded and in short supply, and other elements of the urban infrastructure, including transport, health, education, water, and sewerage, face tremendous pressure from population growth. City planning and control of development through building permits or other means have been largely ineffective.

Greater Cairo can be characterized roughly into several zones (see Exhibit III-2 on the following page). Central Cairo and Dokki are heavily populated, with extensive commercial activity, high traffic, and a mixture of upper and lower income areas. Heliopolis and Maadi are less-dense, higher-income residential areas. Embaba is a densely populated, lower-income area. Giza City is a residential and commercial area that has expanded rapidly from the Nile west to the Pyramids into formerly uninhabited and agricultural land. Recent major planned residential areas have included El-Aboure to the northeast, Nasr City to the east, and 15th of May City to the southeast.

The greatest concentrations of industry in Cairo are in the Helwan area to the south and Shoubra El-Kheima to the north. During the 1950s Egypt's industrial development turned from its traditional agrarian base (food processing, textiles, fertilizer, cement) to heavy industry that in Cairo's case was sited mostly to the north and south of the most populated areas of the city. In the Helwan area are factories employing about 100,000 workers in production of cement, iron and steel, lead and zinc smelting, foundries, ceramics, vehicles, coke and fertilizers, textiles, bricks, and chemicals. The northern industrial area, Shoubra El-Kheima, consists of more than 450 industrial units of various sizes employing about 87,000 workers in ferrous metallurgy, foundries, lead smelters, ceramics, glass, bricks, textiles, and plastics. Many of these factories are of Russian or Czech design, with minimal or no pollution controls. Large populations have grown up around the factories, with about 1 million people in each of the Helwan and Shoubra El-Kheima areas.

Scattered throughout the remainder of the city, most heavily in Embaba, are numerous typically smaller industrial facilities. Major industries include textiles, metal working, bakeries, brick making, food processing, and tanneries. Large populations reside in close proximity to virtually all of these plants.

Exhibit III-2: The Cairo Region



18

Significant agricultural areas still exist in Greater Cairo but have been shrinking rapidly. The West Bank of the Nile south of Giza is largely agricultural, as are major parts of Shoubra-El Kheima and some of the Helwan area. It is common to see fields of crops adjacent to highly polluting, heavy industrial facilities.

Egypt's economy grew by nearly 4 percent per year from 1983 to 1992. While this rate is impressive, much of the gains have been consumed by population growth (2.3 percent). A significant factor in slowing income growth in Egypt is the dominance of the public sector. About two-thirds of all urban wage earners are employed in the public sector; 65 percent of these jobs are in government and 35 percent are in state-owned enterprises. In Cairo, 75 percent of industrial production takes place in state-owned factories, which include nearly all of the large installations. The IMF, World Bank, and foreign creditors have pushed Egypt toward significant economic reform, including price decontrol; termination of subsidies for agriculture, energy, and public enterprises; privatization; liberalization of foreign trade; and private sector development.

B. Influence of Cairo's Climate and Geographic Setting on Environmental Problems

Climate and geography combine to exacerbate the impacts of air pollution and mitigate the impacts of water pollution in Cairo.

Cairo has a desert climate characterized by dry heat. Monthly mean temperatures range from 14° Celsius in January to 29° Celsius in July. Annual mean rainfall is only 22 mm, as rains typically occur only during the winter months. Wind speeds are low, averaging 2-4 meters/second. The prevailing wind is from the north for nine months of the year and from the south or southwest from January to March.

The general absence of rainfall minimizes washout, normally an important mechanism for removing air pollution from the atmosphere. Stable atmospheric conditions and Cairo's valley location also reduce dispersion. As a result, air pollutants remain in Cairo's atmosphere for long periods, building up and increasing the potential for human exposure and formation of secondary pollutants such as ozone. Air pollutants that fall from the atmosphere through dry deposition (e.g., particulates) are not washed from the ground by rainfall and can be readily re-entrained by winds. Prevailing winds from the north most of the year blow pollutants from the industrial zone in Shoubra-El-Kheima directly into the city. The three months of southerly winds bring pollutants from industrial Helwan. Easterly or westerly winds, which arrive from uninhabited, pollution-free areas, are rare.

By contrast, the major processes that typically move pollutants into surface and ground waters—leaching and runoff—are of little significance in Cairo. Direct discharge is the only important means by which the city could pollute the Nile's water.

Despite its upstream course of more than 6,000 kilometers, the Nile is relatively unpolluted when it reaches Cairo. It is a very large river, with daily flow varying from 80 to 150 million cubic meters. This large flow could provide extensive dilution of the estimated 2-3 million cubic meters of domestic sewage and 0.2 million cubic meters of industrial effluents generated daily in Greater Cairo. In fact, though, much of this wastewater is not discharged to the Nile in Cairo but is conveyed through drains all the way to the Mediterranean Sea. Pollution problems that might be caused by Cairo's wastewater are exported downstream rather than incurred by Cairo residents. In sum, health risks in Cairo from surface water contamination are minimal, because Cairo receives plenty of clean water from upstream and sends its own dirty water downstream.

C. Overview of Environmental Conditions in Cairo

Cairo is unfortunately at a point in its development where it still faces significant traditional environmental problems (water supply, sanitation and wastewater, solid waste, food hygiene, vector-borne diseases) as well as serious and growing modern threats (air pollution, occupational health, toxic and hazardous materials). A rising standard of living should eventually eliminate the traditional problems, although increased industrial and consumer activity will intensify the challenges of modern problems.[1]

About 15 years ago fewer than half of Cairo's residents had acceptable water and sewer service. Most Cairenes relied on shallow wells and hand pumps, communal water standpipes, or water vendors for drinking water. Water pressure at dwellings connected to the water system was often inadequate, necessitating pumps to pull water through the system to homes and tanks for storage. Drinking water became contaminated because pumps created negative pressure in the water mains, inducing inflow of ground water and sewage. Storage tanks were often open to atmospheric deposition, rodents, and birds, allowing further contamination of drinking supplies.

Cairo's sewer system reached only about half the population and was frequently blocked and overloaded. More than 100 sewage flooding incidents occurred daily in the streets of Cairo, often extending inside people's homes or shops. None of the sewage reaching treatment plants received even acceptable primary treatment. The population that was not served by sewers made do with drains to streets and canals or pit latrines and septic tanks that were rarely emptied. Needless to say, the incidence of disease related to poor sanitation (acute diarrhea, dysentery, typhoid, schistosomiasis, ascariasis) was high.

Today, this set of environmental conditions in Cairo has much improved. With the expenditure by the GOE and foreign donors of several billions of dollars on water and sewer projects, roughly 90 percent of the city's population receives piped potable water in their homes and more than 75 percent is sewered. Cairo's water treatment plants use reliable technologies and provide adequate volumes of water. Sewage ponding incidents have virtually ended. Within several years, all of Cairo's sewage will be treated to acceptable primary standards and most to secondary levels. These improvements have occurred despite the city's rapid population growth.

---

[1] For a general discussion of this issue, see: 1) U.S. Agency for International Development, Office of Health, *Toward a Healthier Environment: A Strategy for Environmental Health in LDCs*, 1991 and 2) K.R. Smith, "The Risk Transition," Working Paper No. 10, Honolulu, Hawaii: Environment and Policy Institute, East-West Center, 1988. The following document argues cogently that meshing environmental and development policies leads to significant economic growth and a cleaner environment: The World Bank, *World Development Report 1992*. New York, Oxford University Press, 1992.

Assuming the city can adequately operate and maintain this water and sewer infrastructure and keep pace with growth,[2] Cairo will have managed to solve most of its traditional environmental problems. One significant traditional problem remains, though. In Cairo, less than two-thirds of the 10,000 tons of solid waste generated per day is collected and managed. The remainder is discarded into streets, canals, drains, and neighborhood dump sites, where it is left to rot. The collected waste is generally sorted for recyclables and then open-dumped. The city has no operating sanitary landfills or incinerators for solid waste disposal. Both the discarded solid wastes and the collected and dumped wastes can cause adverse health impacts by fostering rats and other vermin. Accumulations of the wastes are often burned, contributing to air pollution.

Modern environmental problems in Cairo associated with consumer and industrial activities are serious and may be worsening. Greater Cairo includes about 25 percent of Egypt's population but a much higher share of the country's polluting activities: 41 percent of Egypt's thermal electric generating capacity, 48 percent of the nation's motor vehicles, more than 50 percent of energy consumption, and 64 percent of industry. Fuel use for electric power generation in Cairo tripled in the 1980s, while the number of motor vehicles more than doubled.

This concentration of polluting activities in Greater Cairo does not make extensive use of modern pollution control or prevention technologies. About half the fuel used by Cairo's electric power stations is heavy fuel oil that is high in sulfur; the other half is clean-burning natural gas. Cairo's vehicle fleet is old (65 percent of the cars are more than 10 years old) and poorly tuned and maintained. Motor gasoline is low octane and contains high levels of lead additives.

Enforcement of industrial pollution control laws is minimal, and few factories operate either air or water pollution control equipment. Visiting consultants have reported that the larger industrial plants spew huge quantities of both waste and product (as a result of sloppy production methods and controls) unchecked into the air and water. There are even reports that donor-financed pollution control equipment at some plants is turned off except when outside inspections are expected. Industry and hospitals in Cairo produce an estimated 30,000-65,000 tons annually of hazardous and infectious wastes that receive no special management and are simply dumped.

This concentration of minimally controlled pollution in the midst of one of the world's most densely populated cities can produce severe health risks.

Air pollution in Greater Cairo has exceeded U.S. and World Health Organization (WHO) health standards for every major pollutant. The levels of particulate matter and lead in Cairo's ambient air are higher than in nearly all other large cities in the world. Scattered

[2] Cairo's water and sewer management institutions will have to greatly increase their revenues to do this. User charges now cover less than half of water and sewer operation and maintenance costs, not to mention capital needs for system expansion and eventual replacement.

data suggest high levels of toxic substances in Cairo's food and drinking water[3] and in the blood of Cairo residents.

In the following sections, we examine Cairo's environmental problems—both traditional and modern—in more detail and estimate their impact on the health of residents. The discussion is organized into six broad topics: air pollution, water pollution, solid waste, food contamination, lead, and environment-related microbiological diseases.

D. Air Pollution

Ambient levels of air pollutants in Cairo have been sampled or monitored for more than 25 years by the Egyptian Ministry of Health, the National Research Center, other academic researchers, and various consulting firms. Although inconsistent monitoring locations and varying analytical methods make interpretation of the data difficult, pollution levels seem to have generally increased with population, industrial activity, energy, and vehicle use through the late 1980s, with a mixed pattern since then.

Current ambient concentrations for all major air pollutants in Cairo approach or exceed levels that threaten public health. The table below compares the most recent data for major air pollutants in Greater Cairo with U.S. health-based standards. Comparisons with WHO standards would show a similar pattern. We do not compare the data with Egyptian ambient air pollution standards because these often do not reflect current international knowledge about health effects. The ranges in the data below reflect the variation for each pollutant across the handful of sites monitored.

Table III-2: Concentrations of Air Pollutants in Cairo

Pollutant	Concentration (ug/m^3)	U.S. Standard (ug/m^3)
Sulfur Dioxide	40-156 annual mean	80 annual mean
Particulate Matter	349-857 annual mean	75 annual mean
Nitrogen Oxides	90-750 hourly means	100 annual mean
Carbon Monoxide	1,000-18,000 hourly means	40,000 1-hour; 10,000 8-hour
Lead	0.5-10 annual mean	1.5 quarterly mean
Ozone	100-200+ hourly maximum	235 hourly maximum

The sources of these pollutants in Cairo and their significance to health will be discussed in the following sections. Other air pollutants for which monitoring or sampling data in Greater Cairo are virtually nonexistent include numerous toxic metals and organic compounds (e.g., cadmium and benzene) and indoor pollutants.

---

[3] Conflicting data sets, particularly regarding lead in drinking water and pesticides in food, leave uncertainty about exactly how high the levels of toxic substances are.

D1. Sulfur Dioxide

Sulfur dioxide is formed largely by combustion in industry, power plants, and vehicles of fuels containing sulfur. Industry (heavy industry and small workshops, bakeries, etc.) probably produces slightly more than half of the sulfur dioxide emissions in Cairo, and power plants (which burn about half high-sulfur fuel oil and about half clean natural gas) produce slightly less than half. Diesel trucks, buses, and cars also contribute a small amount. Sulfur dioxide concentrations appear to be decreasing in central Cairo and increasing in Shoubra El-Kheima.

Short-term exposure to sulfur dioxide can narrow the airways and cause difficulty in breathing in healthy individuals at about 2,500 ug/m^3 and in exercising asthmatics (the most sensitive population) at about 650 ug/m^3. The latter level is likely to be reached in Cairo only in the industrial areas of Shoubra El-Kheima, and only for several days per year.

Longer-term exposure to sulfur dioxide has been linked by epidemiological studies to increased mortality and hospital admissions from respiratory diseases. Such effects (independent of accompanying particulate matter or smoke) are thought to occur at 24-hour concentrations exceeding 500-700 ug/m^3. Again, this level is rarely reached in Cairo. There is equivocal evidence for increases in cough, chronic phlegm, and upper and lower respiratory disease at about 100 ug/m^3 on an annual average basis. This level is exceeded by a small amount in Helwan and by a greater amount in part of Shoubra El-Kheima.

In sum, despite the fact that sulfur dioxide concentrations in much of Cairo exceed the U.S. health-based standard, we expect few adverse health effects from this pollutant.

D2. Particulate Matter

Particulate matter (PM) represents a broad class of chemically and physically diverse substances that exist as discrete particles suspended in air. Particles range from large ones that fall out of the atmosphere quickly to small particles that remain suspended indefinitely. The small particles are most hazardous to health, as they can be inhaled deep into the lungs and lodge there, aggravating existing respiratory and cardiovascular disease and prompting other adverse biological responses.

Concentrations of particulate matter across Cairo are extremely high, higher in fact than in any of the world's other largest cities. When measured as Total Suspended Particulates (TSP), PM concentrations exceed U.S. standards by a factor of nearly 10. Other parameters relating to PM—dustfall and smoke—also exceed recognized international standards. PM levels in Cairo's air seem to have increased consistently until the late 1980s, and have declined modestly since then. We estimate that if PM in Greater Cairo were reduced to natural background levels, about 3,000-16,000 deaths and 90-270 million restricted activity days would be avoided each year.[4] (A restricted activity day is one on which an individual feels ill and cannot pursue a normal level of activity. In the United States, more than half of all restricted activity days result in days of work loss.)

For reasons explained in Volume Two, these projected health impacts of PM in Cairo are more likely to be overestimated than underestimated. Nevertheless, the health risks from PM appear significant. PM also causes significant economic damage in terms of soiling, reduced crop productivity, and diminished visibility. It is clear that preventing these impacts would significantly benefit the economy and national health.

There is no inventory of sources of particulate matter emissions in Cairo. Industrial processes, particularly the cement, iron, and steel plants in Helwan, are probably the largest source. Other major sources include natural sand and dust, power plants, construction, open burning of trash, and motor vehicles (particularly diesel engines). Understanding the contribution of natural sources and developing an emissions inventory for the anthropogenic sources should be high priorities. Controlling the major emission sources could then follow.

D3. Nitrogen Oxides

Nitrogen oxides (NO_x) are generally formed in high-temperature combustion processes such as power plant and industrial boilers and motor vehicle engines. In Cairo, perhaps 80 percent of NO_x comes from power plants and industry, with the remainder from motor vehicles. Motor vehicles contribute less than in many other areas, because most cars have low-temperature, inefficient combustion engines.

Little sampling or monitoring for NO_x has taken place in Cairo. Typical *hourly* concentrations in the frequently studied industrial and trafficked areas exceed the U.S. standard for *annual mean* concentrations. Monitoring in Cairo has been insufficient to determine an annual mean at any location or to characterize the spatial variability of NO_x concentrations.

Nitrogen oxides can irritate mucous membranes, aggravate preexisting respiratory illnesses, and cause coughs, headaches, and shortness of breath. No reliable dose-response relationships have been developed for exposure to NO_x, but one study found a 19 percent increase in respiratory illness (relative to controls) in an area with NO_x concentrations similar to those in Cairo. We cannot confidently project the health impacts of nitrogen oxides in Cairo, except to say they may be significant.

---

[4] For most environmental problems for which we estimate risks, we calculate the risks associated with the *entire* problem—the risks that would be avoided if the entire problem was eliminated and the concentration of the pollutant was reduced to zero. For PM in Cairo, though, natural background sources (desert sand and dust, sea salt, rock weathering) are significant and likely not manageable in any cost-efficient manner. Thus, we choose to estimate the risks associated with only the anthropogenic portion of the PM problem; the portion that might perhaps be practically addressed. Limited information cited in Volume Two suggests that about one-third of Cairo's TSP is from natural sources. For purposes of comparison, the health risks associated with the entire PM problem (both natural and anthropogenic sources) are 3,800 - 22,000 deaths and 120 - 370 million restricted activity days per year.

D4. Carbon Monoxide

Carbon monoxide (CO) in Cairo comes almost entirely from automobiles, with industrial plants contributing a small additional amount. CO is usually a localized pollutant, with high concentrations possible at curbside on crowded streets during busy traffic hours and rapid declines at other times and places. No long-term routine CO monitoring takes place in Cairo, and data derive from several older, limited studies of traffic areas. For this project we conducted some additional spot sampling for CO in Cairo that suggested levels approximately the same as those found in larger studies in the early 1980s.

Carbon monoxide reacts with hemoglobin in the blood, reducing the blood's ability to carry oxygen. At moderate levels of CO, healthy people can usually compensate for this oxygen deficit. In individuals with preexisting heart disease, however, moderate levels of CO can cause problems associated with reduced oxygen delivery to the heart, such as increased susceptibility to angina pain and decreased tolerance for exercise. CO begins to elicit these effects at one-hour concentrations of about 60 ug/m^3, or eight-hour concentrations of 25 ug/m^3. CO in Cairo does not seem to reach these levels, though a continuing increase in traffic without exhaust emission controls might occasionally threaten these levels in highly exposed locations.

Studies of highly exposed workers in Cairo (traffic policemen, garage mechanics, bus drivers) have shown significant negative effects from a combination of carbon monoxide and lead. Sixty-two percent of the individuals studied had manifestations of cardiopulmonary illness. We speculate that street vendors and other highly exposed groups could suffer similar effects.

In sum, carbon monoxide in Greater Cairo probably causes significant health problems for individuals in highly exposed occupations and minimal problems for the general population.

D5. Lead

About two-thirds of lead emissions in Cairo come from automobiles fueled with leaded gasoline; the other third comes from the dozen or so lead smelting operations in the city. Lead from cars is distributed throughout the city, while the smelters have a major impact on their immediate vicinity. Air emissions of lead are probably the primary source of lead entering the environment. The lead undergoes numerous environmental processes, and people are eventually exposed to it through air, water, soil, and food. Concentrations of lead in Cairo's air substantially exceed health standards in some locations and are below standards in others. Concentrations of lead in Cairo residents' blood, reflecting total exposure from air and other routes, far exceed safe levels.

The serious health effects of lead in all media are discussed thoroughly in Subsection G, beginning on page III-18.

Virtually all gasoline used in Cairo contains lead additives as inexpensive anti-knock agents. Approximately 20 percent of cars use 90 octane gasoline with 0.9 g/l of lead, while 80 percent use 80 octane gasoline with 0.4 g/l of lead. The average lead level is thus 0.5

g/l, which exceeds levels in many developing countries. Furthermore, all developed countries and some developing countries rely primarily on unleaded gasoline, which is rarely used in Egypt. The GOE's Environmental Action Plan proposes that by 1995 leaded gasoline will contain no more than 0.15 g/l, and unleaded gasoline will be available. There are some indications, however, that this lead phase-down is not happening. Lead phase-down requires refineries to invest in alternate procedures for increasing the octane rating of gasoline, an investment that typically costs several cents per gallon of gasoline.

Cairo's lead smelters produce horrific conditions for their workers and nearby residents. The concentration of lead in indoor air at one smelter was 2.5 mg/m^3, 500 times the U.S. occupational exposure limit. The outdoor concentration of lead 500 meters downwind of the smelter exceeded 50 ug/m^3, more than 30 times the U.S. ambient standard.

D6. Ozone

Ozone is a secondary air pollutant produced by complex atmospheric reactions of nitrogen oxides and reactive volatile organic compounds (VOCs) in the presence of sunlight. Conditions in Cairo are favorable to forming ozone, with large emissions of NO_x and probably VOCs, extensive sunshine, warm temperatures, and stable air. There has been no emissions inventory in Cairo for VOCs, but the major sources are typically evaporation of solvents and gasoline, industrial processes, incomplete combustion, and natural phenomena.

Ozone has not been monitored routinely in Cairo, and data are available only from several limited research studies. These studies show variable peak ozone readings: below, near, and occasionally above the U.S. standard.

Ozone is a primary constituent of photochemical smog. At high exposure concentrations and exercise levels, it is a respiratory irritant that impairs lung functions and leads to lower respiratory symptoms such as cough and chest discomfort. In healthy individuals when exercising heavily, these symptoms can begin to appear at the peak ozone levels seemingly present in Cairo. For asthmatics and those with other preexisting respiratory conditions, symptoms can occur at lower levels. Science is only now providing information on the long-term effects of exposure to ozone at levels present in Cairo. Such levels may increase the likelihood of chronic lung injury, leading in some cases to fibrosis, chronic bronchitis, and heightened susceptibility to respiratory infections.

A best guess that combines limited monitoring information for Cairo with the emerging dose-response information for ozone is that most of Cairo's population experience one to several days per year of mild adverse symptoms caused by ozone. Asthmatics suffer more frequent and serious health effects. This assessment, however, is highly uncertain.

D7. Other Toxic Air Pollutants

Numerous other toxic air pollutants such as benzene, formaldehyde, cadmium, nickel, and benzo-a-pyrene are likely found in Cairo's ambient air and may cause adverse health impacts. No systematic monitoring has been performed for these pollutants, nor are they routinely monitored elsewhere in the world. Such metals and organic compounds have carcinogenic and other effects at low concentrations. We have projected health risks from these compounds by performing a rough analysis that combines limited sampling data on metals with modeled estimates for other compounds. Our analysis includes metals from all sources and toxic organic compounds only from mobile sources.

The results project an estimated 234 to 700 excess cancer cases per year among Cairo's population.[5] This estimate is highly uncertain, however, as it relies on a simple ambient air dispersion model and crude projections of emissions of various compounds per kilometer travelled by various vehicles.

D8. Indoor Air Pollution

Although indoor air pollution has been studied little in Cairo, numerous studies around the world have found it to pose high health risks. Some indoor air pollutants of significant concern elsewhere are likely to be important in Cairo also: environmental tobacco smoke (ETS or "second-hand smoke"); pollutants from cooking stoves (CO, NO_x, particulates); biological contaminants such as molds, fungi, mites, and allergens; and household toxics, particularly pesticide sprays. Several studies of indoor air pollution in Cairo and Egypt are summarized in Volume Three and support this possibility. Residences equipped with gas or (of more concern) kerosene appliances were often found to have concentrations of nitrogen oxides and carbon monoxide exceeding outdoor ambient standards. A study in a village outside Cairo found similar results, and significantly more health problems in homes using biomass fuels. Another study found a relationship between the number of mites in Cairo house dust and the health of residents.

Although these findings suggest potentially important risks from indoor air pollution in Cairo, several factors that often lead to high risks elsewhere—airtight homes, extensive use of toxic household products (solvents, paints, pesticides, asbestos, urea-formaldehyde insulation), use of dirty fuels for cooking and heating (coal, charcoal, wood, dung), and a long heating season—are not typical of Cairo. We speculate that these mitigating factors may diminish in importance as Cairo develops economically. Rising incomes may bring greater use of air conditioning in enclosed buildings and perhaps more consumer purchases of modern products containing toxic ingredients. This subject warrants investigation.

E. Water Pollution

Polluted water may cause health risks in Cairo by several means. Most obviously, risks can arise when individuals drink contaminated water. Contamination may be present in the raw water supply, take place during treatment, or occur inadvertently in water distribution, storage, or the home. Health risks may also arise from direct contact with contaminated water while individuals are working, washing, or swimming. Water pollution may also be an indirect source of human health risk, as when individuals consume crops

---

[5] These estimates of cancer risks and those in other sections of the report have been derived using the U.S. Environmental Protection Agency's ("U.S. EPA") intentionally conservative cancer risk assessment procedures. U.S. EPA's procedures provide an "upper bound" rather than a "best" estimate of cancer risks to avoid underestimating the potency of carcinogens. Many analysts have argued that a best estimate—as opposed to a conservative estimate—of the true cancer risk for a chemical would be one or more orders of magnitude less than an estimate using U.S. EPA's procedures.

irrigated with contaminated water, or when they ingest fish that bioaccumulated pollutants while living in contaminated water. Each of these risk pathways has been investigated separately.

E1. Risks from Drinking Water

Nearly all residents of Greater Cairo receive treated drinking water through individual connections to their homes. The water utility is the General Organization for Greater Cairo Water Supply (GOG). GOG operates 16 water treatment plants producing about 3.5 million cubic meters of potable water each day. Most of the water is withdrawn from intake points in the Nile, with additional ground water sources providing about 8 percent of the supply. Typical treatment at GOG plants begins with chlorination. Next, alum or other flocculants are sometimes added to remove iron and manganese, particularly from ground water. The water is then clarified, chlorinated again, passed through sand filters, and rechlorinated. The finished water then flows to storage or pump stations for distribution. At this point, Cairo's drinking water is nearly always clean.

Problems in the water distribution system, however, lead to erratic water supplies and/or contamination of the drinking water in some areas of the city.

Much of the system has inadequate storage capacity, limiting opportunities to produce water during low demand periods and distribute it during peak demand. While the transmission main network is generally adequate, the distribution pipes are often small and poorly looped, resulting in pressure loss in some areas before the water reaches the consumer. The distribution system is comprised of pipes of numerous materials from a variety of sources and, in the older areas of the city, has deteriorated significantly. These factors further limit the pressure at which water can be pumped through parts of the network. The result is erratic water pressure and unreliable supply to residences in various areas.

To compensate for erratic water supply, many buildings are equipped with pumps and holding tanks. Unfortunately, pumping water from the distribution system creates negative pressure, increasing the likelihood of infiltration of ground water and sewage into the pipes. In addition, many of the tanks are open to contamination by atmospheric deposition, birds, and animals.

Ongoing system upgrades are improving the reliability of the system and reducing contamination of the drinking water after treatment. Supply capacity is increasing, additional reservoirs are planned, pump booster stations are being constructed to improve pressure, and new transmission systems are being installed to accommodate growth. Improvements planned or completed under the 1990 Master Plan update are expected to provide enough capacity to meet current demands.

The portion of Greater Cairo's population receiving water in their homes through this system is not certain. GOG officials estimate over 90 percent. A USAID water supply expert suggested 95 percent. A 1990 study estimated that 1.4 percent (almost 100,000 people) of East Bank residents were served by public fountains rather than individual household connections. For purposes of analysis associated with this project, we have assumed that 90 percent of the Greater Cairo population is served by water connections to their homes.

Individuals relying on a neighborhood standpipe for water typically use much less water than individuals with a connection to their home. Water must be transported from the standpipe to the home (often by hand in buckets) and stored. Transportation and storage expose the water to possible contamination. Reduced availability of water and increased likelihood of its contamination significantly increase the risk of infectious disease among residents without in-home connections. (See Subsection I, beginning on page III-24, on microbiological diseases.)

To estimate the health risks from drinking water contamination in Greater Cairo, we obtained and analyzed several data sets on the chemical quality of surface water in the Nile, ground water, water after treatment at GOG plants, and tap water in Cairo residences. Using these data, the Nutrition Institute's estimate of 2.8 liters per day as the average per capita consumption of drinking water, and U.S. EPA dose-response information for each chemical, we arrived at the following calculations of health risks from drinking water contamination:

- **Up to 2.5 excess cancer cases per year from carcinogenic byproducts of chlorine disinfection.** (As explained previously, cancer estimates using U.S. EPA methods are likely to be substantial overestimates by one or more orders of magnitude.) No non-cancer health impacts are expected.

- **Zero to 467 excess cancer cases per year from carcinogenic pesticides.** The wide range reflects contradictory data sets. Data from a study of the Nile as a water source and from GOG monitoring indicate very low concentrations of pesticides. However, a tap water sampling study indicates much higher pesticide concentrations. Depending on which data sets are correct, non-cancer impacts may also be possible.

- **Trivial risk of cancer or non-cancer health effects from other chemical contaminants except lead.** Except for lead (see Subsection G below) all such contaminants in drinking water occur at levels significantly lower than their reference doses.[6]

- **Undetermined risk from lead.** Lead in both Nile water and treated drinking water averages about 6 ug/l. However, a major study of tap water found lead concentrations of 200 to 700 ug/l, with an average of nearly 500 ug/l. Lead at such levels in drinking water would constitute a major health hazard. We are surprised that so much lead could enter the supply through the water distribution system or homes and suggest additional investigation to clarify the issue. This

[6] The reference dose (RfD) for a chemical is the dose which, when consumed daily by an individual for a lifetime, is sufficiently safe to yield only a trivial risk of adverse health effects. The RfD is similar in concept to the Acceptable Daily Intake. RfDs have a margin of safety built into them. Thus, a dose exceeding the RfD is not necessarily unsafe. A dose under the RfD is almost certainly safe.

subject is discussed further in the section on lead in all environmental media in Cairo.

- **Unquantifiable health risks from microbiological agents in drinking water.** Levels of these agents in water sources and treated water are low. However, drinking water can be contaminated later in the distribution system or during storage. Subsection I evaluates the risk of microbiological diseases in Cairo from environmental sources. It is difficult to apportion the total incidence of microbiological diseases among specific causes such as contaminated water, erratic water supplies, or poor personal hygiene. The rate at which microbiological diseases are transmitted depends on a combination of factors, and contaminated water is only one of them.

E2. Risk from Direct Contact With Contaminated Water

Working, swimming, bathing, or washing articles in the Nile and canals could cause microbiological disease among individuals engaged in these activities. Concentrations of bacteria in these waters probably vary widely across times and locations (particularly with proximity to sources of human waste). Limited sampling data from various locations on the Nile in Cairo suggest that bacteria concentrations are generally within suggested safe levels. Fecal contamination of canals is probably higher. Risk of microbiological disease from direct contact, like the risk from pathogens entering water distribution systems, cannot be estimated in isolation from other causes of microbiological disease. We would guess that risk to the general population of Cairo from direct contact is low because most residents have little cause to be in the water.

E3. Risk from Irrigating Crops With Contaminated Water

The concentrations of chemicals and bacteria in the Nile water are well within guidelines for safe irrigation of food crops. We found no data on water quality in irrigation canals. We doubt that levels of chemical contaminants in canals are excessive, though levels of microbiological contaminants might be. This pathway may also contribute to the overall incidence of microbiological disease in Cairo.

E4. Risk from Consumption of Contaminated Fish

Based on data on levels of carcinogenic pesticides in Nile fish near Cairo, fish consumption (average of 9 g/day), and dose-response for the pesticides, we estimate 1 to 46 excess cancer cases per year among Cairo residents.

E5. Ecological Impacts of Nile Water Quality

Although the ecological effects of Nile water quality are not within the scope of this project, we nevertheless investigated this issue quickly. Ambient concentrations of pollutants in Nile River samples were compared with U.S. water quality standards for protecting aquatic life. Concentrations were not found to exceed standards for acute, short-term exposures. However, concentrations of lead in the Nile consistently exceeded standards for long-term exposures, and concentration of mercury and copper also occasionally exceeded standards. It should be noted that U.S. aquatic life standards were developed to protect aquatic species common in the United States and may not be appropriate for species indigenous to the Nile.

F. Solid and Hazardous Wastes

About 0.8 kg of solid waste is generated per person per day in Cairo, for a total daily volume of about 10,000 tons. Approximately two-thirds of this is from the residential sector, and one-eighth each from the commercial and municipal (mostly street cleaning) sectors. By composition, 46 percent is food, 21 percent is paper, and the remainder consists of metals, plastic, and other materials. The proportion of food waste increases in lower-income areas, while the proportion of potentially recyclable waste (paper, metals, plastic, etc.) increases in higher-income areas.

Perhaps only about half of Cairo's solid waste is collected and managed. Collection rates vary by area as a function of income, ranging from a low of about 10 percent in some of the poorest areas to over 70 percent in upper income areas. The uncollected waste is dumped in streets, canals, vacant areas, or other temporary dump sites. It is often burned on site when it builds up to noxious levels.

Much of the collected waste is managed by a unique group of people known as the Zaballeen. The Zaballeen collect waste from residents for a monthly fee and transport it by truck or donkey cart to one of about a dozen Zaballeen communities, where it is carefully picked over for recycling. The various recyclables are separated and sold. Even food waste is used—the Zaballeen raise pigs on the food scraps. The Cairo Cleaning and Beautification Agency also collects solid waste, largely from the streets and public containers, and not from residences. Recently, the municipal government has attempted to sell franchise rights to private companies to collect waste in specified areas. Private collection companies have found it profitable to serve higher-income areas because of their ability to pay for services and the greater value of their waste for recycling. The private companies collect the waste by truck and bury it at disposal sites or deliver it to the Zaballeen for recycling.

After collected waste is picked over for recycling, most of the remainder is deposited in open dumps outside the city. Cairo has no operating sanitary landfills, and the three composting plants can handle only up to 2 percent of the city's solid waste. Several incinerators were built but are now inoperative.

Hazardous wastes from industrial facilities do not appear to be handled separately from normal solid wastes. Large toxic stockpiles have accumulated in heavy industrial areas such as Helwan, Shoubra El-Kheima, and Embaba. Estimates of hazardous waste production range from 20,000 to 50,000 tons per year.

Medical and hospital wastes present special problems. They are generally disposed of with other solid wastes and can pose infectious disease hazards to those who collect, transport, and dispose of the wastes. Some university and private hospitals have installed incinerators for their wastes, but these function sporadically due to lack of spare parts and poor maintenance. Public hospitals indicated that special disposal of their wastes has not been a high-priority concern. Hospital waste constitutes much less than 1 percent of the volume of municipal wastes.

It is not possible to offer a quantitative assessment of the degree of health risk resulting from solid and hazardous waste management practices. The qualitative discussion below suggests how health risks might arise:

- Large volumes of waste are either never collected or are left to fester and rot after collection and extraction of recyclables. These waste piles are typically near residential areas. They support rodent, insect, dog, and cat populations that contribute to transmission of infectious diseases. Health risks of this sort are discussed in the section on microbiological diseases. In general, we believe uncollected and discarded solid waste is probably less of a contributing factor to infectious disease than are non-environmental factors (overcrowding, poor nutrition, etc.) and other environmental factors relating to sanitation, particularly lack of water and excreta disposal facilities in some neighborhoods.

- The Zaballeen's close contact with solid wastes undoubtedly raises the issue of solid waste as a contributor to disease in Zaballeen communities. This issue could be investigated through epidemiological studies comparing health in Zaballeen communities with health in socioeconomically similar communities that are not involved so closely with solid waste.

- Discarded or dumped wastes are often open burned when they accumulate to certain levels. Such open burning contributes mostly particulate matter and toxic pollutants to air pollution. We surmise that open burning of waste is a relatively small contributor to air pollution problems.

- Discarded solid wastes may pollute surface or ground waters and contribute to risk through drinking water contamination. However, nearly all pathogens from solid waste that find their way into a drinking water source will be eliminated by chlorination at Cairo's water treatment plants. It is unlikely that concentrations of chemical contaminants in solid wastes are high enough to create chemical-related risks in drinking water.

On balance, aside from the potential impact on the Zaballeen, we believe solid and hazardous wastes are likely to pose low health risks in Cairo.

G. Lead

Lead is a widely distributed environmental pollutant that has been linked to serious adverse health effects among infants, children, men, and women. At levels common in Cairo, lead can affect mental development, blood chemistry, kidneys, and nervous, reproductive, and cardiovascular systems. Researchers have increasingly been able to link the impacts of lead to levels of environmental exposure and resulting concentrations in human tissues and fluids. Because of the high levels of lead in Cairo in all environmental media (air, water, and food) and the health risks they pose, we have consolidated information on lead into a single section in this report.

G1. Sources of Exposure

Air. The major source of lead in air is combustion of leaded gasoline by automobiles. Gasoline used in Cairo has contained relatively high lead content at an average of 0.5 g/l (0.9 g/l for high octane gasoline and 0.4 g/l for low octane). The GOE is reducing this level toward a goal of 0.15 g/l by 1995, but there is doubt as to whether this reduction is occurring as planned. If this lead phase-down occurs, the contribution of leaded gasoline to concentrations of lead in the body will decrease significantly, despite the increase in automobiles and traffic in the city. Lead smelters likely contribute a smaller tonnage of lead to the Cairo atmosphere than do automobiles, but the smelter emissions and resulting health effects are concentrated in much smaller geographic areas. Concentrations of lead in air range from about 0.5-10 ug/m^3 in different locations in Cairo, often well above the U.S. health-based standard of 1.5 ug/m^3. Lead concentrations in ambient air around smelters are commonly above 10 ug/m^3 and occasionally climb as high as 50 ug/m^3.

Drinking water. There is uncertainty about the concentration of lead in drinking water due to conflicting data sets. The largest and most comprehensive study of Cairo's tap water found very high concentrations ranging from 200 to 700 ug/l. Two smaller studies found levels under 20 ug/l. Studies of tap water in the United States find lead levels below 50 ug/l, even in old homes with lead pipes. Lead levels measured by the Cairo Water Authority in treated water before the water entered the distribution system were quite low, around 6 ug/l, suggesting that lead originating from the raw water (Nile and ground water) and treatment plants is negligible. Thus, either:

- Sources in the water distribution system or home (lead pipes, pumps, storage tanks, solder, fittings, meters, and joints between meters and home plumbing) contribute large amounts of lead to tap water; or

- There is an error in the largest study of lead in tap water.

If the estimates in the largest study are accurate, tap water is responsible for nearly 70 percent of total lead intake by the average Cairo resident. If the much lower estimates from other studies are accurate, tap water is responsible for about 8 percent of lead intake, with food as the predominant source.

Food. Food is a significant source of exposure to lead in Cairo, estimated at either 30 percent or 87 percent of total intake, depending on the level of lead assumed to be in drinking water. Sampling of food in Cairo for lead has been limited. The only study estimating the lead content of the average Egyptian diet finds total lead intake from food similar to that in other developing countries. Precisely where this lead comes from, however, is not clear. We speculate that most lead in food probably originates in the air. Lead from the air deposits on foodstuffs as they are grown, transported, and displayed and sold at markets. Lead that has settled on the soil may be absorbed into crops through plant roots and when plants are consumed by livestock. Food preserved in lead-soldered cans (commonly used in Egypt) often absorbs 10 times the lead already in the food. Lead is also found in fertilizer and irrigation water, and in ceramic glazes on pottery in which food may be prepared and served. Studies of the lead content of food at each step from field to consumption will contribute to designing effective measures to reduce lead intake through food.

Dust and soil. Exposure to lead through ingestion of contaminated dust and soil may be important for children in Cairo, as suggested by studies showing a high lead content in playground dust and urban soil. The lead content of playground dust in Cairo often exceeds the U.S. standard for remediation of contaminated soils at abandoned hazardous waste sites. However, the limited data on dust and soil and children's behavior in ingesting them are not sufficient to allow quantitative estimates of their exposure.

Occupational sources. A final source of exposure to lead is occupational. Workers can be exposed to lead at their jobs, bring the lead home on their bodies, clothes, or possessions, and expose others. There are inadequate data to assess the risk to the general population of such secondary occupational exposures. Studies in Cairo of smelter workers, traffic policemen, and, to a lesser degree, garage mechanics and bus drivers document extremely high levels of exposure among the workers themselves and resulting serious health damages.

G2. Human Exposure to Lead and Resulting Health Effects

Human exposure to lead can be gauged most accurately by measuring the level of lead in body tissues or fluids: blood, hair, bone, semen, and urine. Concentration of lead in the blood is the most common measure of exposure and is usually expressed in micrograms of lead per deciliter of blood.

Three independent studies in the 1980s found an average blood lead level of about 30 ug/dl for men in Cairo. Blood lead concentrations in women appear slightly lower; a figure of 27.5 ug/dl has been used for women in this analysis. Sub-populations of Greater Cairo that have been under-represented in studies of blood lead levels include children and people living near smelters. Very limited data suggest mean blood lead levels of about 22 ug/dl for children in Cairo and more than 50 ug/dl for those living near smelters. Highly exposed smelter workers had an average blood lead level of 80 ug/dl. For comparison, mean blood lead levels in the United States are now about 4 ug/dl for adults and 5 ug/dl for children. The levels in Cairo are significantly higher than those reported by the United Nations Environment Programme for 20 cities in developing and developed countries throughout the world.

The blood lead levels of Cairo residents suggest extremely serious damage to health. In the United States, a "level of concern" has been established for children of 10 ug/dl, at which lead poisoning prevention should begin. For adults in the workplace, blood levels exceeding 50 ug/dl trigger medical removals. Workers are allowed to return to work only when their blood lead level falls below 40 ug/dl.

Several large cross-sectional and longitudinal studies have quantified statistical associations between blood lead and the incidence of adverse health effects. Experimentation with animals has provided additional understanding of some of the physiological impacts and has established causality for some effects. We have applied the more confidently known dose-response relationships to blood lead concentrations among Cairo's residents to project health risks in Cairo. The wide range of impacts, including impacts on the cardiovascular, nervous, reproductive, excretory, and digestive systems, is notable. If blood lead concentrations in Cairo could be reduced to levels comparable to those in the United States[7], we estimate that the following health effects would be avoided:

- **Loss of intelligence in children.** An estimated average of *4.25 IQ points is lost per child* in Cairo from exposure to lead. Lead interferes with several processes in a child's highly sensitive developing nervous system.

- **Infant mortality.** An estimated *820 infants die annually* in Cairo because of their mothers' exposure to lead. High blood lead levels in pregnant women correlate with reduced gestational age for newborns; reduced gestational age increases infant mortality.

- **Heart attack, stroke, and premature mortality.** An estimated *6,500-11,600 heart attacks, 800-1,400 strokes, and 6,300-11,100 premature deaths occur annually* among Cairo's population of older men (age 40-75) and women (age 45-75) as a result of high exposure to lead. Elevated blood lead levels correlate with increased blood pressure in adults, and high blood pressure is a significant factor in cardiovascular illnesses. These relationships are stronger for men than for women.

These estimated adverse health impacts from lead in Cairo are very large. Other suspected effects from lead have not been quantified because dose-response relationships for them are more speculative. These include, for example, possible carcinogenic effects and aggravation of osteoporosis and other effects in post-menopausal women.

H. Food Contamination

Several important kinds of contaminants from environmental sources may be in the food consumed by Cairo residents, including pesticides, metals, and microbiological agents. Toxic chemicals in food add to human exposure from other environmental media and can contribute to cancer, lead poisoning, and other chronic effects. Microbiological contaminants can lead to food-borne bacterial, viral, and helminthic infections. We exclude from consideration in this analysis some types of food contaminants from non-environmental sources: food additives (saccharine, nitrite preservatives, food dyes), natural carcinogens (aflatoxin in peanuts), and substances created in or added to foods as they are cooked (products of incomplete combustion as foods are grilled, baked, or seared; contaminants picked up from cookware or water used for boiling).

Pesticides may enter foods in several ways. Pesticides applied to crops in the field may remain on food surfaces or be incorporated systemically into the plant. Subsequent washing, processing, and cooking may remove some but not all of the pesticide residue.

---

[7] As for several other environmental problems, here we estimate the risks associated with the portion of the problem that is due to man's activities, excluding risks due to presumably unmanageable natural sources. Some human exposure to natural background sources of lead is inevitable. As a very rough approximation, we assume that current U.S. blood lead levels—among the very lowest in the world—represent the minimum achievable despite natural background sources.

Pesticides may also be applied to crops after harvest to prevent spoiling during transport and storage. Pesticides may appear in crops irrigated with reused water that was contaminated upstream by pesticides used on other crops.

Metals similarly may be found in foods through many processes. Many plants absorb metals from soil and water. (The metals may be in the soil or water naturally or as a result of air deposition or contaminated irrigation water.) Metals can also come from the application of pesticides and fertilizers containing metals, processing and canning of foods, and deposition of airborne metals on exposed foods in transport, storage, or as they are displayed and sold in roadside markets.

Fish, livestock, and a few plants will bioaccumulate many pesticides and metals, which become concentrated to levels far beyond those at which they occur in air, water, soil, and animals' food. This is particularly the case for lipophilic pesticides that concentrate in fatty tissues.

Many varieties of microbiological contaminants are found in food, including salmonella, shigella, staphylococcus, clostridium perfringens, bacillus cereus, e. coli (signifying human fecal contamination), and helminths. These agents are widely distributed in the environment and can be kept out of foods only through sanitary procedures at each step from crop production through food consumption. Some means by which these agents can enter foods include use of fecally contaminated water for crop irrigation; food handling by infected persons; flies and rodents; preparation of food on contaminated surfaces, cooking vessels, and utensils; coughing on exposed food; and eating with unwashed hands. Most microbiological agents multiply rapidly in food stored at inappropriate temperatures. In most cases refrigeration minimizes growth of these agents, and in other cases food needs to be kept sufficiently hot. Although cooking kills many agents, cooked food can be quickly reinfected and, if food is not consumed promptly, colonies can multiply to dangerous levels.

Health risks from food contamination are assessed by different methods for chemical and microbiological contaminants.

H1. Health Risks from Chemical Contaminants in Food

For chemical contaminants, standard risk assessment techniques can be used. A profile of the average diet is obtained, indicating the quantity of each food consumed. With sampling data on the levels of different contaminants in each food, dietary exposure to each can then be estimated. Finally, to project health risks, standard dose-response relationships can be applied to the calculated doses for each contaminant.

We were unable to obtain sufficient data to implement this approach fully for Greater Cairo. Thus, our assessment of health risks from chemical contaminants in food is seriously incomplete.

We obtained dietary data for two groups: infants in their first year of life and adults. These data represented the average diets for all of Egypt, not just Greater Cairo. Contaminant data were available only for a single metal, lead, and for organochlorine pesticides such as DDT, lindane, and dieldrin, which generally were not used in Egypt after the 1970s. The pesticides currently used (organophosphorus, carbamates, pyrethroids) are much less long-lived than organochlorines, and most are not thought to be carcinogenic. Therefore, they likely pose lower risks than the residues of the 20-year-old organochlorines. Without food residue data for the newer pesticides, we cannot be sure. We suspect heavy metals other than lead may also contribute to health risks through food. Other metals have been measured in significant concentrations in Cairo's atmosphere and dustfall and some food, and local studies show cadmium as well as lead uptake in crops. More research is needed to satisfactorily characterize the risks from chemical contaminants in Cairo's food supply.

Based on these data, we calculate that:

- Pesticides in food result in high lifetime excess cancer risks of about 4×10^{-2}. Among Cairo's total population, this could result in 7,000 excess cancer cases per year. For both infants and adults, food intake of each of four organochlorine pesticides exceeds the reference doses by factors of 8 to 33, suggesting the possibility of non-cancer health impacts also. (For reasons discussed in Volume Two, we question these results. The units for pesticide residue measurement may be incorrectly reported. The reported pesticide residue concentrations in Egypt are 2 to 3 orders of magnitude higher than for other countries. This may or may not be correct: this issue needs further investigation.)

- Lead from food contributes a significant portion of the lead intake by Cairo residents. This intake in turn has very serious health effects among the population (see the subsection on lead). Average lead intake from food in Egypt appears similar to that in other developing countries for which such data are available, and far above that in developed countries.

Several measures can effectively reduce concentrations of toxic chemicals in food. Reducing the use of pesticides and environmental releases of metals are obvious steps. Where crops are grown is also important; metal concentrations in crops decline sharply as one moves farther from heavily traveled roads or industrial areas. For today's degradable pesticides, the time from applying pesticides to picking fruits or vegetables significantly influences residue levels. Washing, soaking, cooking, or processing food also usually reduces both pesticide and metal concentrations.

H2. Health Risks from Microbiological Agents in Food

It is not possible, for several reasons, to project health risks from microbiological agents in food using dose-response functions. Instead, in the section below, we estimate the incidence of disease in Cairo attributable to environmental causes, including food contamination.

We note here only some studies indicating that pathogenic organisms are commonly found in food in Cairo, often at high concentrations. These studies include food served by street vendors; raw and cooked meat in factories, markets, restaurants, and hotels; weaning foods typically served to infants; and rice dishes prepared in different establishments. The studies found organisms that can cause several types of food poisoning in roughly 10-60 percent of the food samples analyzed. In general, food contamination was more likely in a lower income setting. For example, food from three- and four-star hotels showed lower rates of contamination than food from street vendors and poorer homes. A consistent factor in microbiological contamination was storing foods at inappropriate temperatures or for long periods of time. The varieties of food poisoning caused by these organisms are typically mild, lasting less than 24 hours with nausea and diarrhea, but often no fever or vomiting.

I. Microbiological Diseases

This section evaluates health risks in Greater Cairo from diseases caused by microbiological agents and related to environmental pollution. These diseases include acute diarrhea, dysentery, infectious hepatitis, typhoid fever, and many others. Agents responsible for these diseases include bacteria, protozoa, viruses, and helminths (worms).

The symptoms in the majority of cases of these diseases, all of which are easily treatable, are relatively mild—uncomfortable but transient diarrhea, nausea, and often fevers and vomiting. Some rarer diseases have more serious effects and are occasionally even fatal. Most of the diseases weaken their victims, making them more susceptible to other health problems. Chronic diarrhea or helminth infections contribute to long-term malnutrition and poor growth. Most of the diseases are of more concern in infants and the elderly, who typically are less able than adults to tolerate the loss of fluids that accompanies these diseases when they are not treated.

Data on mortality or morbidity for most of the diseases are not available. Data in Egypt are reported only for a larger class of diseases—"infectious and parasitic diseases"—of which environmentally related diseases constitute a large, but unknown, portion. We do not consider many infectious and parasitic diseases environmentally related; for example, transmission and persistence of measles and sexually transmitted diseases are not related in an important way to environmental pollution. Infectious and parasitic diseases in Egypt are responsible for about 10 percent of total deaths and 30 percent of deaths among young children.

Environmentally related microbiological diseases are prevalent in developing countries and warm climates. Their incidence is related to a broad set of intertwined factors: poverty, poor sanitation, poor housing, overcrowding, malnutrition, limited and impure water supplies, lack of sewage disposal and treatment, and inadequate health care and education. Some of these factors are associated with environmental pollution and are thus relevant to this study. For this reason, we include some cases of microbiological disease among the health risks caused by environmental problems in Greater Cairo.

Risk assessment for these diseases is extremely difficult. Lack of data on concentrations of disease agents to which people are exposed—and poorly understood dose-response relationships—prevent use of the predictive approach that is used for most environmental problems, in which dose x potency = predicted risk. Instead, risk for microbiological diseases is typically assessed through a reverse approach, in which data on observed incidence of disease are apportioned backward among environmental vs. other causes. In this study, this approach is severely hampered by the incomplete, unreliable, and imprecise nature of statistics on morbidity and mortality in Cairo and the general difficulty of attributing cause to environmental or other factors.

Despite these difficulties, we have developed a rough quantitative estimate of the microbiological health benefits of improved environmental conditions in Cairo. We estimate that extending good water and sewerage service to Greater Cairo's entire population would eliminate the following:

- About 6.1 million days of diarrhea each year. This includes 2.9 million days of diarrhea among young children aged 0-5, and 3.2 million days among the rest of the population.

- About 1,700-5,500 deaths per year.

These estimates are derived from two of Egypt's more reliable data sets on health: the periodic nationwide "Demographic and Health Survey," a rigorous statistical sample survey of Egyptian households; and the Central Statistical Agency (CAPMAS) compilation of number and cause of deaths. Several assumptions have been made to generate estimates for Cairo from these sources:

- The prevalence of diarrhea in adults is about one-fifth the prevalence in young children.

- The effectiveness of environmental interventions in reducing morbidity and mortality in Cairo is represented by median figures identified in a large literature review of studies throughout the developing world.

- Ninety percent of Greater Cairo's population is supplied with potable water of good quality and quantity, and 75 percent is adequately sewered. The health benefits we estimate are for extending services to the unserved 10 and 25 percent of the population. (We do not estimate additional reductions in incidence of disease by improving the quality of service to the 90 or 75 percent already served, as was discussed in the section on water pollution.)

Calculations and assumptions are described in more detail in Volume Two. Our estimates should be regarded as approximate at best; the uncertainties associated with quantitative work in this area are large. A qualitative discussion of the impact of environmental factors on rates of microbiological diseases may be most appropriate.

Most environmentally related microbiological diseases involve disease agents that are spread through oral ingestion of human feces. An infected individual excretes the agent, which may live and (in some cases) multiply in the feces. Another individual can be infected by ingesting the fecal matter itself or fecally contaminated water, food, or soil. For this to happen, fecal matter must be present in the individual's immediate environment. Its presence can result from unsanitary use/care of latrines, indiscriminate defecation by children, overflows or backups from sewers, discharge of untreated domestic waste from sewers to water courses, etc. Next, an individual must make the necessary type of contact with the source. Generally this means direct contact, with transfer of fecal matter from hands to mouth, or ingestion of fecally contaminated water or crops fertilized with sewage. The specific pathways are quite varied and do not lend themselves to generalization. For example, a mother with contaminated fecal matter under her fingernails can infect her infant while breast-feeding, or an individual can become infected by eating raw produce that has been freshened at the market with fecally contaminated water. Furthermore, the degree of importance of each pathway varies with each disease; for some, contaminated water is a primary source of infection (bacterial diarrhea), while for others walking barefoot on insufficiently treated human waste may be the chief source (ascariasis).

Another group of diseases is transmitted by vectors such as insects (mosquitos, flies, lice), snails, arachnids (mites), and animals (rats, dogs, cats). Often the agent is transmitted to the human through a bite, as with malaria and rabies. Some agents require a vector as an intermediate host before they infect humans, as in the case of snails and schistosomiasis.

The diseases that are not formally vector-related can also be transmitted via vectors in the following fashion. Pathogens can be transported on the legs and bodies or in the digestive tracts of certain vectors, particularly flies, cockroaches, and other insects that breed in or eat feces. For example, a fly breeding near a latrine could pick up *shigella* bacteria from infective feces and land on uncovered human food, where this bacteria could multiply to a level high enough to infect those who eat the food. This pathway is normally a less significant route of transmission than direct fecal-to-oral transmission.

In each of these pathways, environmental factors (e.g., untreated sewage, uncollected garbage) significantly increase the amount of the infective agent in people's immediate surroundings, the prevalence of vectors, or both. Thus we consider these microbiological diseases environmentally related. Such diseases include at least:

- Acute diarrhea
- Dysentery
- Enteric fever (typhoid, paratyphoid)
- Encephalitis
- Tetanus
- Acute poliomyelitis
- Typhus and other rickettsioses
- Scabies
- Malaria
- Cholera
- Hepatitis A
- Rabies
- Leptospirosis
- Helminthiases

Environmental conditions in Cairo with which we are concerned in this project can contribute to the spread of these diseases in several ways:

- **Lack of water.** Inadequate water supplies that limit washing and cleaning may exist in Cairo not only for homes not connected to the piped public water system, but also for homes affected by low water pressure, broken water mains, and other causes of erratic water supplies.

- **Contaminated water.** Many microbiological agents live in water. Cairo's drinking water as it leaves the treatment plant is normally adequately disinfected, but microbiological contaminants may enter by infiltration through the distribution system or when water is stored.

- **Lack of sewage conveyance.** The fecal-to-oral pathway can be broken by ensuring that human excrement is conveyed away from where people are likely to come into contact with it.

- **Lack of sewage treatment.** Appropriate treatment of sewage, in a sewage treatment plant or in septic tanks and cesspools under proper loading and soil conditions, will remove nearly all harmful microbiological agents from wastewater.

- **Uncollected solid waste.** From one-third to two-thirds of Cairo's solid waste is not collected, and collected waste is typically picked over and dumped. The discarded waste provides food and a breeding ground for disease vectors.

- **Food contamination.** Environmental food contamination is that which occurs outside the home and is reasonably subject to governmental inspection and regulation. It includes contamination of food during cultivation, processing, packaging, storage, marketing, and preparation by restaurants and street vendors.

The quality of water supplied is less important than having a reliable water supply in the first place. Treating human excreta properly (in sewage treatment plants, for example) is less important than conveying it away from people. Although water quality and sewage treatment are not vital in controlling most types of microbiological disease, they are of significant value, respectively, in reducing traditional water-borne bacterial diseases (cholera, typhoid, shigella) and some helminth-related diseases. In Cairo, sewage treatment is less important as a disease prevention measure because most of Cairo's sewage (whether treated adequately or not) is conveyed away from the metropolitan area by drains, thereby minimizing human exposure to it.

More complete collection and better disposal of household refuse is another environmental factor that can reduce incidence of vector-related diseases. We estimate this value as relatively low, however, because of the greater importance of sanitary measures indoors rather than outdoors.

Factors that we term non-environmental, or beyond the scope of this study, are also important in transmission of microbiological diseases. Critical non-environmental factors include:

- Poor personal and domestic hygiene.

- Inadequate health care, immunization, and education.

- Lack or non-use of toilets.

- Overcrowding and poor housing. Close living conditions increase person-to-person disease transmission.

- Poor nutrition and food preparation in the home.

From the extensive literature on reductions of disease after health-related interventions, one can judge the effectiveness of environmental and non-environmental measures. A consistent conclusion is that non-environmental factors are as or more important than environmental factors in the incidence of these diseases. For example:

(1) Feachem et al. (1981) studied numerous infectious and parasitic diseases and assigned them to groups having similar modes of transmission. He then ranked each of several possible control approaches according to its effectiveness in interrupting the primary mode of transmission for each disease group. His list of control approaches includes improvements in water quality and availability, excreta disposal and treatment, personal and domestic cleanliness, drainage and sullage disposal, and food hygiene. For each type of illness, alternate control approaches were ranked as being of no, little, moderate, or great importance in disease control. Among environmental factors, Feachem found water availability and excreta disposal to be consistently more important than water quality and excreta treatment. Personal and domestic cleanliness and food hygiene are also very important.

(2) Esrey, et al. (1985), reviewed 67 studies from 28 countries that analyzed the impact of several sorts of interventions on incidence of diarrhea. He found the following median reductions in diarrheal morbidity:

	percentage
Improvements in water quality	16
Improvements in water availability	25
Improvements in water quality and availability	37
Improvements in excreta disposal	22[8]

In further work, Esrey et al. (1991) found that non-environmental hygiene interventions (health awareness education, handwashing campaigns) reduced morbidity by a median 33 percent. He also found that interventions were likely to reduce mortality by a greater percentage than they reduced morbidity.

The conclusions of Feachem and Esrey and evidence from other research are generally consistent. In comparing the health risks posed by Cairo's environmental problems, only a minority of all the cases of environment-related microbiological diseases should be attributed to environmental causes.

J. Issues in Comparing Risk Estimates for Different Environmental Problems

In the preceding sections, we have estimated the health risks caused by each of the various environmental problems in Cairo. Our aim is to compare the estimates and thereby

[8] We use these percentages in our rough estimate of the reduction in diarrhea morbidity that might result in Cairo if good water and sewer service were extended to all residents.

rank the problems by their severity. For several reasons, however, the risk estimates that we have developed for different problems may not be directly comparable.

J1. Differing Risk Estimation Procedures

A first issue is that risks have been estimated for problems defined in three somewhat different ways.

(1) For most problems that we have dealt with, risks have been estimated for the entire problem—for all the pollutants associated with the problem, whether they derive from anthropogenic or natural sources. In these cases, the risk estimate is equivalent to the health effects that would be abated if the problem disappeared, and if the ambient levels of all the pollutants associated with the problem were reduced to zero.

(2) For two problems where natural sources of pollutants are important (particulate matter, lead), risks have been estimated for only the fraction of the problem deriving from anthropogenic activities. For these problems, the risk estimate is equivalent to the health effects that would be abated if ambient levels of the pollutants were reduced to natural background levels, not to zero.

(3) For microbiological diseases caused by environmental problems, another approach has been used. It has not been possible to estimate the number of cases of these diseases, or the fraction of cases attributable to environmental in contrast to other causes. Instead, we estimate the number of cases that would be abated if a major environmental program were implemented to extend household water and sewer service to the remainder of Cairo.

These three approaches to estimating risks involve some compromises between: (1) making the risk estimates more useful in guiding policy decisions and (2) ease of analysis.

In general, we would like to make the risk estimates useful to decision makers by estimating risks for each problem, with risks defined as the total that could be abated by plausible environmental interventions. In general, we do not want to include risks that are unlikely to be abated by plausible interventions, such as risks from natural background sources, because including them would give decision makers a misleading sense of how much risk is feasibly at stake in each problem area. Thus we generally prefer to use the second approach above to estimate risks. However, using the second approach instead of the first involves significant additional analytical effort (i.e., separating out natural vs. anthropogenic contributions to risk) and in most cases makes little substantive difference (e.g., for most environmental pollutants, anthropogenic sources are predominant and natural sources are irrelevant or nearly so). So, for most problems we use the first approach, and for a few problems (where we have sufficient data and making the extra analytical effort is justified by the importance of the problem) we prefer the second approach.

The third approach, used for microbiological diseases, is much less preferable. In this approach we do not estimate the total risk that could be abated by plausible environmental interventions, but only the risk abatable by a single plausible environmental intervention (albeit a particularly important intervention). Additional risks could be abated by additional plausible interventions; for example, improvements in water and sewer service to served portions of Cairo would abate additional microbiological disease risks. Because of data deficiencies and analytical difficulties, this less preferable approach is the best we can do for microbiological diseases.

In sum, these risk estimation approaches have implications for comparing the relative severity of environmental problems:

- Risks estimated using the second approach are estimated in a way we consider ideal. Risks from particulate matter and lead are estimated in this manner.

- Risks estimated using the first approach are in general slightly overestimated. They should thus be reduced slightly (to account for the inclusion of natural as well as anthropogenic pollution sources) when compared with the estimated risks for particulates and lead.

- Risks estimated using the third approach are significantly underestimated. Risks from microbiological diseases are estimated for only one of many plausible environmental interventions, whereas all plausible interventions are included in the risk estimates for particulates and lead. The estimates for microbiological diseases should thus be increased significantly when compared with estimates for particulates and lead.

J2. Differing Degrees of Conservatism in Health Effects Information

We use the U.S. EPA's dose-response information for pollutants. In compiling this information, U.S. EPA has generally attempted to avoid underestimating the health effects of a chemical. For chemicals with more uncertainty about their health effects, U.S. EPA typically adopts a larger margin of safety. For chemicals whose effects are well understood (e.g., from extensive epidemiological studies of effects on humans), U.S. EPA is likely to provide a relatively small margin of safety. U.S. EPA's health effects data base does not provide "best guesses" about the potency of each chemical. Instead, it provides potency estimates that are likely not lower than the true potencies. Different degrees of conservatism are inherent in this data base, with substantial implications for interpreting our risk calculations. Nearly all of our risk calculations for this project fall into one of the following four categories:

- **Cancer risk estimates.** If we use evidence based on limited animal studies, our estimate of cancer incidence resulting from pollutants is likely to *substantially overestimate* the true number of resulting cancer cases. For example, the number of cancers from pesticides in food is unlikely to be as high as the 7,000 we estimate using U.S. EPA's cancer potency factors; it is more likely to be 700 or 70 or even less. The same is true, to a lesser extent, of cancer risk estimates for pollutants based on evidence from studies of humans.

- **Estimates of non-cancer effects based on epidemiological studies of humans.** These provide *best estimates* and are not expected to be biased either high or low.

They are derived generally by estimating a relationship between the level of concentration and the incidence of a health effect in the human population exposed to the pollutant, with no conservatism intentionally built into the process. The potency estimates for air pollutants and lead are of this sort. (A different issue is involved in using this potency estimate to extrapolate to ambient conditions in Cairo. We have argued previously that there is likely some overestimate of risks in Cairo resulting from this extrapolation.)

- **Estimates of non-cancer effects based on reported health statistics.** Typically, reported health statistics should be adjusted to account for possible under or over reporting. They may then be further adjusted by apportioning the estimated cases of a disease among environmental and other causes. There is substantial uncertainty in making such adjustments, but unless an adjustment is intentionally made in a conservative or non-conservative manner, these are *best estimates*.

- **Estimates of the number of individuals exposed to a pollutant at levels exceeding the RfD for the pollutant.** When exposure only modestly exceeds the RfD (perhaps 1 to 10 times the RfD), the number of people exposed will *greatly exceed* the number of people likely to suffer the health effect. When exposure is much higher than the RfD, the number of people suffering the health effect will approach the number of people exposed.

In comparing projected health effects for different environmental problems, the numerical bias of each method must be kept in mind.

J3. Disparate Health Effects Across Environmental Problems

Different environmental problems cause a mix of different health effects, ranging from serious and permanent (death, stroke) to mild and transient (headaches, restricted activity days, diarrhea). In addition to considering the number of health effects caused by each environmental problem, we should consider the severity of these effects. How should we rank the relative severity of two problems, one of which causes a small number of serious health effects and the other many more mild health effects?

Other CRA studies have often used a severity index or a set of weights that reflects the relative severity of different health effects. Ideally, the severity index should be culturally based to reflect the relative seriousness of various health effects specifically in the local culture (see USAID, 1990, for an example for Thailand). Alternatively, a multicultural index can be used, such as the World Bank/WHO's approach for estimating loss in "Disability-Adjusted Life Years" for numerous diseases and injuries (World Bank, 1993).

For the Cairo CRA, we were not able to locate an appropriate Egyptian severity index, and decided not to use one of the multicultural indices. For the most part, we felt confident in considering severity of health effects only as a qualitative factor in ranking different problems, without resorting to explicit quantitative weighing. Nearly all the environmental problems we analyzed for Cairo were responsible either for many severe and many mild health effects, or few severe and few mild health effects.

These four types of problems and interpretive difficulties beset all comparative risk analyses. There is no quantitative or fully satisfactory solution for them. The general approach is to rely on the judgment of those conducting the study to provide rough and appropriate adjustments to the raw calculations of health effects for each environmental problem.

K. Summary Ranking of Health Risks

In this project, we have acquired a large amount of data on emissions and concentrations of pollutants in Cairo, and human exposure to them. These data have been combined with information on health effects that may be caused by environmental pollutants to estimate the likely number of adverse health impacts resulting from each environmental problem. We then rank environmental problems by the number and severity of adverse impacts they cause.

Although grounded in science, comparative risk analysis is ultimately qualitative and subjective. Available information on both the levels of pollutants and their potential health effects is limited and uncertain. Our summary judgment about each environmental problem in Cairo thus involves combining our estimate of the number and severity of health effects with an understanding of the quality and biases of the data underlying the estimate.

We reflect our level of certainty in these judgments by classifying each environmental problem into one of four categories: higher risk, middle risk, middle/lower risk or lower risk. We feel confident in assigning most problems to one of these four ranking categories, but are unable to make further distinctions within categories about the relative risks posed by the problems. We believe there are substantial differences in risk between problems in different categories. Table III.3 on the following page summarizes our ranking of environmental problems in Cairo based on the health risks they pose.

Table III-3: Relative Health Risks From Environmental Problems in Greater Cairo

Higher Risks:

Particulate Matter Air Pollution
Lead (in all media)
Microbiological Diseases From Environmental Causes

Middle Risks:

Microbial Food Contamination
Ozone Air Pollution

Middle/Lower Risks:

Sulfur Dioxide Air Pollution
Carbon Monoxide Air Pollution
Indoor Air Pollution
Drinking Water Contamination by Chemicals
Drinking Water Contamination by Microbiological Agents
Solid and Hazardous Wastes

Lower Risks:

Toxic Air Pollutants
Other Water Pathways: Direct Contact, Irrigation, Fish Consumption

Uncertain Risks:

Nitrogen Oxides Air Pollution
Metals in Foods
Pesticides in Foods (middle risk if available data are accurate; lesser risk if not)

Higher Risk Problems

Particulate matter (PM) air pollution in Cairo exceeds health-based standards by a factor of 5 to 10, with levels in Cairo higher than in any of the world's largest cities. Other parameters relating to PM—dustfall and smoke—also far exceed recognized international standards. We estimate that reducing PM concentrations in Cairo to natural background levels might prevent about 3,000 to 16,000 deaths and from 90 to 270 million days of restricted activity each year. (These are likely overestimates because of difficulties in extrapolating U.S. dose-response relationships to the extreme conditions in Cairo.) Industry is probably the major source of PM in Cairo.

Lead is widely present in food, water, and air in Cairo. The average lead levels in the blood of Cairo men is about 30 micrograms per deciliter and slightly lower for women, both well above the levels in other large cities. Reducing Cairo blood lead levels to U.S. levels (approximately natural background levels) would significantly improve the mental development of children (about 4.25 IQ points per child), reduce infant mortality by 820 deaths per year, and reduce deaths from cardiovascular illness by 6,300-11,100 per year. (The death figures may also represent overestimates.) Cairenes' exposure to lead comes mainly from food or water, though most of the lead probably enters the environment initially from highly leaded gasoline or lead smelters.

Microbiological diseases related to environmental conditions are common in Cairo, including diarrheal diseases, infectious hepatitis, typhoid fever, schistosomiasis, and many others. These diseases cause up to 10 percent of all deaths among the general population, and up to 30 percent of deaths among young children. Environmental factors, such as the quantity and quality of water supplies, disposal and treatment of excreta, solid waste collection, and food contamination, significantly affect the transmission and persistence of these diseases. However, their incidence is related as much or more to non-environmental factors (e.g., malnutrition, inadequate health care and education, overcrowded housing, poor domestic hygiene) as to environmental ones. The two most important environmental factors in controlling these diseases are:

- Providing sufficient quantities of water to residences to support washing and other sanitary practices.

- Providing toilets and sanitary sewers to remove human excrement from immediate human surroundings.

Other environmental improvements involving water quality, sewage treatment, solid waste collection, and food hygiene are less important. We estimate that extending good water and sewer service to the unserved fraction of Cairo's population would reduce the days of diarrhea suffered by city residents by 6.1 million per year and prevent 1,700-5,500 deaths per year. These estimates would be much higher if a very large portion of Cairo (relative to other large cities in developing nations) were not already provided with water and sewer service. Additional health benefits would result from improving the quality and reliability of water and sewer service to those already served.

Middle and Lower Risk Problems

Air pollution. Although levels of several air pollutants in Cairo often exceed health standards, it is not by as much as particulate matter (PM). Non-PM air pollutants also generally cause less severe health effects and, at levels prevailing in Cairo, often affect only small, particularly sensitive groups (e.g., asthmatics). Among the other air pollutants, ozone appears likely to have the most significant health impacts and is probably responsible for several days per year of relatively mild adverse symptons among much of Cairo's population. Monitoring data on ozone are very limited, so this assessment is uncertain.

Water pollution. Water pollution poses relatively low risks in Cairo for several reasons. First, the Nile arrives in the city reasonably clean and is a good source for drinking and irrigation. About 90 percent of the population is supplied with piped public drinking water, which receives adequate disinfection at treatment plants. Contaminants entering the water distribution system can cause problems but, as noted above, water quality is of less concern in microbiological disease incidence than other factors. Finally, most of Cairo's domestic and industrial wastewater effluents are conveyed away to the north through drains. As a result, most risks from Cairo's water pollution are exported out of the city.

Solid waste. Solid waste and environmental food contamination (contamination that occurs outside the home and is reasonably subject to governmental inspection and regulation) are also less important factors in the transmission of microbiological diseases.

Occupational exposure. Finally, although the team did not set out to investigate occupational exposures, we did find information suggesting that occupational exposures to toxic substances pose substantial health risks in Cairo.

K1. Factors Considered in Ranking Environmental Problems

Table III-4, beginning on page III-36, displays our conclusions and judgments about the factors we considered in comparing the risks of different environmental problems. For each problem, the table covers:

- **Estimated health effects.** In many cases, we have estimated both the number and type of health effects across Cairo's population. In other cases, we can make only qualitative statements about the health effects likely to result.

- **Severity of the health effects.** The particular health effects from the problem are classed as severe, moderate, or mild.

- **Quality of the exposure data.** This column indicates both the general quality of the data on emissions, ambient concentrations and doses of pollutants, and likely biases in our analysis of the data. For example, important classes of contaminants may be omitted from the analysis, resulting in an underestimate of risks. Alternatively, very conservative assumptions might be made about contaminant transport and exposure, resulting in an overestimate of risks.

- **Nature of the health data.** This column indicates whether the underlying health effects data used in the risk assessment yield best estimates or conservative estimates. In general, epidemiologically derived relationships yield unbiased "best" estimates. Estimates of the number of cancer cases and people "at risk" from doses exceeding RfDs will typically substantially exceed the actual number of cases.

The final column of the table provides a summary judgment of the health risk posed by the problem compared with the health risks posed by other environmental problems in Cairo. The final column relies on information from the other columns.

TABLE III-4 Comparative Health Risks From Environmental Problems

Problem	Estimated Health Effects	Severity Of Each Effect	Quality Of Exposure Data	Nature Of Estimate	Summary
Air Pollution					
Sulfur Dioxide	Rare impacts on exercising asthmatic Possible respiratory symptoms for general population in limited areas.	Mild	Fair	Best estimate.	Middle/Lower Risk
Particulate Matter	3,000-16,000 deaths/year. 90-270 million restricted activity days/year.	Severe Mild	Good	May be overestimate because of extrapolation outside range of experience	Higher Risk
Nitrogen Oxides	Possible respiratory symptoms in general population.	Mild	Poor	Uncertain. Insufficient monitoring and dose-response information.	Uncertain.
Carbon Monoxide	Minimal in general population. Significant cardio-pulmonary effects in highly exposed occupations.	Medium	Poor	Best estimate.	Middle/Lower Risk
Lead	Lead in all media discussed below.				——
Ozone	Perhaps 1 - several days/yr of mild adverse symptoms among the general population. Worse for asthmatics.	Mild	Poor	Best estimate, but uncertain. Insufficient monitoring and dose-response information.	Middle Risk
Toxic Air Pollutants	234-709 cancers/year No non-cancer effects	Severe	Poor. Modelling omits effects from some toxics from industry.	Number of actual cancers likely to be far lower.	Lower Risk
Indoor Air Pollution	Likely respiratory symptoms and illness among those using kerosene and biomass for cooking/heating.	Medium	Poor	Uncertain. Very few studies.	Middle/Lower Risk

TABLE III–4 Comparative Health Risks From Environmental Problems (cont.)

Problem	Estimated Health Effects	Severity Of Each Effect	Quality Of Exposure Data	Nature Of Estimate	Summary
Water Pollution					
Drinking Water Contamination from Chemicals Except Lead	3–470 cancers/year Doses of non–carcinogens less than reference doses.	Severe	Good except that large differences in data sets on pesticides cause divergent cancer estimates.	Number of actual cancers likely to be much lower.	Middle/Lower Risk or Lower Risk, depending on pesticide data.
Lead in Drinking Water	Lead in all media discussed below. Conflicting data about lead levels in tap water leave uncertainty about significance of drinking water contribution.				———
Microbiological Agents in Drinking Water	Diseases from microbiological agents discussed below. Water quality probably of moderate importance in incidence of microbiological diseases.				———
Direct Contact, Irrigation, Fish Consumption	1–46 cancers/year Slight contribution to microbiological diseases.	Severe Nearly all mild	Poor	Number of actual cancers likely to be much lower.	Lower Risk
Solid and Hazardous Wastes	Modest contribution to microbiological diseases. Small contribution to effects from PM air pollution. Likely significant effects in Zaballeen communities.	Nearly all mild Variable Variable	Poor	———	Middle/Lower Risk

TABLE III-4 Comparative Health Risks From Environmental Problems (cont.)

Problem	Estimated Health Effects	Severity Of Each Effect	Quality Of Exposure Data	Nature Of Estimate	Summary
Lead	Adults: 6,300-11,100 deaths/year	Severe	Good	May be an overestimate because of extrapolation outside range of experience.	Higher Risk
	Children: 4.25 IQ points lost/child 820 infant deaths/year	Medium Severe	Good	Best estimate	
Food Contamination					
Pesticides	7,000 cancers/year (?) Doses exceed RfDs, suggesting possible non-cancer effects.	Severe Variable	Questionable. Pesticide levels reported are far higher than those elsewhere.	Number of actual cancers likely to be much lower.	Uncertain.
Metals	Significant contribution to effects from lead. No data for other metals.	Severe Unknown	Fair No data	Best estimate. No data	Uncertain.
Microbial Agents	Likely moderate contribution to microbiological disease incidence.	Nearly all mild	Fair	Best estimate.	Middle Risk
Microbiological Diseases	1,700-5,500 deaths/year 6.1 million days of diarrhea/year	Severe Mild	Both environmental and non-environmental factors contribute importantly to these diseases. Effects estimated are approximately those that could be avoided if good water and sewer service were extended to all Cairo residents. Further benefits could accrue from improving water/sewer service to those already served.		Higher Risk

K2. Interpreting the Rankings

Several points should be made about interpreting the results of this study. These points stem from choices made in establishing the methodology for this project.

First, the ranking is based on health risks. A focus on other types of risks might lead to a different ranking of problems.

Second, the ranking is intended to reflect "residual risks," or risks that remain from environmental problems despite controls now in place. The fact that a problem poses low residual risk does not imply that a control program addressing the problem is low priority. The problem may pose low risk because a control program has reduced the risks to a low level, and continuing the program may be critical to keeping the risk low.

Third, the ranking is based on an estimate of the aggregate health effects of problems to the population of Greater Cairo. Severe effects on a small sub-population are treated as less important than moderate effects on a large population. A problem that is geographically widespread and affects many people will rank high under this approach. A localized problem that affects few people, even though it may affect them severely, will rank lower.

Fourth, several environmental problems of potential importance to the health of Cairo's population have not been covered in our analysis. They include problems that the GOE is unlikely to be able to do much about (e.g., global climate change), problems for which basic data were not available (e.g., noise), problems omitted because of limitations on our project level of effort (e.g., radiation, occupational exposures to toxic substances), and problems that do not relate primarily to pollution (e.g., malnutrition, overcrowding, traffic accidents). Because we did not address a problem does not mean it is not important.

Finally, a ranking of problems by risk will not necessarily match the priority that should be given to control programs for each problem. Management of environmental risks—what one chooses to do about environmental problems—will depend on many factors in addition to the magnitude of the risks. Important risk management factors that are not addressed in this report include the cost and technical feasibility of control measures for different environmental problems, public opinion, political concerns, legal authority, and institutional issues. In setting priorities for control efforts, all these factors should be considered. One might find that good opportunity exists to reduce risks associated with a lower-risk problem, while nothing very effective can be done about a higher-risk problem.

On balance, though, we believe a general correlation *is likely* between environmental problems posing higher residual risks and problems for which additional control efforts will prove most cost-effective. A risk ranking is a useful tool in setting priorities. To move from ranking risk to designing control programs and setting priorities, another level of analysis is necessary. Alternative control measures must be evaluated against all risk management factors.

SECTION IV

FURTHER POSSIBLE COMPARATIVE RISK ANALYSIS IN EGYPT

SECTION IV
FURTHER POSSIBLE COMPARATIVE RISK ANALYSIS IN EGYPT

This section reviews experience to date in comparative health risk analysis for Greater Cairo and outlines options and recommendations for further work in Egypt. Additional options will arise as the Cairo CRA findings are disseminated in Egypt and it becomes apparent whether policy makers find the work useful.

A. Observations Based on the Cairo CRA

While conducting the CRA in Cairo, we assessed the extent to which factors contributing to successful and valuable CRAs elsewhere are present in Egypt. We offer several observations.

Sufficient environmental information is available in Egypt for a CRA based on health risks. This is clearly the case for Cairo and Alexandria. A CRA for other areas would likely depend on aggregating data for similar communities and analyzing health risks for a composite typical community, for example, in the Delta or Upper Egypt.

Sufficient information probably does not exist in Egypt for a thorough CRA based on economic and welfare risks. As in health risk assessment, a CRA based on economic risk begins with data on how a problem affects the quality of the environment. But then two different varieties of data are needed:

- How the changed environmental quality changes human use of the environment.

- The monetary value of the changes in human use.

These data are largely culture-specific, reflecting the make-up of the local economy and social preferences about lifestyles and activities. Few studies appear to have been done in Egypt that can provide such data.

Environmental expertise and data are scattered and poorly coordinated in Egypt. While we found sufficient data for our purposes and extensive technical expertise on environmental issues, these resources were difficult to identify and access. Environmental data on Cairo are developed and held by a wide variety of institutions and individuals that are often unaware of each other's work in the same field. Data sets on the same issue sometimes conflict, with no conclusion reached as to why (e.g., disparate data on concentrations of lead in tap water). Enhancing communication and coordination among Egypt's environmental professionals through a future CRA would be of great benefit.

The reliability of some Egyptian environmental data is questionable. Most Egyptian environmental data have not been generated under rigorous procedures for quality assurance and control. A major concern is that most data are not peer-reviewed, and journal

65

articles are not refereed. A future CRA that encourages experts to focus on and review each other's data and conclusions would be beneficial.

There are questions about the GOE's ability to implement stronger environmental protection measures. The ultimate benefit of CRA projects and the primary reason people are interested in participating in them is their contribution to more effective environmental protection. CRA is fruitless, however, if the government is unable to act on environmental problems because of perceived economic constraints or other factors. Several individuals we spoke with in Egypt expressed skepticism about the GOE's commitment to environmental action. These individuals contended that the GOE has developed thorough environmental plans, but that progress in implementing them has been slow. Egypt does not need another planning exercise like a CRA if waiting for its completion will further delay action.

We are not in a position to judge such criticisms. CRA might produce another study that sits on bookshelves and gathers dust. Or it might serve as a more useful guide to action than past planning efforts, because it can point to a few prioritized environmental measures rather than a long, unaffordable list of suggestions that have not been prioritized.

Two steps could enhance the contribution of a future CRA to meaningful environmental protection. First, any future CRA (unlike this pilot effort) should include both risk assessment and risk management components. Second, a future CRA should include efforts to involve and educate the public. A growing concern for the environment among Egyptians will likely prompt more serious government attention to environmental problems.

B. Previous Comparative Risk Analyses

Before considering options for further CRA work in Egypt, it is useful to review the nature of past CRA projects in other countries. These provide models of the range of choice for Egypt. The EPA's recent *Guidebook to Comparing Risks and Setting Environmental Priorities* (USEPA, 1993) reviews much previous CRA experience and provides guidance for future projects.

In the United States, CRAs have become an increasingly important component of environmental policy development and priority setting. CRAs typically serve two objectives:

(1) **Setting more rational priorities.** Environmental problems are analyzed (risk assessment) and prevention or control measures are designed and evaluated (risk management). Risk management measures are selected and then implemented through action plans, budget allocations, and performance measures.

(2) **Strengthening environmental management institutions.** CRAs are designed to induce a wide range of people—government agencies, the public, industry, and academia—to work together to develop consensus on problems and solutions. A CRA pushes these disparate groups to share data and appreciate each other's perspectives. This process forges a strong coalition for action once the assessment is completed. A CRA also typically allows technical

personnel (scientists, researchers) who staff CRA work groups to have a more effective voice in policy decisions.

The first objective depends largely on the substantive findings of the CRA, while the latter depends on procedures used to conduct the CRA.

Participants in U.S. CRAs include a project manager, a steering committee of governmental officials, a public advisory committee, technical work groups of environmental experts from varied organizations, and often contractors to provide support. Major products, which typically include technical reports, a government environmental policy statement, and perhaps a State of the Environment Report, are widely disseminated. A complete CRA might take nine months to two years.

The relatively few CRAs conducted outside the United States have been much more limited in terms of objectives and level of effort.

CRAs in Bangkok, Thailand (USAID, 1990) and Quito, Ecuador (USAID, 1993) have been conducted largely by expatriate consultants with little involvement by host country institutions. They have aimed to test methodologies[1] and provide information useful in setting priorities, not to build stronger indigenous environmental management capabilities. They have focused only on health risks and risk assessment, not risk management.

By contrast, several CRAs in Hungary and Bulgaria have used CRA procedures to develop community environmental action plans (ISC, 1993). The projects covered both risk assessment and management as well as all types of environmental risks. Objectives were largely procedural—to encourage democratization, support decentralization and empower local officials to plan communities' futures, and develop working relationships among the diverse local groups interested in environmental protection. There was much less emphasis on analytical rigor and quality of rankings than in other CRA projects.

A CRA in Silesia, a highly industrialized and polluted area spanning the Czech and Polish border, has been the most ambitious project outside the United States (IEc, 1992). The project has included risk assessment and management components and has analyzed health and ecological risks. It has been managed by a broad-based local environmental management committee, with technical work performed by U.S. consultants under the direction of local technical work groups. These groups and the project have been the vehicle for coordinating environmental management policy across the region. Project participants are now selecting the most appropriate industrial pollution prevention and control investments, seeking financing for these investments, and integrating environmental concerns into the restructuring of regional industry.

[1] The study in Quito added two elements to the health risk assessment approach used in previous CRAs: an emphasis on health outcome assessment and ethnographic investigation of health-related behavior. The ethnographic investigations (through structured interviews and focus groups with local residents) in particular add significant understanding. This enhanced approach to CRA for health risks has been termed "Environmental Health Assessment" (USAID, 1993a).

C. Options for Further Possible CRA in Egypt

Experience with CRA elsewhere suggests a range of ways to organize further work in Egypt. The major variables concern the objectives and clients to be served. Other issues such as project organization, scope, timing, resources, and cost depend on the objectives.

C1. Choices in CRA Objectives and Clients

In our view, CRA can be designed to provide substantive or procedural benefits, or both.

Substantive benefits accrue from the conclusions drawn by the CRA. These benefits include a more accurate understanding of the relative severity of environmental problems and better environmental priorities. Realizing substantive benefits depends on both the accuracy of the CRA conclusions and their persuasiveness in eliciting action by those implementing environmental policy.

Procedural benefits accrue from how a CRA is performed. The diverse participating entities learn to work together and develop a shared vision of environmental protection goals and methods. Public knowledge and concern about environmental issues increase, as does public participation in government decision making.

Clients for further CRA work in Egypt might include the USAID mission, the donor community, and/or the GOE. Six combinations of objectives and clients are possible, as presented in Table IV-1 on the following page.

Cells 2 and 4 in the table do not represent worthwhile primary objectives for further CRA work. Sufficient coordination on environmental issues already exists through formal and informal procedures, both within the USAID mission and among the relatively small number of environmental personnel at donor agencies. Thus, we focus further consideration of CRA options on the remaining four cells.

C2. Choices Regarding CRA Organization

In general, a CRA may be performed in one of two ways:

- Relatively quickly by a small team that would probably include several U.S. CRA experts and several Egyptian environmental experts. This was the model used for the study of Greater Cairo.

- Over a longer period of time by several work groups of local individuals from government, academia, research institutions, industry, NGOs, and the public. Participants would be selected for their technical expertise in some aspect of the Egyptian environment. A salaried Egyptian project director would manage the effort, reporting to a policy committee representing the sponsoring organizations. Several consultants would support the work groups.

Table IV-1: CRA Client/Objective Options

Client	Substantive Objectives	Procedural Objectives
USAID Mission	1. Improve mission's environmental priorities.	2. Increase mission staff's ability to work together on environmental issues.
All Donors	3. Improve environmental priorities across the portfolio of donor projects.	4. Increase coordination across donor environmental staffs.
Government of Egypt	5. Improve the GOE's environmental priorities.	6. Improve working relationships and share data among the range of organizations concerned with the environment in Egypt. Increase public involvement.

The first approach has the advantages of speed and lower cost. The second approach offers other advantages:

- **Procedural benefits.** The second approach is best if improving interaction among people and institutions concerned with the environment is considered important (cell 6 in the table).

- **"Buy-in" by the sponsoring organization.** If the sponsoring organization's staff participate intensively in the project, that organization has more opportunity to buy into the recommendations than if the CRA is performed by outside parties. Buy-in is critical if project recommendations are to be implemented.

- **Local expertise.** During the CRA process, many judgments must be made to fill gaps in data or standard methods. It is better for these judgments to reflect the knowledge of local experts than expatriate consultants.

In light of the above considerations about objectives, clients, and general approach to performing a CRA, we see three basic options for further CRA work in Egypt:

(1) A CRA intended primarily to provide substantive benefits to USAID mission environmental priorities. Such a CRA could be performed relatively quickly by a team of expatriate and Egyptian consultants working under the close supervision of mission staff. Liaison with the GOE would also be desirable.

(2) A CRA intended primarily to improve and coordinate the environmental priorities of donor agencies in Egypt. Such a CRA could be performed relatively quickly by a team of expatriate and Egyptian consultants selected by donors and working under the supervision of a donor committee. Liaison with the GOE would also be desirable.

(3) A CRA intended to provide substantive and procedural benefits to the GOE (and incidentally to the donors). Such a CRA would be performed over a

longer time period mostly by cross-organizational work groups of Egyptian environmental experts supported by domestic and foreign consultants.

The three CRA options raise several important questions:

For option 1: Is the USAID mission ready for a more systematic, analytical approach to setting priorities for environmental assistance? How important is a joint USAID and GOE approach to setting environmental priorities, as opposed to separate approaches?

For option 2: Is environmental assistance to Egypt important enough that donors will contribute staff time and funding for a CRA?

For option 3: Our concerns address whether the GOE realistically can be expected to subscribe to the process and results of a CRA. Is the GOE ready for Egyptian society to become more concerned about the environment and to respond by devoting more effort to environmental protection? Is the GOE comfortable with more open decision making on environmental questions by groups other than the executive and legislative elites (e.g., technical staff, academics, the public)?

D. Additional Design Issues Relevant to Possible Future CRAs

Once a decision has been made about the interrelated issues pertaining to clients and objectives, several other less critical design issues should be addressed.

D1. Participants and Their Responsibilities

A CRA for the primary benefit of the mission or donor agencies can be organized in the same way as the Greater Cairo pilot CRA. A CRA for the primary benefit of the GOE would follow the broad-based CRA model developed in the United States. The following would play key roles:

- A steering committee to provide overall direction to the project. Each agency sponsoring the project, including the GOE and donors, would be represented on the committee.

- A project manager to coordinate project activities and provide day-to-day management. The project manager should be an energetic Egyptian, knowledgeable in environmental issues, who has direct access to senior officials in the sponsoring agencies. He/she should be hired full-time with administrative and staff support.

- A public advisory committee to ensure public participation and ensure that the CRA work is understood, relevant, and credible to the local populations. Members should be broadly representative of Egypt's regions, organizations, and interests.

- Work groups of technical experts from participating government agencies, research centers, universities, and elsewhere.

- Egyptian and expatriate consultants to fill various roles: advise on project setup and initiation, provide training for participants and technical support for the project manager, and assist the work groups.

D2. Geographic Scope

At the finest level of detail, a CRA might again study Greater Cairo to evaluate environmental risks across socioeconomic groups and geographic zones. This approach would be useful if there is strong concern about environmental equity and the levels of threat faced by population subgroups.

Alternatively, future CRAs could study areas other than Greater Cairo. First priority might be a rural area quite different from Cairo. Informed national environmental policy requires an understanding of the risks facing both urban and rural areas.

At the highest level of aggregation, a CRA covering all of Egypt seems possible. Sufficient data would not exist for many areas, so risks would have to be estimated using analogy or extrapolation from similar areas where data do exist. A CRA for the entire country would be a large undertaking. As diversity among geographic regions increases, so does the effort needed to collect and analyze data.

D3. Risk Types to Cover in Future CRA Work

Because they are important anywhere in the country, health risks should be a focus of any CRA.

Whether or not to analyze economic and welfare risks is a more difficult question. Despite the lack of information on these risks, we recommend that they be included in any future CRA. Economic damages from pollution are of extreme importance to Egypt's current economy and its potential for future growth. Pollution has major adverse economic impacts through increased health care costs, reduced worker productivity, lower agricultural yields (particularly from limited reuse of water), and perhaps decreased tourism. A ranking of environmental policies that reflects analysis of economic damage might differ sharply from a ranking based only on health risk analysis.

Ecological risks seem less important than health or economic concerns for future work in Egypt. Ecological damages caused by pollution in Egypt might be dealt with most effectively through site-specific studies and policies.

D4. Public Involvement in CRA

We strongly recommend efforts to increase concern and support for environmental protection by involving the public in CRA work. This might happen in two ways:

- Public participation in and guidance for the CRA, through a representative public advisory committee.

- Public dissemination of knowledge gained during the CRA through educational seminars and publication of findings in easily accessible documents, perhaps including a State of the Egyptian Environment report.

D5. New Environmental Sampling

A future CRA need not be limited to existing data. New sampling and analysis could fill some of the inevitable gaps in knowledge at modest cost.

D6. Environmental Problems to be Addressed

A future CRA might analyze several additional topics beyond those included in the Cairo study: occupational exposure to toxic substances, radiation, accidental releases from industrial facilities, and noise. If the project's geographic scope includes rural areas, the CRA should also address agriculture-related problems such as salinity, sedimentation, nutrients, and pesticides. CRA organizers should also discuss whether to include global problems (climate change and ozone depletion) in the project scope.

D7. Coverage of Risk Management Issues

A future CRA might be limited, as this pilot effort has been, to assessing risks. Alternatively, the future effort might include analyzing alternative strategies for managing the identified risks. This would require a significantly larger effort, but would provide greater benefits to policy makers concerned with setting priorities and implementing action programs.

A CRA that extends beyond risk assessment to risk management would include four additional steps:

(1) Fill important data gaps in understanding the highest-risk environmental problems.

(2) Develop alternative management strategies for each environmental problem.

(3) Analyze the costs and benefits of each strategy.

(4) Develop implementation plans for selected strategies.

REFERENCES

REFERENCES

Esrey, S.A., R.G. Feachem, and J.M. Hughes (1985). "Interventions for the Control of Diarrhoeal Diseases Among Young Children: Improving Water Supplies and Excreta Disposal Facilities" in *Bulletin of the World Health Organization*, Vol. 63 (4): 752 - 772.

Esrey, S.A., J.B. Potash, L. Roberts, and C. Schiff (1991). "Effects of Improved Water Supply and Sanitation on Ascariasis, Diarrhoea, Dracunculiasis, Hookworm Infection, Schistosomiasis, and Trachoma" in *Bulletin of the World Health Organization*, Vol. 69 (5): 609 - 621.

Feachem, Richard G., et al. (1981). *Health Aspects of Excreta and Sullage Management: A State-of-the-Art Review.* Washington, DC: Transportation, Water, and Telecommunications Dept., World Bank.

Finkel, A. (January 1990). *Confronting Uncertainty in Risk Management, A Guide for Decision Makers.* Resources for the Future.

Garetz, William V. (1993). "How to Move Quickly to Risk-Based Environmental Management: A Specific Proposal" in: C. Richard Cothern, ed., *Comparative Risk Assessment.* Lewis, Ann Arbor.

Government of the Arab Republic of Egypt (May 1992). *Environmental Action Plan.*

Gold, Lois Swirsky et. al. (1993). "Possible Carcinogenic Hazards from Natural and Synthetic Chemicals: Setting Priorities" in: C. Richard Cothern, ed., *Comparative Risk Assessment.* Lewis, Ann Arbor.

Industrial Economics, Inc. (IEC, May 1992). *Project Silesia Comparative Risk Screening Analysis.*

Institute for Sustainable Communities (ISC), South Royalton, Vermont (1993). Personal communication with George Hamilton, executive director.

U.S. Office of Management and Budget, (August 1990). Office of Information and Regulatory Affairs. *Regulatory Program of the United States.*

U.S. Agency for International Development, (December 1990). Office of Housing and Urban Programs. *Ranking Environmental Health Risks in Bangkok, Thailand.*

U.S. Agency for International Development/Egypt (May 1992). *Country Program Strategy 1992-1996 (Environment).*

U.S. Agency for International Development, (USAID-October 1993). Water for Sanitation and Health (WASH) Project. *Environmental Health Assessment: A Case Study Conducted in the City of Quito and the County of Pedro Moncayo, Pinchincha Province, Ecuador.* WASH Field Report No. 401.

U.S. Agency for International Development, (USAID-October 1993). Water for Sanitation and Health (WASH) Project. *Environmental Health Assessment: An Integrated Methodology for Rating Environmental Health Problems.* WASH Field Report No. 436.

U.S. Environmental Protection Agency; (USEPA, September, 1993). Office of Policy, Planning, and Evaluation; Regional and State Planning Branch. *A Guidebook to Comparing Risks and Setting Environmental Priorities.*

The World Bank (1993). *World Development Report 1993: Investing in Health.* Oxford University Press.

I PN-ABT-314

Project in Development and the Environment

Comparing Environmental Health Risks in Cairo, Egypt

Volume Two: Technical Annexes

September 1994

Submitted to:
USAID/Egypt
Submitted by:
PRIDE

USAID Contract Number:
ANE-0178-Q-00-1047-00
USAID Project Number:
398-0365

Sponsored by:
USAID/NE/DR/ENR
Implemented by:
Chemonics International
and its associates

2000 M Street, NW, Suite 200, Washington, DC 20036
Telephone: (202) 331-1860 • Fax: (202) 331-1871

66

TABLE OF CONTENTS

67

ANNEX A

HEALTH RISKS FROM AIR POLLUTION

ANNEX A
HEALTH RISKS FROM AIR POLLUTION

This annex summarizes the data and calculation procedures we have used in estimating the health risks from exposure to air pollution in Greater Cairo. Most of the data on levels and sources of air pollution derive from the background paper written by the air pollution consultant for this project, Dr. Mahmoud Nasralla (Nasralla, 1993a). His background paper is reproduced in Volume 3 as Annex G. Dr. Nasralla is Professor and Director of the Air Pollution Department of the National Research Centre in Cairo. He has been active since 1965 in research, monitoring, and development of management strategies for air pollution in Egypt. In this annex we do not reiterate the material in Dr. Nasralla's paper; we quickly summarize it and indicate where in his paper the topic is discussed in more detail. Material in this annex that derives from sources other than the Nasralla paper is described more fully and referenced to its original sources. This additional information focuses on the potential health hazards posed by different air pollutants and our health risk calculation procedures for Cairo.

RISK ASSESSMENT APPROACH FOR AIR POLLUTION

Health risks from exposure to air pollutants are most commonly estimated by applying dose-response functions to monitoring data on the concentrations of air pollutants to which people are exposed outdoors and indoors.

Available air pollution monitoring data for Cairo are limited both in terms of the pollutants covered and the ability to characterize temporal and spatial variability. For three pollutants (sulfur dioxide, particulate matter {measured as total suspended particulates, smoke, and/or dustfall} and lead) several monitoring stations in Greater Cairo have been operated for sufficient time to provide a sense of both time trends and geographic variation. For other pollutants (nitrogen oxides, carbon monoxide, ozone, other metals) data are limited to several special studies in scattered locations, providing very little information on the variability of concentrations. For other important classes of air pollutants (e.g., toxic organic compounds such as benzene, formaldehyde, and benzo-a-pyrene) no monitoring at all has been conducted, and we estimate ambient concentrations by combining rough emissions estimates and simple dispersion modeling. In all of these cases we assume in our calculations that the available data are representative—that the portions of the city or the times for which monitoring data are not available would show similar concentrations as do the places and times for which data are available. Virtually no data are available on indoor concentrations of air pollutants. In the absence of indoor data we assume that indoor concentrations are identical to outdoor concentrations or, in effect, that people are exposed to outdoor concentrations of pollutants for 24 hours per day.

The common air pollutants likely represent the class of environmental contaminants for which dose-response relationships are best understood. The health effects of many common air pollutants have been studied extensively in both chamber studies with human subjects and in large epidemiological investigations of human populations. By contrast, evidence from testing on animals (with associated uncertainties in extrapolating to humans) is the predominant source of information for other classes of environmental contaminants. Even for carcinogenic health effects, much of the dose-response information for air pollutants derives from studies involving humans.

In this annex, we estimate health risks for each major air pollutant or class of air pollutants in a separate section. In addition, in order to inform the development of possible control measures for the air pollutants, we discuss what is known about the relative contributions of different sources to emissions of each air pollutant in Cairo.

Overview of Air Pollution in Cairo

Ambient levels of air pollutants in Cairo have been sampled or monitored for more than 25 years by the Ministry of Health, the National Research Center, other academic researchers, and various consulting firms. Although inconsistent monitoring locations and varying analytical methods make it difficult to interpret these data, it appears that pollution levels generally increased with increases in population, industrial activity, energy, and vehicle use through about 1988. Findings since 1988 are mixed, with decreasing trends evident for some pollutants in some locations and increases for others. Summary data for the more commonly measured pollutants—sulfur dioxide, particulate matter, and lead—are available for different time periods from different sources:

- Nasralla's background paper provides the most recent data, generally for 1989 - 1992 (Nasralla, 1993a).

- Data for the 1987 - 1989 period and for several earlier periods are summarized in the joint GOE/World Bank Environmental Action Plan (GOE, 1992), the report of the Air Pollution Working Group supporting the Action Plan (Nasralla, 1991a), and the air pollution paper in a recent overview of the Egyptian environment (Nasralla, 1993b).

There is no routine monitoring in Cairo for other air pollutants (e.g., nitrogen oxides, carbon monoxide, ozone, metals other than lead), and information about them depends on a few special studies in scattered locations.

Current ambient concentrations for all major air pollutants in Cairo are near or in excess of levels that threaten public health. Table 1-1 shows the most recent (generally for 1991-1992) data for major air pollutants in Greater Cairo (Nasralla, 1993a). Levels in Cairo are compared with U.S. health-based standards and with World Health Organization (WHO) guidelines. We do not show a comparison with Egyptian ambient air pollution standards because these standards often do not reflect current international knowledge about health effects. The ranges in the concentrations shown in Table 1-1 reflect the variation across the handful of sites for each pollutant where monitoring has been conducted.

The sources of these pollutants in Cairo and their significance to health will be discussed in separate following sections for each pollutant.

Table 1-1. Concentrations of Air Pollutants in Greater Cairo (ug/m^3)

Pollutant	Concentration		U.S. Standard		WHO Guideline	
Sulfur Dioxide	40-156	annual mean	80	annual mean	40-60	annual mean
Particulate Matter	349-857	annual mean	75[1]	annual mean	60-90	annual mean
Nitrogen Oxides	90-750	hourly means	100	annual mean	320	hourly mean(NO2)
Carbon Monoxide	1,000-18,000	hourly means	40,000	hourly mean	10,000	8-hour mean
Lead	0.5-10	annual mean	1.5	quarterly mean	0.5-1.0	annual mean
Ozone	100-200+	hourly maximum	235	hourly maximum	150-200	hourly mean

[1] This standard for total suspended particulates (TSP) was replaced in 1987 with a standard for PM_{10} (particles less than 10 microns in diameter) of 50 for an annual mean and 150 as a 24-hour value not to be exceeded more then once per year. Data on PM_{10} for Cairo are generally not available, so comparison is made with the old U.S. TSP standard.

The activities responsible for emissions of these pollutants are concentrated heavily in Cairo relative to the remainder of Egypt, as shown in Table 1-2.

Table 1-2. Polluting Activities in Greater Cairo as Percentage of Egypt Total

Activity	% of Total	Source
Population	25	CAPMAS, 1993
Thermoelectric generating capacity	41	Nasralla, 1993a, p.3
Motor vehicle registrations	48	MOI, 1992
Energy use	50 +	Nasralla, 1993a, p.3
Industry	64	Nasralla, 1993a, p.3

These activities in Greater Cairo have all increased in recent years, bringing with them roughly corresponding increases in emissions of air pollutants:

- Population increased by 50% from 1976 to 1986 and an additional 5% from 1986 to 1990 (CAPMAS, 1993).

- Use of different fuels increased by the following amounts from 1985 to 1989 (Nasralla, 1993a):

Gasoline	9%
Diesel fuel	14%
Natural gas	65%
Kerosene	4%
Butane gas	- 9%
Heavy fuel oil	16%

- Motor vehicle registrations increased from 100,000 in 1970 to 400,000 in 1980 and over 900,000 in 1990 (Nasralla, 1993a).

These data suggest some slowing in the rate of increase of polluting activities since 1985 relative to the previous decade, and some shift toward greater reliance on less-polluting fuels (much more rapid growth in use of clean-burning natural gas relative to diesel, heavy oil and kerosene). This pattern is consistent with the apparent reduction in the levels of some air pollutants in recent years.

HEALTH EFFECTS FROM SULFUR DIOXIDE

Sulfur dioxide is an irritating gas with a pungent odor and taste. It is highly soluble in water (forming sulfurous acid) and can be oxidized to sulfur trioxide (forming sulfuric acid in water). Sulfur oxides also commonly adsorb onto particles in the air, and the resulting suspended sulfates are thought responsible for much of the adverse health impacts from chronic exposures when there are low or moderate ambient levels of sulfur dioxide. Airborne sulfates also cause reductions in visibility, and wet or dry deposition of acidic sulfates can damage materials and cause ecological changes. In Cairo, atmospheric acids (probably primarily related to sulfur dioxide rather than nitrogen oxides) have sharply accelerated corrosion of the surface of the Sphinx, where the surface calcium carbonate has been partially converted into the fragile soluble calcium sulfate (Nasralla, 1985). Sulfur dioxide is clearly a pollutant causing economic and ecological damages as well as damages to human health.

Sulfur dioxide is formed largely by combustion of fuels containing sulfur by industry, power plants, and vehicles. The residual fuel oil used in Cairo ("mazout") contains about 2.5 - 2.8% sulfur, while the diesel fuel ("solar") contains about 1.2% sulfur (GOE, 1992). Process emissions from smelting or baking raw materials (e.g., ores) containing sulfur can also be a source of sulfur dioxide. No formal emission inventory for sulfur dioxide exists for Cairo. Industry (heavy industry and small workshops, bakeries, etc.) probably produces slightly more than half of the sulfur dioxide emissions in Cairo, and power plants (which burn about half high-sulfur fuel oil and about half clean natural gas) slightly less than half (Nasralla, 1993a). Diesel trucks, buses, and cars also contribute a small amount.

Data on the ambient levels of sulfur dioxide in Greater Cairo are shown in Table 1-3. Data are available only for scattered locations and years, largely because most of the Ministry of Health monitoring data for sulfur dioxide are excluded because they are based on an unreliable analytical techniques (WHO/UNEP, 1992). The most recent monitoring data show sulfur dioxide concentrations to be above the U.S. and WHO health-based standards (U.S. standard: 80 ug/m^3, WHO guideline: 40-60 ug/m^3, both as annual means) for the city center, Shoubra El-Kheima, and Helwan, and near the standards for the two other monitoring locations in Cairo City. Time trends are difficult to determine because of limited data, but it appears that concentrations have increased from 1978 to 1988 in Shoubra El-Kheima and decreased in Cairo City.

Table 1-3. Concentration of Sulfur Dioxide in Greater Cairo (ug/m³)

Year	Cairo City			Shoubra El-Kheima		Helwan	
	Residential	City Center	Suburban	Industrial	Residential		
1991-	55	84	40			105	mean
1992	76	127	54			171	monthly max
	120	308	86			320	24-hr max
1990					96		mean
					176		24-hr max
1988	100 [a)]			156		100 [a)]	mean
				800 [b)]			24-hr max
1993				104			mean
1979		260 [a)]					mean
1978				67			mean

Sources:
Nasralla, 1993a, except:
[a)] Nasralla, 1991a.
[b)] Nasralla, 1993b.

Short-term exposure (from 5 minutes to an hour) to sulfur dioxide can cause narrowing of the airways and difficulty in breathing for healthy individuals at about 2,500 ug/m³ and for exercising asthmatics (the most sensitive population) at about 650 ug/m³.[1] The latter levels are likely to be reached in Cairo only in the industrial areas of Shoubra El-Kheima and only for several times per year.

Longer-term exposures to sulfur dioxide have been linked by epidemiological studies to increased mortality and hospital admissions from respiratory diseases. Such effects have been very difficult to examine independent of effects due to particulate matter or smoke, which have typically accompanied the sulfur dioxide. The U.S. EPA concluded that independent effects of

[1] These concentration thresholds are expressed for a one-hour averaging time -- i.e., exposure to average concentrations of sulfur dioxide at these levels for an hour is likely to lead to these health effects. This and other health effect information in this section for sulfur dioxide is derived from USEPA, 1986.

sulfur dioxide may begin to occur at 24-hour concentrations exceeding 500 - 700 ug/m³. Again, this level seems rarely, if ever, to have been reached in Cairo recently.

For chronic exposures to sulfur dioxide, there is equivocal evidence for increases in cough, chronic phlegm, and upper and lower respiratory diseases at about 100 ug/m³ on an annual average basis. This level appears to be exceeded slightly in Helwan and more significantly in the industrial portion of Shoubra El-Kheima. Sulfur dioxide concentrations at the three monitoring sites in Cairo City are below this level.

In sum, despite the fact that sulfur dioxide concentrations in much of Cairo exceed the U.S. health-based standard, we expect a rather small amount of adverse health effects from this pollutant. The U.S. health-based standard has been set to protect a sensitive population (asthmatics) while exercising, with a significant margin of safety. The levels of sulfur dioxide observed in Cairo are less than levels that have been found in studies elsewhere to cause statistically significant increases in mortality and respiratory hospital admissions among the general population.

PARTICULATE MATTER

Particulate matter (PM) represents a broad class of chemically and physically diverse substances that exist as discrete particles suspended in the air. Particles range from large ones that fall out of the atmosphere quickly to small particles that remain suspended indefinitely. The small particles are most hazardous to health, as they can be inhaled deep into the lungs and lodge there, aggravating existing respiratory and cardiovascular disease and prompting other adverse biological responses. Like sulfur dioxide, particulate matter may also cause significant economic damages (primarily soiling) beyond its health impacts.

Concentrations of particulate matter across Cairo are extremely high, and in fact higher than in any other of the world's largest cities (WHO/UNEP, 1992). Table 1-4 shows the annual mean concentration of total suspended particulates (TSP) at various monitoring sites within Greater Cairo for various years since 1978. The latest concentrations exceed the WHO guideline and the former U.S. standard for TSP by factors of about 5 - 10. Other parameters relating to PM—dustfall and smoke—also exceed recognized international standards.

Table 1-4. Annual Mean Concentrations of TSP in Greater Cairo (ug/m³)

Year	Cairo City				Shoubra El-Kheima	Helwan
	City Center	City Center High Traffic	Residential	Residential High Traffic		Residential
1991	448	661	349	561		857
1990	495 [d]	658 [d]	375 [d]			
1989	632	699	548	602		1,100
1988	649 [c]	704 [c]	602 [c]	591 [c]	528, 680 [b]	838 [a]
1987	646 [c]	641 [c]	502 [c]	935 [c]		1,161 [c]
1983		548 [a]		495 [a]	567 [a]	714 [a]
1978					503 [a]	

Sources:
Nasralla, 1993a, except:
[a] Nasralla, 1991a.
[b] Ali, 1992a (for 2 sites, values over 2 months only).
[c] WHO/UNEP, 1992.
[d] Abdel-Gawaad, 1994.

Historical trends in Cairo's PM levels are difficult to determine, partly because regular monitoring at fixed sites was not initiated by the Ministry of Health until 1985. TSP levels seem to have decreased modestly at most monitoring sites since 1988. Before then, there were only scattered measurements of TSP. Evaluation of time trends in PM levels before the late 1980's must rely on the occasional TSP data and the more common historical measurements of smoke or dustfall. In general, PM levels seem to have increased consistently with the growth of polluting activities in Cairo from the early 1960's through the mid 1980's. For example, Table 1-4 shows TSP increasing significantly from 1983 to 1987 at the three sites with data for both years. Dustfall at three other sites in Shoubra El-Kheima also increased by about 20% during this period (Ali, 1988). Dustfall at a city center site more than doubled from 1962 through 1983. From 1979 to 1983, dustfall increased by 5 - 20% at 4 of 5 other sites (Nasralla, et al, 1986).

We are not aware of any studies explaining the rising then recently falling PM levels in Cairo. We speculate that PM emissions have generally increased with the growth of polluting activities in Cairo, but that this increase has been overcome in recent years with improvements in pollution controls and displacement of oil by clean-burning natural gas.

Health Effects From Particulate Matter

We calculate the incidence of two sorts of health effects from PM in Cairo: deaths and "restricted activity days" (RADs)[2].

Quantitative relationships between exposures to ambient concentrations of PM and these health effects are based on epidemiological studies that have found statistically significant relationships between them. The studies, however, demonstrate only correlation and not necessarily causation. The biological mechanisms that might underlie the correlation are not well understood, but plausible explanations involve both effects resulting from the physical nature of inhaled particles (e.g., irritant effects, altered mucus secretion and flow leading to increased susceptibility to acute infections) and effects related to the particular chemicals comprising the particles (perhaps even including toxicity involving non-respiratory system organs and functions)(USEPA, 1986a).

There are two types of epidemiological studies that have found an association between ambient PM levels and rates for mortality and morbidity. Time series studies look at changes in mortality and morbidity over time as PM levels change, while cross-sectional studies look at changes in these effects across different cities with differing PM levels. Both sorts of studies involve numerous difficult methodological issues (e.g., correction for other influences on mortality and morbidity such as smoking, and correlation of PM levels with other potentially important air pollutants, notably sulfates and sulfur dioxide), and the quantitative findings should be regarded as quite uncertain. To reflect some of the range of uncertainty, we have chosen to use several relationships derived in different studies. The studies and the estimated relationships are summarized in Chestnut and Rowe (1988).

Evans et al. (1984) analyzed data for 100 U.S. cities over a decade and developed the following relationship for mortality:

1. Change in annual deaths/100,000 population = .338 x change in TSP (annual mean in ug/m^3)

Schwartz and Marcus (1986) analyzed daily data from London, England over 14 years and found a different relationship for mortality:

[2] A "restricted activity day" is one on which an individual feels ill and cannot pursue a normal level of activity. They include days spent in bed, days missed from work, and days when activities are restricted to a minor degree due to a health condition. In the U.S., more than half of all restricted activity days result in days of work loss.

2. Change in annual deaths/100,000 population = .402 x change in BS[3] (annual mean in ug/m^3)

A relationship between restricted activity days and PM levels has been derived by Ostro (1987) in an investigation of data from a very large sample survey of health-related behavior among the U.S. population. Ostro found:

3. Change in annual RAD/person = b x 6.33 x change in TSP (annual mean in ug/m^3),

where the coefficient "b" ranged from .003 to .009. This equation also presumes the U.S. figure of 19 as the average annual number of RAD per person, which causes some uncertainty in extrapolating the equation to Cairo.

To estimate the rates of morbidity and mortality due to PM in Cairo, we applied these three equations to Cairo's monitored ambient concentrations of PM and to Cairo's estimated 1993 population of 12 million. Note that the second equation for mortality is specified in terms of British Smoke (BS) rather than in terms of TSP. British Smoke is another measure of PM that differs from TSP in that it focuses on particles that are smaller, more toxic and nearly completely anthropogenically derived. Table 1-5 shows concentrations of BS in Greater Cairo (Nasralla, 1993a):

[3] "BS" is an abbreviation for British Smoke or Black Smoke, another measure of PM. BS measures suspended particles of only a specific smaller size, by drawing polluted air through white filter paper and measuring the degree to which the paper is stained after a period of time. BS is typically only 20-60% of TSP.

Table 1-5. Annual Mean Concentrations of BS in Greater Cairo (ug/m^3), 1991

Site	Concentration
City center	130
Residential, high traffic	102
Residential/industrial	74
Residential	67
Residential	54
Suburban	39
Helwan—industrial	96
Helwan—industrial	67
Shoubra El-Kheima	80

Each of these equations projects the reduction in health effects that will occur with a reduction from current ambient levels of PM. It is not clear how far PM levels in Cairo might possibly be reduced:

- The level of TSP in the air will never reach zero, even in the absence of human activity, because natural sources of particulates (desert dust, sea salt, etc.) in Cairo are quite important. In the next section we discuss the relative contribution of natural and anthropogenic sources to PM in Cairo and draw the very rough conclusion that about 1/3 of current PM concentrations, or about 150 ug/m^3 of TSP, derives from natural background sources. We thus assume 150 ug/m^3 as the lowest level to which TSP might be reduced in Cairo. We calculate the reduction in mortality and morbidity that might result from reducing TSP in Cairo to this low level.[4]

- In contrast, British Smoke is a measure of PM that consists nearly entirely of particles from anthropogenic sources. It is reasonable to assume that it could be reduced to near zero. In using the equation specified in terms of British Smoke for calculating

[4] Note that 150 ug/m^3 as the assumed natural background level of TSP in Cairo is much lower than the lowest concentration of TSP observed at any monitoring station in Cairo for which we show data in Table 1-4 (349 ug/m^3 in 1991 at the residential site in Heliopolis). We believe that all the regular TSP monitoring sites in Cairo are substantially affected by anthropogenic TSP, including the Helopolis site, and that monitored concentrations at these sites are much higher than would be due to natural background sources alone. In personal communication (1994), Nasralla cites monitored TSP concentrations of about 200 ug/m^3 near the Mokattam Hills and 150 ug/m^3 near Nasr City that more nearly represent the contribution of natural background sources alone, although these sites also still likely have anthropogenic contributions.

the health risks associated with PM, we assume that BS could be reduced to a natural background level of 10 ug/m^3.

In applying these equations for estimating morbidity and mortality from PM, we used the most recent data available for TSP (1991 data for Cairo City and Helwan, 1988 data for Shoubra El-Kheima; Table 1-4) and for BS (1991 data for all areas; Table 1-5). Rather than average the data for all the monitors throughout Greater Cairo, we applied the data for Helwan to the population of the Helwan area (approximately 1 million), the data for Shoubra El-Kheima to the population there (approximately 1 million), and the data from the remaining monitors to the remaining population of Greater Cairo (approximately 10 million). We assumed that the population density of each of these areas was uniform within the area, so that, for example, the four TSP measurements within Cairo City each corresponded to the exposure level for one-fourth of the 10 million population in this area.

Using these procedures, we estimate that reducing PM concentrations in Greater Cairo approximately to natural background levels would prevent:

- About 3,300 to 16,000 deaths per year, and

- About 90 million to 270 million days of restricted activity per year.

These estimates of the health risks due to PM are somewhat sensitive to our choice to calculate the risks due only to anthropogenic (potentially abatable) sources of PM, and to our assumptions of 150 ug/m^3 of TSP and 10 ug/m^3 of BS as the natural background levels. Table 1-6 shows the impact of variations in this approach. It is apparent from this table that the estimated number of deaths from PM is far more sensitive to the choice of dose-response function (Equation 1 using TSP or Equation 2 using BS) than it is to the choice of how to deal with natural background PM.

Table 1-6. Alternate Estimates of Particulate Matter Risks

	Estimated Deaths Avoided per Year		Estimated RAD's Avoided per Year
	Equation 1	Equation 2	Equation 3
Eliminate all PM— Anthropogenic and natural TSP = 0 ug/m^3 BS = 0 ug/m^3	21,999	3,771	120 - 370 million
Eliminate all anthropogenic PM— Natural sources assumed at TSP = 150 ug/m^3 BS = 10 ug/m^3	15,915	3,289	90 - 270 million
Eliminate all anthropogenic PM— Natural sources assumed at TSP = 250 ug/m^3 BS = 25 ug/m^3	11,859	2,565	70 - 200 million

Any of these estimates should be regarded as quite uncertain, due to statistical uncertainties in the original research estimating relationships between PM and health effects and to uncertainties in extending to Cairo relationships that were estimated for other places and times. For several reasons, we believe it is more likely that these are overestimates than underestimates.[5]

[5] The two primary reasons for believing these most likely to be overestimates include:

- Considering both particle size and the toxicity of the chemical constituents, the mix of materials in the TSP typically prevailing in the U.S. or Britain is likely to be more virulent than the mix of materials in typical Cairo TSP. In effect, one unit reduction in U.S. or British TSP would provide more of a reduction in health effects than would a one unit reduction in Cairo TSP. Applying the coefficient estimated from U.S. or British TSP to predict health impacts from changes in Cairo TSP will result in an overestimate. This is not true for BS, as BS is likely to be roughly equally virulent in any location. This would make the equation specified in terms of BS more transferable to Cairo than the equation involving TSP, as BS is likely to be more similar across different sites than is TSP.
- Forecasting the effects from reducing PM in Cairo from current to background levels involves extrapolating the relationships developed in the U.S. and England outside the range of experience from which the statistical relationships were derived. We think it likely that the relationship between PM and health effects outside the range of experience is less than linear (i.e., health effects increase less than in proportion to increases in PM, or health effects decrease less than proportionally with decreases in PM) rather than more than linear.

Nevertheless, even though they may be overestimates, we believe that figures of this general magnitude indicate significant adverse health impacts from PM in Greater Cairo. We estimate there are roughly 90,000 deaths per year among the population of Greater Cairo[6]; reducing PM to natural background levels would lower this death rate by about 4 - 18%. The estimated number of restricted activity days due to PM averages 7.5 - 22 per person per year. It is clear that there would be huge benefits to the health of Cairo residents and to the city's economic productivity from preventing these impacts. PM also causes substantial economic damages through soiling, reductions in crop productivity, and deterioration in visibility.

There is no inventory of the sources responsible for particulate matter emissions in Cairo. Industrial processes, particularly the cement and iron and steel plants in Helwan, are probably the largest source. Other major sources include power plants, natural sand and dust, construction activities, open burning of trash, and motor vehicles (particularly diesel engines). A 1986/1987 study by the Academy of Scientific Research and Technology suggested the following relative source contributions:[7]

• Industry and construction	44%
• Power generation	21%
• Public transportation	14%
• Atmospheric heat up (?)	14%
• Open burning of garbage	7%

Of the contribution from industry and construction, over 93% (2660 tons/day) was estimated to derive from the cement plants. Nasralla (1993a) estimated the cement plant emissions at a much lower amount, 650 tons/day of PM.

A subject of some controversy is the contribution of natural sources to ambient PM levels in Cairo. Natural sources of PM are likely extremely difficult to abate. Our health risk calculation assumes reduction of ambient PM levels to natural background levels assumed at 150 ug/m^3 level of TSP and 10 ug/m^3 of BS. Some of the evidence bearing on the contribution of natural sources includes:

- Early work in the 1960s on air pollution in Cairo concluded that atmospheric dust derived largely from natural processes involving the Mokkatam Hills that rise sharply at the eastern edge of the city. The highest dustfall rates in the city were observed at the foot of those hills. Data from 1979 and 1983, though, show lower dustfall rates near the hills than at other sites in the city (Nasralla et al., 1986). More recent chemical analysis of TSP shows that it has substantially different chemical composition

---

[6] The Ministry of Health (MOH, 1993) estimates the Egyptian crude death rate at 7.5 annually per 1,000 population. Assuming that Cairo exhibits a similar crude death rate as the entire country, annual deaths are 90,000 among the estimated 12 million population of Greater Cairo.

[7] We have not been able to obtain the original study. It is cited as "El Kotb, 1987" in EQI, 1991, but the 1987 study by El Kotb that we obtained and reference later in this section does not include this information on PM.

than the exposed components of the Mokkatam Hills. Nasralla concludes that the Mokkatam Hills are a relatively small contributor to Cairo's particulate load (personal communication, 1994).

- Dustfall rates in Cairo are generally higher in the winter and spring months than during the remainder of the year. The perhaps 40% higher dustfall during these months is thought largely due to natural factors: the Khamsin dust storms that come in the late winter and spring, the predominant southerly winds (bringing dustier air from the desert rather than the cleaner air from the delta) during this period, and washout by rainfall during the winter (Nasralla, et al, 1986). On the other hand, the southerly winds during this period also carry the cement dust from Helwan over Cairo, and anthropogenic factors could also contribute to the higher dustfall rate in winter and spring.

- There have been some efforts to determine the natural background rates of dustfall in the Cairo area by looking at data from times or locations (far in the past or largely unaffected by point or area sources) where anthropogenic contributions to dustfall might be expected to be minimal. Ideal data for implementing this approach are not available. The lowest rates of dustfall have been measured in Heliopolis (13 $g/m^2/30$ days in 1979, 10 g/m^2 in 1991) (Nasralla et al, 1986 and Nasralla, 1993a), 9 km north of the industrial zone in Shoubra El-Kheima (14 $g/m^2/30$ days in 1988) (Ali, 1990), and in a location on the periphery of Helwan (11 $g/m^2/30$ days in 1966) (World Bank, 1992). Each of these locations was probably not completely free from dustfall from human causes. We can conclude that the natural background rate of dustfall is probably somewhat less than 10 $g/m^2/30$ days. By contrast, the average dustfall over urban Cairo was 23 $g/m^2/30$ days (1991), in Shoubra El-Kheima it ranged from 44 - 76 $g/m^2/30$ days (1988), and in Helwan it ranged from 38 - 261 $g/m^2/30$ days (1988) (Nasralla, 1993a). These data suggest that natural sources contribute at most about 40% to dustfall throughout Greater Cairo. The contribution of natural sources to TSP should be less than for dustfall, as particles from natural sources tend to be larger and settle out of the atmosphere much more quickly than particles from anthropogenic sources (USEPA, 1982).

- Other work cited by Nasralla in conversation adds credence to the impression that natural sources contribute importantly but not overwhelmingly to PM levels in Cairo. This work includes: a) a finding that the particle size distribution of Cairo's TSP is smaller than might be expected from natural sand and dust; b) differences in chemical composition between Cairo's TSP and surrounding desert rocks and sand; and c) monitored levels of TSP much lower in more rural, outlying areas of Greater Cairo (150 - 200 ug/m^3) than in most of the urban or industrial areas (350 - 900 ug/m^3).

Improving the understanding of the relative contribution of natural sources and the numerous anthropogenic sources to PM concentrations is important. Developing an emissions inventory is a logical precursor to formulating a control strategy for major sources and addressing the substantial health risks posed by PM.

Health Effects From Nitrogen Oxides

Nitrogen oxides (NOx) include several compounds (nitrous oxide N_2O, nitric oxide NO, nitrogen dioxide NO_2, nitrogen tetroxide N_2O_4, nitrogen pentoxide N_2O_5), of which the most stable, common in the atmosphere, and important is nitrogen dioxide. In contact with water, nitrogen dioxide forms nitrous and nitric acids, which are strong irritants to mucous membranes. Nitrogen oxides are also important contributors to acidic deposition.

Nitrogen oxides are generally formed in high-temperature combustion processes such as in power plant and industrial boilers and motor vehicle engines. In Cairo, perhaps 80 percent of NOx comes from power plants and industry, with the remainder from motor vehicles (Nasralla, 1993a). Much of the point source contribution derives from a few very large sources (El Kotb, 1987). The motor vehicle contribution is less than in many areas because of the large fraction of cars in Cairo with older, poorly tuned, inefficient, and low-temperature engines.

Very little sampling or monitoring for NOx has been conducted in Cairo. Listed below are the findings from the several studies that have investigated NOx levels in Cairo:

- Monitoring during 1979 at a heavily trafficked site in the city center found these mean monthly concentrations (Nasralla, 1981):

January - March	0.2 ppm
April - July	0.4 - 0.75 ppm
August - December	0.3 - 0.4 ppm

  Concentrations were highest during May and June, reflecting increased traffic during that time and probably also temperature inversions during those months.

- Brief monitoring at numerous sites in 1984 throughout Cairo and Giza showed hourly concentrations varying over the course of a day between roughly 0.05 ppm - 0.4 ppm. Concentrations varied importantly with the time of day, day of the week, location of the monitors and traffic flow. Hourly concentrations were measured in Shoubra El-Kheima at 0.1 - 0.2 ppm and in Helwan/Tora at 0.05 - 0.15 ppm (El Kotb, 1987).

- Further measurements in Shoubra El-Kheima in 1988 found an annual average concentration of 0.07 ppm in an industrial area and 0.04 ppm in a residential area. The corresponding maximum 24-hour concentrations were 0.11 ppm and 0.09 ppm (Ali, 1992a). During autumn of 1990, measurements near the Shoubra El-Kheima power station showed 24-hour average concentrations ranging from 0.02 ppm to 0.11 ppm (Nasralla, 1991b).

- 1992 screening in Helwan found concentrations ranging between 0.03 and 0.11 ppm (World Bank, 1992).

In sum, excluding the 1979 monitoring at a very heavily trafficked site, typical hourly NOx concentrations have ranged from about 0.04 ppm to 0.4 ppm. For comparison, the U.S.

ambient standard is 0.053 ppm as an annual mean, while the WHO recommends an hourly standard of 0.1 - 0.17 ppm not to be exceeded more than once a month. It is apparent that NOx concentrations in the mostly industrial and trafficked areas that have been studied in Cairo exceed these health-based standards. Monitoring in Cairo has been insufficient to characterize the spatial variability of NOx concentrations beyond these sites.

Nitrogen oxides can irritate mucous membranes, aggravate preexisting respiratory illnesses, and cause coughs, headaches, and shortness of breath. At ambient or near-ambient concentrations, the two key types of health effects are: 1) increased airway constriction in asthmatics after short-term exposures, and 2) increased occurrence of respiratory illness among children associated with longer term exposures. Other effects occur with exposure to higher concentrations.[8]

Among healthy individuals, there is little evidence of airway restriction or decrements in lung function at concentrations below 1.0 ppm, a level not reached in Cairo. Among asthmatics, some adverse, reversible changes in lung function have been observed at concentrations between 0.2 and 0.5 ppm. Surprisingly, no response has been observed in asthmatics at higher concentrations (even as high as 4 ppm), and EPA concludes that "the findings do not provide clear quantitative conclusions about the health effects of short-term exposure to NO_2."

Epidemiological studies have found equivocal evidence that increasing levels of nitrogen dioxide in bedrooms (concentrations of about 0.01 to 0.07 ppm) have increased the incidence of respiratory illness among exposed children. It is speculated that the underlying mechanism may involve nitrogen dioxide impairing components of the respiratory host defense system, which in turn increases susceptibility to respiratory infections. For children age 5 - 12, the study findings suggest about a 20% increase in respiratory infections for each 0.015 ppm increase in the concentration of NO_2 in the child's bedroom (Hasselblad, 1992). This finding would suggest an important health benefit from reducing NOx concentrations in Cairo below the current estimated range of 0.04 - 0.4 ppm.[9] On the other hand, epidemiological studies have not found a significant relationship between NO_2 exposures and respiratory infections among infants of up to two years of age (Samet, 1993). Among adults, elevated prevalence of acute respiratory symptoms was observed for exposures exceeding 0.3 ppm for an 8-hour period (Gamble, 1987), a level that occurs perhaps occasionally at a few locations in Cairo.

EPA concludes that reliable dose-response relationships have not yet been developed for exposure to NOx. Effects in asthmatics from low doses are not replicated at higher doses, even though the higher doses might be expected to produce more severe effects. Effects observed in children are not observed in infants, even though infants might be expected to be more sensitive.

---

[8] The health effects information discussed here derives from USEPA, 1994.

[9] The indoor concentration of NO_2 in Cairo bedrooms is probably much lower than this general range of outdoor concentrations (unless a gas stove is used in the home), so one should not expect a 20% reduction in respiratory disease for each 0.015 ppm reduction below 0.04 ppm.

We conclude that there is some conflicting evidence for adverse health effects from NOx at levels such as prevail in Cairo. We cannot confidently project the health impacts of nitrogen oxides in Cairo, except to say that they may be significant.

HEALTH EFFECTS FROM CARBON MONOXIDE

Carbon monoxide (CO) is a colorless and odorless gas that derives largely from incomplete combustion of fossil fuels. It affects health by complexing with hemoglobin in the blood and thereby reducing the blood's ability to carry oxygen.

CO in Cairo comes almost entirely from automobiles, with industrial plants contributing a very small additional amount. There is no recent emission inventory for CO in Cairo. A 1987 study estimated over 99% of CO emissions in Cairo to be from cars, with major point sources contributing the remainder (El Kotb, 1987). CO emissions in Cairo have grown sharply over time with the growth in automobile traffic (Nasralla, 1993a). Diesel vehicles and power plants emit low amounts of CO because they provide relatively efficient fuel combustion.

There has been no systematic monitoring of CO levels in Cairo. CO is a difficult pollutant to monitor, as it is usually very localized. It can exist at high concentrations near a source while emissions are occurring (e.g., at curbside on a busy street during rush hour) but then dissipate rapidly over time and space, leaving low concentrations a short distance away or a short time after the source abates. No long-term routine CO monitoring network or site exists in Cairo, and data derive from several older, limited studies that concentrated on trafficked areas. For this project we conducted some additional spot sampling for CO in Cairo that suggests levels approximately the same as those found in larger studies in the early 1980s. Available data on CO levels in Cairo are as follows:

- Short-term monitoring in 1984 at numerous high traffic sites, mostly in Cairo center, showed average hourly concentrations varying over the course of a day from about 1 - 18 mg/m^3 (El Kotb, 1987). Concentrations varied significantly with traffic volume, and thus with location, time of day and day of the week. Average hourly concentrations in the less trafficked, more industrial areas of Shoubra El-Kheima and Helwan showed much less variation over time, with hourly average levels ranging from about 2 - 7 mg/m^3.

- One day of monitoring at roof level at a city center site with heavy traffic showed hourly CO concentrations of 8 - 22 mg/m^3 (Nasralla, 1993a).

- Sampling for this project at 10 varied sites around Cairo in November, 1993 found instantaneous concentrations of 0.2 - 15 mg/m^3, with one extreme concentration of 42 mg/m^3.[10]

---

[10] Measurements were taken at each site several times over two days. The instrument used was a portable ambient air analyzer (single beam infrared spectrophotometer, Miran 1B2) provided by the Foxboro Company through their Cairo office, Osman A. Azzam & Co.. We appreciate the assistance of Foxboro, Dr. Azzam, and Dr. Mahmoud Hewehy of Ain Shams University who lent the machine and assisted in the sampling and data

In sum, typical hourly average CO concentrations in more highly trafficked areas of Cairo appear to be roughly 1 - 18 mg/m^3, with lower concentrations in less heavily trafficked areas. For comparison, the U.S. ambient standard for CO is 40 mg/m^3 for one hour, and both the U.S. and WHO have 8-hour standards at 10 mg/m^3. It appears that CO concentrations in Cairo do not exceed these health-based standards. Even increasing the 1984 monitoring data to reflect increased traffic emissions of CO since then (estimated at 15% by Nasralla, 1993a), CO levels in Cairo now probably only rarely approach the levels of the standards.

The adverse health effects from CO exposure relate to the reduced ability of the blood to carry oxygen, potentially resulting in oxygen deficits to the heart, brain, and other organs.[11] At moderate levels of CO, this oxygen deficit can usually be compensated for by healthy people by means such as increased blood flow and dilation of blood vessels. In individuals with ischemic heart disease or coronary artery disease, though, increased oxygen demand from exercise combined with a reduction in oxygen delivery due to exposure to moderate levels of CO may result in decreased time to the onset of angina pain. CO may begin to elicit these effects at approximately one-hour concentrations of 60 mg/m^3 or eight-hour concentrations of 25 mg/m^3. No CO measurements in Cairo have yet reached these levels, though continuing growth of traffic without exhaust emission controls might rarely push CO concentrations above these levels. It is probably also likely that some very highly exposed locations where monitoring has not yet occurred (e.g., in the middle of a busy intersection) might experience concentrations above these levels now. At CO levels perhaps double these, which are very unlikely to occur in Cairo, effects may begin to occur among heavily exercising healthy individuals and among people with anemia or other blood disorders, chronic lung disease, pregnant women, fetuses, and infants. Even higher levels of exposure can cause headaches, fatigue, poor visual perception, and other adverse neurobehavioral impacts in healthy people.

Studies of workers in Cairo that are highly exposed to auto emissions have shown significant negative effects from the combination of carbon monoxide and other pollutants. A study of 205 bus drivers and garage workers in Cairo found 62% of the individuals studied to have manifestations of cardiopulmonary illness (Emara, 198?). Twenty-three percent had chronic obstructive lung diseases (e.g., asthma, chronic bronchitis, emphysema). The average carboxyhemoglobin level in the subjects was 10.0%, relative to a typical baseline level for non-exposed, non-smokers in the U.S. of about 1.7%.[12] Carboxyhemoglobin at 10% can be expected to be associated with all of the health effects described above—serious problems for individuals with cardiopulmonary illnesses, and significantly decreased exercise tolerance and neurobehavioral impacts for otherwise healthy individuals.

Another study of 300 traffic policemen in Cairo found similar results with regard to high rates of chronic respiratory disease and elevated carboxyhemoglobin levels (El-Samra, 198?).

---

interpretation.

[11] The health effects information in this section derives from USEPA, 1992.

[12] Smokers may have carboxyhemoglobin levels of 3 - 8% while they smoke a cigarette. Heavy smokers can have levels as high as 15%.

Carboxyhemoglobin levels averaged about 12% for traffic policemen in Cairo city and about 10% for those working in Giza and Shoubra El-Kheima.

We speculate that street vendors and perhaps other occupations would be similarly exposed to high levels of auto emissions and would likely suffer similar health effects.

In sum, carbon monoxide in Greater Cairo probably now causes significant health problems for individuals in highly exposed occupations and minimal problems for the general population.

HEALTH EFFECTS FROM LEAD

About two-thirds of lead emissions to the atmosphere in Cairo come from automobiles fueled with leaded gasoline, with the remainder from the dozen or so lead smelting operations in the city (Nasralla, 1983a). Lead from cars is distributed throughout the city, while the smelters have a major impact on their immediate vicinity. Air emissions of lead may be the primary source of lead entering the environment. The lead undergoes numerous environmental processes, and people may be exposed to lead originally emitted into the air ultimately through air, water, soil, dust and/or food.

The very serious health effects caused by lead are discussed thoroughly in a separate section on the impacts of lead in all media. Concentrations of lead in Cairo's ambient air exceed health-based standards in much of the city, and residents of Cairo have very high levels of lead in their blood.

Virtually all of the gasoline used in Cairo contains lead additives as inexpensive anti-knock agents. Approximately 20 percent of cars use 90 octane gasoline with 0.9 g/l of lead, while 80 percent use 80 octane gasoline with 0.4 g/l of lead. The average lead level is thus 0.5 g/l, an amount above levels in developed countries and many developing countries, where most of the fleets run on unleaded gasoline (OECD, 1993; WHO/UNEP, 1992). The GOE's Environmental Action Plan proposes that by 1995 leaded gasoline will contain not more than 0.15 g/l and unleaded gasoline will be available. There are some indications, however, that this lead phase-down is not happening. Lead phase-down requires investment at refineries in alternate procedures for increasing the octane rating of gasoline, costing typically several cents per gallon of gasoline (GOE, 1992).

Cairo's lead smelters produce unhealthy conditions for their workers and nearby residents. The mean concentration of lead in indoor air at one smelter was 2.5 mg/m^3, 500 times the U.S. occupational exposure limit (Shakour, 1992). The outdoor concentration of lead 500 meters downwind of the smelter exceeded 50 ug/m^3, more than 30 times the U.S. ambient standard (World Bank, 1992).

HEALTH EFFECTS FROM OZONE

Ozone is a secondary air pollutant produced by complex atmospheric reactions of nitrogen oxides and reactive volatile organic compounds (VOCs) under the influence of sunlight.

Conditions in Cairo are favorable to forming ozone, with large emissions of NOx and reactive VOCs, extensive sunshine, warm temperatures, and stable air (Nasralla, 1984). All of these conditions are most severe during the summer in Cairo, and ozone concentrations should be at their highest then. There has been no emissions inventory in Cairo for VOCs, though the major sources are typically evaporation of solvents and gasoline, industrial processes, incomplete combustion processes, and natural phenomena. Motor vehicles are probably the most significant source of both NOx and VOCs.

Ozone has not been monitored on a routine basis in Cairo and data are available only from several limited research studies. These studies show peak ozone readings sometimes below, sometimes nearing, and sometimes above the U.S. standard of 235 ug/m^3 (as an hourly average, not to be exceeded more than once per year) and the WHO guideline of 150 - 200 ug/m^3. The studies of ozone levels in Cairo include:

- Monitoring in 1979 on 6 - 9 days each month at unspecified sites found ozone levels exceeding 200 ug/m^3 for at least one hour on 74% of the days. The maximum 1-hour concentrations were in excess of 1,000 ug/m^3 (WHO/UNEP, 1992). Levels were clearly the highest during the summer months.

- Monitoring during the summer of 1989 at a residential site showed maximum half-hourly concentrations of only 110 - 140 ug/m^3, well below the health-based standards (Nasralla, 1993a).

- Ozone concentrations exceeded 100 ug/m^3 for 7 of the 17 days of monitoring during the fall of 1990 at a site near the Shoubra El-Kheima power station (Nasralla, 1991b). At two other sites in Shoubra El-Kheima, though, peak hourly ozone concentrations never exceeded 90 ug/m^3.

These limited monitoring results show widely varying concentrations and are not sufficient to portray current ozone levels across Greater Cairo. We do not believe there is sufficient information about current ozone levels to allow an assessment of the health risks posed by this pollutant in the city. A more thorough monitoring program for ozone would be valuable.

Ozone is a primary constituent of photochemical smog. As a function of the concentration of ozone and the level of exercise by an individual exposed to it, ozone can be a respiratory irritant causing impairment of lung functions and lower respiratory symptoms such as cough and chest discomfort. In heavily exercising healthy individuals, these symptoms can begin to appear at the peak ozone levels seemingly present in Cairo. For asthmatics and those with other preexisting respiratory impairments, they can occur at even lower levels (Hayes, 1989). Ozone has been found to increase both the frequency and severity of asthma attacks. There is not yet adequate scientific information on the long-term effects of exposure to ozone at levels like those in Cairo. There is a possibility that such levels increase the likelihood of chronic lung injury, leading in some cases to fibrosis and chronic bronchitis (Whitfield, 1991).

Ostro (1994) cites the findings from several epidemiological studies relating the incidence of a variety of health effects to ozone exposure. The quantitative relationships developed by these studies are rather uncertain, because each study examined a different health effect and no study is therefore either supported or weakened by the results of another study. Ostro summarizes the findings of the studies as follows:

Table 1-7. Effects of 1 ppm (1.96 mg/m³) Change in Ozone

Annual Health Effects	Estimated Coefficient*
Respiratory hospital admissions / person	0.0077
Days of minor restrictions in activity / person	34.0
Days of respiratory symptoms / person	54.75
Days of eye irritation / person	26.6
Asthma attacks / asthmatic	68.44

* The coefficients relate the number of effects to the annual average of the daily 1-hour maximum ozone concentration.

Using these coefficients and the estimated Cairo population of 12 million, we can do a hypothetical calculation of health risks associated with ozone in Cairo. If we assume that the current annual average of the daily maximum 1-hour ozone concentrations in Cairo is 80 ug/m³ and that this level would be cut in half, then the following health effects would be avoided each year:

- Respiratory hospital admissions 1,900
- Minor restricted activity days[13] 8.3 million
- Days of respiratory symptoms 13.4 million
- Days of eye irritation 6.5 million
- Asthma attacks 0.84 million[14]

These effects are not additive, as one individual might experience several of them at the same time. For example, most of the hospital admissions will be associated with asthma attacks, and an individual suffering respiratory symptoms would often restrict his or her activity.

Note again that these calculations are based on a hypothetical 50% reduction in ozone levels from assumed current levels. We have insufficient data to characterize current actual

[13] A minor restricted activity day is one on which one's activity is restricted but not to the degree of bed disability or absence from work.

[14] This calculation also assumes that 5% of Cairo's population has asthma.

ozone levels in Greater Cairo, and we do not know what level of reduction in current ozone concentrations might be feasible.

It appears that health effects from ozone in Cairo are likely to be widespread but not severe. Most of Cairo's population might be expected to have between one and several days per year on which mild adverse symptoms occur from ozone. Asthmatics will suffer more frequent and serious health effects.

On balance, we would estimate that ozone causes moderate health risks in Cairo. Given the insufficient monitoring data and unsettled dose-response information, however, this assessment is highly uncertain.

HEALTH EFFECTS FROM OTHER TOXIC AIR POLLUTANTS

Numerous other toxic air pollutants such as benzene, formaldehyde, cadmium, nickel, and benzo-a-pyrene that may also cause adverse health effects can likely be found in Cairo's ambient air. Sources of such pollutants are widespread in Cairo: motor vehicles, industry, use of solvents and paints, fuel evaporation and combustion, etc. No systematic monitoring has been performed for these pollutants in Cairo, nor are they routinely monitored elsewhere in the world. Such metals and organic compounds can produce carcinogenic or other effects at very low concentrations.

We have projected the health risks from these compounds by performing a very rough analysis, combining limited sampling data on metals with modeled estimates for other compounds. Our analysis covers: 1) metals from all sources; and 2) toxic organic compounds from mobile sources only. Our risk analysis for toxic substances is therefore incomplete and provides an under-estimate of risks—we omit the risks associated with organic compounds from both point sources (e.g., products of incomplete combustion from industrial fuel use, evaporative emissions from petroleum storage tanks) and area sources (e.g., dry cleaners, gas stations). We cannot quantify exactly how much of the air toxics problem in Cairo remains unaddressed by this analysis. In the U.S., about 60% of the cancer incidence associated with air toxics has been attributed to motor vehicles (Haemisegger, 1985). If we assume that the mix of sources of air toxics is similar in Cairo as in the U.S. and add the fact that our analysis for Cairo includes risks from metallic air toxics whatever their source, we would guess that the following analysis covers perhaps 2/3 of the risks associated with air toxics in Cairo.

Toxic Metals

Little monitoring has been done for toxic metals in Cairo's ambient air. We found references to two limited studies: monitoring in Cairo's central district during 1983 (Nasralla, 1991c) and in Shoubra El-Kheima during 1988 (Nasralla, 1991a). Mean concentrations of metals found in these two studies are shown below.

Table 1-8. Concentrations of Metals in Cairo Air (ug/m^3)

Metal	Central District	Shoubra El-Kheima
Chromium	0.40	0.19
Manganese	0.14	0.20
Cobalt	0.07	---
Nickel	0.30	0.18
Zinc	0.30	1.20
Cadmium	0.05	0.05
Lead	2.50	1.20

To represent the concentration of metals in Cairo as a whole for our risk calculations, we averaged the concentrations found in these two studies.

Toxic Organic Compounds

Monitoring data for toxic organic compounds were not available, so we instead derived estimates of their ambient concentrations. We first estimated emissions of these compounds in Greater Cairo, then performed crude air quality modelling to estimate the ambient concentrations that would result from these emissions. The methods used for each of these steps are described below.

It was possible to estimate emissions of toxic organic compounds only from mobile sources. The information necessary to estimate emissions from other sources—point sources or area sources—was not available. Our subsequent estimates of ambient concentrations and health risks for these compounds thus count only the contribution of mobile sources.

Emissions Estimates

We estimated toxic organic air emissions from mobile sources in two steps. First, contaminant-specific emissions factors (in grams of the pollutant emitted per mile traveled) are estimated for each model year for four basic classes of vehicles: light and heavy duty gasoline-powered vehicles, and light and heavy duty diesel-powered vehicles. The emissions factors vary as a function of vehicle type, engine type and efficiency, and the nature of the pollution control devices in use on each vehicle class during each model year. Older vehicles tend to have higher emissions per mile than do newer vehicles. The second step is to estimate the number of miles travelled by each type of vehicle. Multiplying the number of vehicles of each class and model year by the miles driven by the average vehicle in the class/model year and then by the appropriate emission factor gives total emissions for the class/model year. Summing across classes and model years then yields an estimate of total emissions.

For our calculations, we simplified this procedure. We chose to apply a single emission factor for all vehicles in a class, ignoring the fact that the class is actually comprised of vehicles from a wide range of model years with different emission rates. Instead, we chose to assume that all vehicles in the class were from a single model year, choosing the model year and corresponding emission factor that best represents the average age and emission rate for all vehicles in the class. For example, EEAA (1993) shows the age in 1992 of the light duty gasoline vehicle fleet: 23% are from model years before 1970, 15% from model years 1970 - 1975, etc. Instead of counting the number of cars from before 1970 and using an emission factor for them, the number of cars from 1970 - 1975 and using a different factor for them, and so forth, we chose a single model year to represent the entire light duty gasoline fleet. We then chose the emission factor appropriate for that chosen model year, and applied that emission factor for the entire fleet.

For this analysis, the emission factors for various toxic air pollutants from mobile sources were drawn from U.S. EPA sources (USEPA; 1985, 1987, 1993). We generally chose representative model years and associated emission factors for vehicles when catalytic converters were not in use, since these devices, to the best of our knowledge, are not in common use in Cairo. When separate emission factors were not given for vehicles without catalytic converters, we used emission factors for the U.S. 1974 model year, since this was the last year before catalytic converters were required in the U.S. If this information was not available, we used the emission factors for the overall 1974 U.S. fleet. The contaminants considered, the vehicle class associated with the contaminant emissions, the emission factors used for each contaminant, and the method used to derive the emission factors are found in Table 1-9.

By using the emission factors presented in these U.S. EPA sources, we assume that the average speed and fuel efficiency assumptions used to derive these emission factors are also valid for vehicles in Cairo.

To obtain total annual emissions, we multiplied the emission factors for a vehicle class by the annual estimated miles travelled by all the vehicles in Cairo in the class. Certain contaminant emissions are associated with gas-fueled vehicles only, some are emitted from diesel-fueled vehicles only, and others are emitted from both kinds of vehicles. In addition, emission factors may be different for light and heavy duty vehicles using each fuel type. To match the emission factors with the appropriate measure of miles travelled, we needed an estimate of the number of vehicles in Cairo in each class, and the number of miles travelled by the average vehicle in each class. Table 1-10 shows the number of vehicles in each class registered in Greater Cairo in 1992, and our assumptions about the annual kilometers travelled by the average vehicle in each class. Kilometers were then converted to miles for use in this assessment.

Table 1-9. Emission Factors

Contaminant	Emission Factor (g/mile)	Source and Nature of Estimate
1,3 Butadiene	9.6E-02	Gasoline vehicles only Expressed as % of total Hydrocarbon (HC) emissions Estimated using 1974 HC emission level *
Asbestos (low)	4.0E-03	Both gasoline and diesel vehicles
Asbestos (high)	2.8E-02	Identical emission levels expected from all types of vehicles Estimated using 1984 EPA data
Benzene	1.5E-01	Gasoline vehicles only Expressed as % of total exhaust and total evaporative HC emissions Estimated using 1974 model year levels of HC emissions *
Diesel Particulates	1.9E-01	Diesel vehicles only Estimated using 1974 EPA model year data
Ethylene	9.2E-01	Gasoline vehicles only Expressed as % of total hydrocarbon emissions Estimated uisng 1986 EPA light and heavy duty fleet data and 1974 HC emission level *
Ethylene Dibromide	5.9E-04	Lead gasoline vehicles only Higher emission levels expected from non-cat. equipped vehicles Estimated using 1986 EPA light duty fleet data
Formaldehyde	1.2E-01	Both gasoline and diesel vehicles Expressed as % of total HC emissions Estimated using 1986 EPA gasoline and diesel fleet data and 1974 HC emission level *
Organics Associated with Gasoline Particulates (light duty)	2.3E-02	Gasoline vehicles only Higher emission levels expected from heavy duty vehicles
Organics Associated with Gasoline Particulates (heavy duty)	7.2E-02	Estimated using 1970-74 EPA light duty model year data and pre-1987 EPA heavy duty model year data
Acetaldehyde	3.6E-02	Both gasoline and diesel vehicles Estimated by taking 300% of 1990 emission factor (general relationship between above factors and corresponding 1990 factors) **

Sources: U.S. EPA, 1987.
* U.S. EPA, 1985.
** U.S. EPA, 1993.

Table I-10. Number of Vehicles and Kilometers Travelled in Cairo

Vehicle Class	Number	Average km/yr
Automobiles	662,000	12,000
Trucks	136,000	12,000
Taxis	83,000	24,000
Buses	18,000	36,000
Motorcycles	Omitted	Omitted

Sources: Registrations from EEAA, 1993.
Kilometers travelled per vehicle are assumed

I2b. Dispersion Model

To estimate dispersion of the toxic emissions over the Greater Cairo area, we used a simple box model derived from Sullivan (1988a,b). This model assumes that emissions are uniformly emitted across the area of the box. The model also assumes complete mixing of the emissions over the area of the city and within a given mixing height. The box model calculation is (Sullivan, 1988a):

$$C = Q\,(x/uz) \times 10^6$$

where:

C	=	concentration of the contaminant (ug/m^3),
Q	=	emission of the contaminant (g per m^2 per second),
x	=	square root of the area of the city (m),
u	=	wind speed (m/s),
z	=	vertical dispersion term (m),
10^6	=	factor to convert g to ug.

The vertical dispersion term estimates the extent of vertical mixing of pollutants. It is calculated as (Sullivan, 1988b):

$$z = (0.06)\,(x/2)\,[(1 + (x/2)\,(0.0015)]^{0.5}$$

where:

z	=	vertical dispersion coefficient (m) and
x	=	square root of the area of the city (m).

For this assessment, we ignored the effects of atmospheric decay or transformation of the contaminants. Ignoring this will result in overestimated air concentrations. We also ignored wet and dry deposition of contaminants. Wet and dry deposition would also tend to lower the air concentration of the contaminant, but would do so by transferring the contaminant to another medium, such as water or soil, to which humans may also be exposed. The wind speed was assumed to be 3 meters/second for this model (Nasralla, 1993a). The area over which emissions disperse was set at 400 km^2, the surface area of Greater Cairo.

Risk Assessment for Toxic Air Pollutants

Table 1-11 shows our calculations regarding the health risks resulting from toxic air pollutants in Greater Cairo.

The first column represents the ambient concentration of the pollutant, assumed constant across the city. The concentrations for metals are from the two sampling studies mentioned earlier. The concentrations for organic pollutants and asbestos are those estimated as deriving from mobile sources, calculated by estimating emissions from mobile sources and applying a simple dispersion model.

The remaining columns in Table 1-11 show calculations of the risks posed by these ambient concentrations. All the dose-response information for the pollutants, including determinations of whether or not each pollutant is a carcinogen, derives from U.S. EPA. Most of this information has been peer-reviewed by a panel of U.S. health scientists and has subsequently been compiled in EPA's health effects data base, the Integrated Risk Information System (IRIS).

Some of the pollutants are probable or proven human carcinogens by inhalation. These are shown as having unit risk factors, which represent the excess lifetime cancer risk faced by an individual breathing the pollutant for a lifetime at a concentration of 1 ug/m^3. Non-carcinogens are shown with an "x" in the unit risk column. The unit risk factors incorporate standard EPA assumptions regarding the average individual's body weight (70 kg) and ventilation rate (20 m^3 of air breathed per day). The lifetime individual cancer risk from exposure to each pollutant in Cairo is the product of the unit risk factor for the pollutant and its ambient concentration. In subsequent columns of Table 1-11, lifetime risks are converted to annual risks by dividing by an assumed 70-year lifetime. Annual individual risks are then converted to population risks for Greater Cairo by multiplying by the assumed 12 million population of the city.

For other pollutants and also for some carcinogens, non-carcinogenic health effects (e.g., systemic toxicity, mutagenic effects) are also of concern when the pollutant is inhaled. These pollutants are shown as having Reference Concentrations, or RfCs. Many pollutants do not yet have RfCs established; they are shown with an "x" in the reference concentration column. The RfC for a pollutant is the concentration of the pollutant in air which, if inhaled for a lifetime, is without significant risk of adverse effects. The RfC represents a virtually safe level of exposure to a pollutant, rather like the concept of an Acceptable Daily Intake (ADI). Exposures below the level of the RfC are without significant risk. Exposures above the level of the RfC

95

Table 1-11. Risk Calculations for Cairo Air Toxics

Contaminant	Concentration (ug/m3)	Unit Risk per (ug/m3)*	Lifetime Individual Risk	Annual Individual Risk	Population Risk (cases/year)	Reference Conc. (ug/m3)	Hazard Index
1, 3 Butadiene	2.19	2.8E-04	6.1E-04	8.7E-06	105	x	x
Asbestos (h)	0.11	2.6E-02	2.8E-03	4.0E-[illegible]	478	x	x
Asbestos (l)	0.11	6.6E-04	7.1E-05	1.0E-06	12	x	x
Benzene	3.42	8.3E-06	2.8E-05	4.1E-07	5	x	x
Diesel Particulates	0.76	1.7E-05	1.3E-05	1.9E-07	2	x	x
Ethylene	20.95	2.7E-06	5.7E-05	8.1E-07	10	x	x
Ethylene Dibromide	0.01	2.2E-04	3.0E-06	4.2E-08	1	x	x
Formaldehyde	3.22	1.3E-05	4.2E-05	6.0E-07	7	7.0E+02	4.6E-03
Organics Assoc. w/ Gas Particulates: no catalyst + leaded fuel	0.52	5.1E-04	2.7E-04	3.8E-06	46	x	x
Acetaldehyde	1.61	2.2E-06	3.5E-06	5.1E-08	1	x	x
Cadmium	0.05	1.8E-03	9.0E-05	1.3E-06	15	1.8E+00	2.9E-02
Hexavalent Chromium **	0.01	1.2E-02	1.8E-04	2.5E-06	30	x	x
Total Chromium **	0.30	x	x	x	x	2.0E-03	1.5E+02
~~Manganese~~	0.17	x	x	x	x	5.0E-02	3.4E+00
Cobalt	0.07	x	x	x	x	x	x
Nickel	0.24	x	x	x	x	7.0E+01	3.4E-03
Zinc	0.75	x	x	x	x	7.0E+02	1.1E-03
Lead	1.85	x	x	x	x	x	x

Total Cancer Cases/Year: 234-708

* All unit risks are EPA 1987 with the exception of:
  Organics associated with gas particulates (Lewtas, 1991)
  Diesel particulates (EPA, 1991; no SAB review yet.)

** Five percent of total chromium assumed to be hexavalent.

96

are not necessarily unsafe, they are simply above those that can be said to be safe. EPA's approach for calculating a RfC involves taking an appropriate lifetime-adjusted No Observed Effect Level (NOEL), No Observed Adverse Effect Level (NOAEL), Lowest Observed Effect Level (LOEL), or Lowest Observed Adverse Effect Level (LOAEL)—derived from either laboratory animal and/or human epidemiology data for the chemical—and dividing it by an appropriate uncertainty (safety) factor. Safety factors are intended to establish a RfC sufficiently far below an experimentally determine LOAEL that adverse effects are extremely unlikely to be observed for exposures at the RfC level. The more uncertainty there is in translating the experimental conditions under which the LOAEL was observed to conditions of human exposure, the greater the safety factors will be.

If exposure to a pollutant exceeds the level of the RfC, EPA currently has no accepted method to determine the probability of an adverse health effect occurring. Exposure exceeding an RfC does not necessarily mean that the effect will occur, but the probability of the effect occurring increases as the exposure increases above the RfC. EPA often signifies this by calculating a "Hazard Index" for the exposure, given by the ratio between the exposure concentration actually experienced and the RfC. At Hazard Indices of 1 or below, the exposure can be assumed to be safe. At Hazard Indices exceeding 1, there may be some risk of incurring the adverse effect potentially caused by the pollutant. The more the Hazard Index exceeds 1, the greater the risk. In Table 1-11, we calculate Hazard Indices for each pollutant to suggest the non-cancer health effects risk it poses.

Estimated cancer and non-cancer risks from toxic air pollutants are shown in Table 1-11.

This table shows that 234 to 700 cancer cases per year over the entire Greater Cairo population may result from exposure to metals and to mobile source emissions of toxic organic air pollutants. Including toxic organic air pollutants from industrial and area sources would increase these estimates by up to about 50%, if U.S. experience provides a guide. In our view, though, other countervailing factors are more important and we believe this estimate is more likely to be a substantial overestimate than an underestimate. These estimates should be considered upper-bound estimates because they are based on EPA unit cancer risks that are intentionally extremely conservative[15] and on a conservative box model of pollutant mixing that ignores atmospheric decay and deposition. We believe that the cancer risks from toxic air pollutants are probably far smaller than the estimated 234 to 700 cases per year.

---

[15] EPA's unit cancer risks are described by the Agency as 95th percentile upper bound estimates. This means that the true potency of a chemical in causing cancer is 95% likely to be less than that reflected in the unit cancer risk and only 5% likely to be greater than the unit cancer risk. In effect, EPA's policy in developing unit cancer risk estimates is to avoid being wrong in underestimating the potency of a carcinogen. Many analysts have argued that a best estimate—as opposed to a conservative estimate—of the true unit cancer risk for a chemical would be one or more orders of magnitude less than EPA's unit cancer risk. The primary issue lies in the statistical procedure chosen by EPA for extrapolating the results obtained in experimentation on animals at high doses to situations where humans are exposed to low doses. For a discussion of this issue, see the appendix "Regulatory Impact Analysis Guidance," in U.S. Office of Management and Budget, Office of Information and Regulatory Affairs: Regulatory Program of the United States, August 21, 1990.

Two pollutants—chromium and manganese—have hazard indices exceeding one, and thus may pose some threat of non-cancer health effects. Exposure to chromium is well above its reference concentration. Other pollutants appear to raise no threat of non-cancer impacts.

Given the limited and exploratory nature of this analysis of air toxics in Cairo, we believe this issue deserves closer investigation.

INDOOR AIR POLLUTION

Although indoor air pollution has been studied very little in Cairo, the numerous studies around the world that have found it to pose high health risks suggest that it may be of concern in Cairo also. Some of the indoor air pollutants of most significance elsewhere are likely to be important in Cairo also: environmental tobacco smoke (ETS or "second-hand smoke"); pollutants from cooking stoves (CO, NOx, particulates); biological contaminants, such as molds, fungi, mites, and allergens; and household toxics, particularly pesticide sprays. ETS contains numerous carcinogenic compounds, some of which are mutagenic as well. ETS has been found in U.S. studies to be responsible for a similar number of cancer cases as from all carcinogens in outdoor air in total. Air in homes with ETS contains more mutagenic particles than either homes with wood-burning stoves or outdoor areas heavily trafficked by diesel vehicles. A high proportion of Egyptians smoke. Some types of allergens that are often associated with dust particles are likely a significant problem in Cairo, though tree and weed pollens are probably of less concern in Cairo than in more vegetated areas. Molds and other biological agents can multiply in the increasing proportion of Cairo's buildings that are closed and climate-controlled. Use of toxic pesticides in residences in Cairo is widespread to control house files, mosquitoes, fleas, cockroaches, etc. Abdel Gawaad (1994) presents a more extensive review of other indoor air pollutants of concern in Cairo.

Abdel Gawaad reported three studies on indoor air pollution in Cairo that deserve special mention. In one by Salem, numerous species of mites were found in Cairo house dust. Less than half as many mite species were found in the homes of healthy individuals as in the homes of those who were ill. Two other studies focused on the health impacts from indoor air pollutants associated with fuel combustion:

- Ali (1992b) found that residences equipped with gas- or kerosene-fueled appliances (cookers, heaters) often had indoor concentrations of nitrogen oxides and carbon monoxide exceeding outdoor ambient standards. In particular, burning kerosene indoors put inhabitants at high risk. Pollutant concentrations decreased with distance from the kitchen and decreased with better in-home ventilation.

- Ali (1989) studied indoor air in a village outside of Cairo that resembled the squatter settlements around Greater Cairo (Abdel Gawaad, 1994). This study also found elevated indoor concentrations of CO and NOx. Homes using biomass fuels showed much higher concentrations of these and other pollutants (carbon dioxide, ammonia, TSP) than those using gas cook stoves. Health problems were much more frequent in homes using biomass fuels: respiratory infections, asthma, eye infections, neonatal deaths, and low birth weight babies.

These findings suggest potentially serious risks from indoor air pollution in Cairo. On the other hand, several factors that often lead to high indoor air pollution risks elsewhere—airtight buildings, extensive use of toxic consumer products and building materials (e.g., solvents, paints, pesticides, asbestos, urea-formaldehyde insulation), and a long heating season—are not really typical of Cairo. We might speculate that these mitigating factors will diminish in importance as Cairo develops economically over time. Rising incomes will bring greater use of air conditioning in tighter, enclosed buildings and perhaps more consumer purchases of modern products containing toxic materials.

Indoor air pollution may pose significant health risks under some circumstances in Cairo presently, and risks will likely increase in the future. Further study on this issue would clarify its importance.

REFERENCES

Abdel-Gawaad, 1994. Abdel-Gawaad, A.A. Ranking Environmental Health Risks in Cairo, Egypt. Background paper for the Cairo CRA. January, 1994.

Ali, 1989. Ali, O.F., El-Sayed El-Sherif, M.A. El-Sherif, and Saad N. Motawea. "Indoor Air Quality and Human Exposure Assessment in an Egyptian Village." Egyptian Journal of Occupational Medicine. 13.2:161-170.

Ali, 1990. Ali, Esmat A. "Studies on Air Pollution in the Industrial Region North of Cairo," in Egyptian Journal of Occupational Medicine 14.2(1990):203-210.

Ali, 1992a. Ali, Esmat A. "Toxic Effects of Industrial Pollution on Vegetation and Their Use as Bioindicators," in Journal of the Egyptian Society of Toxicology 8(1992):107-112.

Ali, 1992b. Ali, Esmat A. "Combustion of Air Pollutants in Cairo Houses" Egyptian Journal of Occupational Medicine. 16.2:141-46.

CAPMAS, 1993. Central Agency for Public Mobilization and Statistics. Statistical Year Book June 1993. Cairo.

Chestnut and Rowe, 1988. Chestnut, Lauraine G., and Robert D. Rowe. (RCG/Hagler, Bailly, Inc.). "Ambient Particulate Matter and Ozone Benefit Analysis for Denver," Draft Report prepared for U.S. EPA, January, 1988.

EEAA, 1993. Egyptian Environmental Affairs Agency, Technical Cooperation Office for the Environment. "Project Proposal: Vehicle Inspection Centers and Licensing System." Proposal to the World Bank, February 25, 1993.

El Kotb, 1987. El Kotb, M.M., and Gary Borman. "Air Pollution From Motor Vehicles in the City of Cairo." Foreign Relations Coordination Unit, Supreme Council of Universities, Progress Report no. 11, 1987.

El-Samra, 198?. El-Samra, G.H. "Health Effects of the Environmental Pollution by Automobile Exhaust in Different Cities in Egypt." Foreign Relations Coordination Unit, Supreme Council of Universities, Progress Report no. 3, 198?.

Emara, 198?. Emara, A.M. "Health Effects of the Environmental Pollution by Automobile Exhaust in Different Cities in Egypt." Foreign Relations Coordination Unit, Supreme Council of Universities, Progress Report no. 4, 198?.

EQI, 1991. Environmental Quality International. "Assessment of Environmental Problems in Egypt." Submitted by EQI to Japan International Cooperation Agency, 1991.

Evans, 1984. Evans, J.S., T. Tosteson, and P.L. Kinney. "Cross-Sectional Mortality Studies and Air Pollution Risk Assessment." Environment International 10(1984):55-83.

Gamble, 1987. Gamble, J., W. Jones, and S. Minshall. "Epidemiological-Environmental Study of Diesel Bus Garage Workers: Acute Effects of NO_2 and Respirable Particulate on the Respiratory System." Environmental Research 42(1987): 201-214.

GOE, 1992. Government of the Arab Republic of Egypt, Egyptian Environmental Affairs Agency. Environmental Action Plan. May, 1992.

Haemisegger, 1985. Haemisegger, E., A. Jones, B. Steigerwald, and V. Thompson. The Air Toxics Problem in the United States: An Analysis of Cancer Risks for Selected Pollutants. Prepared for U.S. EPA Office of Air and Radiation, and the Office of Policy, Planning and Evaluation. EPA-450/1-85-001. May, 1985.

Hasselblad, 1992. Hasselblad, V., D.M. Eddy, and D.J. Kotchmar. "Synthesis of Environmental Evidence: Nitrogen Dioxide Epidemiology Studies." Journal of the Air and Waste Management Association 42(1992):662-671.

Hayes, 1989. Hayes, S.R., A.S. Rosenbaum, T.S. Wallsten, R.G. Whitfield, and R.L. Winkler. "Acute Ozone Exposure-Response Relationships for Use in Health Risk Assessment." Presented at the Annual Meeting, Society for Risk Analysis, October 29 - November 1, 1989.

MOH, 1993. Ministry of Health, Information and Documentation Center. "Basic Health Statistical Data," February, 1993.

MOI, 1992. Ministry of Industry, General Traffic Department, Statistics Department. Statistical Report on Motor Vehicles Registered in Egypt, August 31, 1992.

Nasralla, 1981. Nasralla, M.M., and A.A. Shakour. "Nitrogen Oxides and Photochemical Oxidants in Cairo City Atmosphere." Environment International. 5(1981):55-60.

Nasralla, 1984. Nasralla, M.M., and A.A. Shakour. "Auto-Exhaust Emissions of Hydrocarbons and Nitrogen Oxides into Cairo Atmosphere." 2nd Egyptian Congress of Chemical Engineers, March 18 - 20, 1984.

Nasralla, 1985. Nasralla et al. (GOM and NRC). Atmospheric Pollution and Deterioration of the Sphinx. 1985 (Arabic).

Nasralla et al, 1986. Nasralla, M.M., A.A. Shakour, and E.A. Ali. "Particulate Matter in the Cairo Atmosphere. 1. Dustfall and its Chemical Constituents," in Environment International 12(1986):587-591.

Nasralla, 1991a. M.M. Nasralla, editor. "Air Pollution and Noise in the Egyptian Environment." Report for the Egyptian Environmental Affairs Agency in support of the Environmental Action Plan. November, 1991.

Nasralla, 1991b. Nasralla, M.M. "Impact of Shoubra El-Kheima Electricity Power Station on the Environment of the Surrounding Residential Area." Draft Report, May, 1991.

Nasralla, 1991c. Mahmoud M. Nasralla and Esmat Abd el-Shakour. "Air Pollutants in the Helwan Industrial Area," in Environmental Affairs Agency and General Organization for Industrialization: Industrial Environmental Map Progress Report. (Friedrich Ebert Stiftung, 1991).

Nasralla, 1993a. Nasralla, M.M. Air Pollution in Greater Cairo. Background Paper for the Cairo CRA. December, 1993.

Nasralla, 1993b. Nasralla, M.M. "Air Pollution," in Rouchdy Saleh, editor. Egyptian Environment ... An Overview. Cairo: Embassy of Canada. April, 1993.

OECD, 1993. Organization for Economic Co-operation and Development, Environment Directorate. Risk Reduction Monograph No. 1: Lead. Background and Experience With Reducing Risk. Paris, 1993.

Ostro, 1987. Ostro, Bart D. "Air Pollution and Morbidity Revisited: A Specification Test." Journal of Environmental Economics and Management. March, 1987.

Ostro, 1994. Ostro, Bart D. "Estimating Health Effects of Air Pollution: a Methodology with an Application to Jakarta." Paper for the World Bank, March, 1994.

Samet, 1993. Samet, J.M. et al. "Health Outcomes" in Nitrogen Dioxide and Respiratory Illness in Children, part I. Cambridge, MA: Health Effects Institute; research report No. 58, 1993.

Schwartz and Marcus, 1986. Schwartz, Joel, and A.H. Marcus. "Statistical Reanalysis of Data Relating Mortality to Air Pollution During London Winters 1958 - 1972." Presentation to EPA Clean Air Science Advisory Committee. Research Triangle Park, North Carolina. December, 1986.

Shakour, 1992. Shakour, A., M.M. Nasralla, M.I. Mohamed, and M.A. Hassanien. "Effects of long-term exposure of lead and cadmium on cholinergic enzymes." International Journal of Environmental Health Resources 2(1992):138-146.

Sullivan, 1988a. Sullivan Environmental Consulting, Inc. Preliminary Plans of Attack (POAs) for Air Toxics / Region III and Pennsylvania Studies. Memorandum to Art Koines and James Hembey from David Sullivan. March 8, 1988.

Sullivan, 1988b. Sullivan Environmental Consulting, Inc. Results of county-by-county air toxic analyses for the Comparative Risk Project. Memorandum for Distribution from David Sullivan. May 30, 1988.

USEPA, 1982. U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office. Air Quality Criteria for Particulate Matter and Sulfur Oxides. (EPA-600/8-82-029a). December, 1982.

USEPA, 1985. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Compilation of Air Pollutant Emission Factors, Vol. 2: Mobile Sources. (AP-42). 1985.

USEPA, 1986. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Review of the National Ambient Air Quality Standards for Sulfur Oxides: Updated Assessment of Scientific and Technical Information, Addendum to the 1982 OAQPS Staff Paper. (EPA 450/05 86-013). December, 1986.

USEPA, 1986a. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment. Second Addendum to Air Quality Criteria for Particulate Matter and Sulfur Oxides (1982): Assessment of Newly Available Health Effects Information. (EPA/600/8-86/020F). December, 1986.

USEPA, 1987. U.S. Environmental Protection Agency, Office of Mobile Sources, Emission Control Technology Division. Air Toxics Emissions from Motor Vehicles. (EPA-AA-TSS-PA-86-5).

USEPA, 1992. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Review of the National Ambient Air Quality Standards for Carbon Monoxide: Assessment of Scientific and Technical Information. (EPA-452/R-92-004). August, 1992.

USEPA, 1993. U.S. Environmental Protection Agency, Office of Mobile Sources, Emission Planning and Strategies Division. Motor Vehicle-Related Air Toxics Study. (EPA-420-R-93-005). April 1993.

USEPA, 1994. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Revision to Criteria Document for Nitrogen Oxides. Chapter 16, in draft.

WHO/UNEP, 1992. World Health Organization and United Nations Environment Programme. Urban Air Pollution in the Megacities of the World. Oxford, Blackwell: 1992.

Whitfield, 1991. Whitfield, R.G., T.S. Wallsten, R.L. Winkler, H.M. Richmond, S.R. Hayes, and A.S. Rosenbaum. "Assessing the Risk of Chronic Lung Injury Attributable to Long-Term Ozone Exposure." Argonne National Laboratory, Argonne, Illinois. July, 1991.

World Bank, 1992. Norconsult International. Environmental Assessment and Screening of the Helwan Area, Egypt, Draft Report for the World Bank. June 1992.

ANNEX B

HEALTH RISKS FROM WATER POLLLUTION

ANNEX B
HEALTH RISKS FROM WATER POLLUTION

This annex summarizes the data and calculation procedures we have used in estimating the health risks from exposure to water pollution in Greater Cairo. Much of the data on levels and sources of water pollution in Cairo come from the background paper written by the water pollution consultant for this project, Dr. Fatma El-Gohary (El-Gohary, 1993). Her background paper is reproduced later in this volume as Annex H. Dr. El-Gohary is Professor of Water Pollution Control and Director of the Environmental Sciences Division of the National Research Centre in Cairo. She has been active in water pollution research in Egypt since the early 1960's.

Polluted water may cause health risks in Cairo by several means. Most obviously, risks can arise when individuals drink contaminated water. The contamination may derive from the raw water supply, it may be added during the treatment process, or it may enter inadvertently in the water distribution system, during storage, or in the home. Health risks may also arise from direct contact with contaminated water while individuals are working, washing, or swimming in it. Water pollution may also cause human health risks through several less direct pathways, including consuming food crops irrigated with contaminated water, or consuming fish that have bioaccumulated pollutants while living in contaminated water. Each of these different risk pathways has been investigated separately.

BACKGROUND ON WATER POLLUTION IN CAIRO

The Nile River meanders about 6,650 kilometers through six countries from its headwaters in Burundi to the Mediterranean Sea. The last 1,600 kilometers of this journey are through Egypt. Cairo is situated immediately upstream of the Nile Delta about 250 kilometers from the Mediterranean Sea. The Nile River and its alluvial aquifer meet all of Cairo's freshwater demand, including that for human daily use (consumption and domestic uses), agriculture, and industry. Just as the Nile River is the primary source of fresh water, it is also the primary receptor of wastewater and drainage generated by domestic, industrial, and agricultural activities.

Surface Water Quality in the Nile at Cairo

Upstream of Cairo, the Nile receives large flows of mostly untreated domestic, agricultural, and industrial wastewaters (Welsh, 1992). Between the Aswan High Dam and Cairo, 43 towns with populations exceeding 50,000 and approximately 1,500 villages discharge their wastes to the river. Only eight wastewater treatment facilities treating about 0.3 million m^3 of wastewater per day existed in this area as of 1992. Most of the residents in this area depend on irrigated agriculture for their livelihood, and 2.3 billion m^3 of drainage water loaded with fertilizers, pesticides, and organic material is returned to the Nile annually in Egypt upstream of Cairo. Industry is less prevalent upstream of Cairo than in the Greater Cairo area or downstream, but 35 major factories discharge about 125 million m^3 /year of industrial wastewater with little treatment (El-Gohary, 1993).

With such large upstream pollution loads, one might expect the Nile at Cairo to be highly polluted. But it is not, mostly because the Nile has a large flow ranging from 80 to 150 million cubic meters per day at Cairo. For comparison with this flow, Greater Cairo generates daily 2 - 3 million cubic meters of domestic sewage and 0.2 million cubic meters of industrial effluents daily (El-Gohary, 1993). (Most of Cairo's wastewater flow is not in fact discharged to the Nile, but is conveyed through drains all the way to the Mediterranean Sea, as will be discussed subsequently.)

The quantity of water in the Nile has been recorded since the Pharonic period. Water quality monitoring programs were initiated by various organizations as early as 1976. These programs collected samples at numerous points along the Nile from the Aswan High Dam to the Delta. Monitoring frequency ranged from monthly to annually. The early monitoring programs analyzed samples for conventional pollutants including temperature, pH, total dissolved solids (TDS), nutrients, dissolved oxygen (DO), biological oxygen demand (BOD), and chemical oxygen demand (COD). Table 2-1 summarizes the results of monitoring in 1976 - 1977 at Cairo. Water quality appeared good, with dissolved oxygen levels exceeding 7 mg/l to support a full range of aquatic life, and BOD, COD, and nitrate levels low suggesting modest impact of pollution from humans. Table 2-2 shows data for 1988 at several locations in Greater Cairo. Water quality again seemed generally good, with some deterioration evident since 1976, particularly for BOD. This deterioration over time is confirmed by monitoring over the entire Nile in Egypt during the decade from 1976 - 1985. During this period, a multi-parameter index for the quality of Nile water declined significantly, due to increased industrial and agricultural discharges (DRI, 1989).

Table 2-1. Nile River Water Quality at Cairo, 1976 - 1977

CONSTITUENT	CONCENTRATION RANGE
Temperature, °C	13 to 29
Turbidity (Silica Scale), mg/l	10 to 100
Total suspended Solids (105°C), mg/l	5 to 60
Total Dissolved Solids (105°C), mg/l	170 to 300
pH	7.9 to 8.4
Total Alkalinity (as $CaCO_3$), mg/l	110 to 140
Total Hardness (as $CaCO_3$), mg/l	100 to 120
Calcium, mg/l	18 to 28
Magnesium, mg/l	9 to 15
Chlorides (Cl), mg/l	16 to 28
Sulfates (SO_4), mg/l	15 to 27
Fluorides (F), mg/l	0.1 to 0.2
Ammonia (N), mg/l	Not detected
Nitrate (N), mg/l	Note detected
Nitrate (N), pg/l	5 to 800
Silicate (SiO_2), mg/l	4 to 8
Total Organic Nitrogen (N), mg/l	0.4 to 1.5
Dissolved Oxygen, mg/l	7.2 to 9.2
BOD (5-day, 20°C), mg/l (Filtered samples)	1.5 to 3.0
COD, mg/l	8 to 30
Phenols, pg/l	2 to 300
Chlorpphyll a, pg/l	6.3 to 25.3
Total Algal Count, cells/l	10^3 to 10^4

Source: El-Gohary, 1993

Table 2-2. Analysis of Water Samples in Greater Cairo, 1988

Waterways in Governorate	Sampling Sites	Date	Results of Analysis (mg/l)						
			PH	TDS	DO	BOD	COD	Nitrate	Fecal Coli. (MPN/100 ml)
River Nile - main stream	Maadi	Sept. 1988	7.8	230	7.9	10.0	20	nil	990
Damietta Branch	Roda	"	8.0	236	7.7	11.0	20	0.01	1,100
Rosetta Branch	Imbaba	"	7.8	230	7.6	9.5	17	nil	1,600
Ismailia Branch	Shoubra El-Kheima	"	7.8	230	7.9	9.4	18	0.05	1,000

The earliest monitoring data regarding fecal coliform that we obtained were for ten drain outfalls in the Nile through Cairo in 1984 (Youssef, 1985). Levels ranged from 300 to 1600 MPN per 100 milliliter. These levels indicate moderate contamination from human sewage. The sampling points, however, likely reflected the quality of water in the drains more than it did the Nile generally. The data from 1988, in Table 2-2, showed slightly higher levels of fecal coliform—990 - 1600 MPN per 100 milliliter—but they also were obtained for drain outfalls.

Data for conventional water quality parameters since 1988 show a variable pattern over time. Welsh (1992) provides graphs showing dissolved oxygen, BOD, and fecal coliform at different locations on the Nile for several years. At some locations one or more of the parameters has improved over time, while at other locations there has been a deterioration. There is no consistent pattern. The most recent data for a Nile site at Cairo in 1991 show dissolved oxygen still at about 7 mg/l, BOD at about 14 mg/l, and fecal coliform slightly below 1,000 MPN per 100 milliliters.

Very little monitoring has been done for toxic pollutants (e.g., heavy metals, pesticides, synthetic organic compounds) in the Nile. Organophosphorus, organochlorine pesticides, and PCBs were sampled over three months during 1979 at several Nile locations, including Cairo (Badawy, 1982, summarized in El-Gohary, 1993. Also, unpublished summary data tables obtained from El-Gohary). This monitoring program also measured the levels of organochlorine insecticides in Nile fish from 8 locations, including Cairo (Aly and Badawy, 1982, summarized in El-Gohary, 1993). These insecticides were also sampled in 1985 in fish from Beni-Suef, upstream from Cairo (summarized in Abdel Gawaad, 1994). Metals have been sampled on several occasions, and typical concentrations in the Cairo vicinity are summarized in El-Gohary (1992). The most recent and probably most representative data on metals comes from sampling by the Cairo Water Authority (CWA) of intake water for their drinking water treatment plants. Over 90% of Cairo's drinking water is drawn from the Nile. Since most of the water intake points are located midstream, these data are expected to represent ambient water quality for well mixed portions of the Nile as it passes through Cairo. We were provided with the CWA monthly sampling data for 1992 for intake water at each of Cairo's 12 major water treatment plants. We averaged the monthly data to obtain an annual average, and then flow-weighted the data from each treatment plant to obtain an average across all the plants. The data from these sources on toxic pollutants in Nile water at Cairo and in fish are summarized in Tables 2-3 and 2-4.

Table 2-3. Toxic Pollutants in the River Nile at Cairo in ug/l

Pollutant		Mean Level	Data Source	Mean Level	Data Source
Pesticides	Lannete	1.700	Badawy, 1982	All pesticides "Not Detected" (detection limit unknown)	CWA, 1992
	Dursban	0.007			
	Hostathion	0.510			
	Curacron	0.730			
	Gardona	0.450			
	Atrazine	0.287			
	Lindane	0.002			
	Endrin	0.001			
	Chlordane	-			
	DDT	-			
	DDD	0.002			
PCBs		0.029	Badawy, 1982		
Metals	Cadmium	0.02-0.8	El-Gohary, 1992	0.40	CWA, 1992
	Chromium	0.01-4.1		1.13	
	Cobalt	0.01-4.6		NA	
	Copper	0.0-11.0		6.16	
	Lead	0.01-2.0		5.85	
	Zinc	0.01-28.0		NA	
	Mercury	NA		0.17	
	Manganese	NA		79.43	
	Nickel	NA		2.26	

Table 2-4. Pesticides in Nile Fish

POLLUTANT	MEAN LEVEL (UG/KG)	DATA SOURCE
Sum DDT	86.6	Aly and Badawy, 1982
Endrin	19.6	
Lindane	86.6	
Aldrin	10	Abdel Gawaad, 1994 (Nile catfish)
DDD	460	
DDE	485	
DDT	720	
Dieldrin	70	
Heptachlor	122	
Heptachlor epoxide	950	
Hexachlorobenzene	56	
Lindane	127	
Oxychlordane	20	
Aldrin	-	Abdel Gawaad, 1994 (Nile bolti fish)
DDD	440	
DDE	120	
DDT	-	
Dieldrin	590	
Heptachlor	263	
Heptachlor epoxide	10	
Hexachlorobenzene	90	
Lindane	123	
Oxychlordane	50	

Ground Water Quality in Cairo

Ground water in the Greater Cairo area comes entirely from a semi-confined highly permeable sandy aquifer that underlies the Nile Valley. Pliocene clays underlie this stratum. On the West Bank, it is capped with a low permeability silty clay surface layer that functions as an aquiclude impeding downward flow and offering some protection from leaching of agricultural chemicals and wastewater constituents. On the East Bank the silty surface is more permeable.

Ground-water quality varies widely within a single well field and between fields. The parameters most often of concern include: total dissolved solids, total hardness, chlorides, iron, and manganese. These are generally of concern for aesthetic rather than health reasons. Bacteriological contamination in some shallow wells in unsewered areas is also a problem (El-Gohary, 1993).

A detailed study of water supply and sanitation in Giza surveyed ground water throughout the governorate and found it to be of good quality except for concentrations of iron and manganese. These contaminants impart an undesirable taste and odor to the water. In addition, bacteriological testing found occasional contamination. Unsanitary conditions at the well fields raised questions regarding whether the water supply is contaminated at the source or from the well bore (AE/ECG, 1988). Levels of contamination were not quantified.

On the East Bank, some ground water samples in the Helwan Industrial area contained several parameters suspected to be of industrial origin, including cyanide and phenol (Norconsult, 1992).

Domestic Wastewater Collection and Treatment

Only 10 years ago Cairo's antiquated sewage system was plagued by overflows that swamped streets and homes with raw sewage. In the mid-1970's, over 100 sewage flooding incidents were reported daily. These localized, though persistent, overflows were the result of domestic and industrial discharges that overloaded the capacity of the conveyance system. They were caused in part by improvements in water supply that surpassed the capacity of the wastewater collection system. The Egyptian Government and international donors have financed massive upgrades to the collection and treatment system. A 1988/89 survey of the impact of these upgrades reported that of the 67 chronically flooded neighborhoods covered by the first major project (Cairo Sewerage I), 83 percent no longer experienced major incidents and 65 percent no longer report any flooding (USAID, 1992).

As of late 1993, there were four operating wastewater treatment plants serving the greater Cairo area: Zenein and Abu Rawash on the West Bank and Berka and Helwan on the East Bank. Two more plants, Shoubra El Kheima and Gabal el Asfar, are under construction in northeast Cairo. All plants with the exception of Abu Rawash will eventually provide secondary treatment. Currently, the Zenein plant on the West Bank provides secondary treatment and achieves a 95 percent removal efficiency (Taylor Binnie; 1992). Helwan also provides secondary treatment now, while the Berka plant's secondary treatment facilities will be operating soon. The new plants under construction on the East Bank will provide secondary treatment when completed. Table 2-5 summarizes the current status and planned treatment capacity for each plant by 1995 (El Gohary, 1993). None of the six plants discharge to the Nile near Cairo. Three plants will discharge through agricultural drains to the Northern Lakes and the Mediterranean, while the effluent from two plants will be used largely for desert irrigation and reclamation. Only one plant will discharge eventually to the Nile, through an agricultural drain downstream to the Rosetta Branch. Cairo's domestic wastewater is therefore nearly completely conveyed away from the metropolitan area.

Table 2-5. Status of Cairo Waste Water Treatment Plants in Late 1993

		TREATMENT	EVENTUAL CAPACITY (M^3/DAY)	STATUS	DISCHARGE
East Bank	Shoubra El-Kheima	2°	600,000	Under construction.	To drain to Mediterranean
	El-Berka	1°	600,000	1° operating now, receiving 300,000 m^3/day. 2° on line very soon.	To drain to Mediterranean
	Gabar El-Asfra	2°	1,000,000	Under construction. Ready 1996.	To drain to Mediterranean
	Helwan	2°	300,000	Operating. Receiving only 100,000 m^3/day because most industry in Helwan is not allowed to connect without pretreatment.	Used for land reclamation in the area.
West Bank	Zenein	2°	330,000	Operating well. Recently rehabilitated. Excessive flow of roughly 270,000 m^3/day now goes to Abu Rawash.	To agricultural drain to Rosetta Branch.
	Abu Rawash	1°	400,000	Operating. No plans for upgrade to 2°.	Some to agricultural drain, some used for irrigation.

Estimating the proportion of population connected to the sewer system is difficult given the rapid growth in Cairo and, in particular, the growth of the informal sector. In 1986, an Unsewered Areas Project was initiated to identify unsewered areas and quantify the number of people residing in them. The identification survey found that the total unsewered population within Cairo was at least 1,738,000 (AMBRIC, 1987). Using total population figures from the 1986 census, this represented over 15 percent of the population of greater Cairo (CH2MHill, 1990). An estimated 60 percent (1,100,000) of the unsewered population lived on the West Bank, about 36 percent (620,000) lived on the East Bank, and the remaining 1 percent (18,000) resided on the Nile River islands. Given the rapid and chaotic growth in Cairo, these distributions have likely shifted since 1986. In fact, a joint USAID - CWA West Bank unsewered areas project was recently attributed with letting out contracts that will result in the connection of 2.2 million more people to the West Bank sewage network (AMBRIC, 1992). A 1989 review estimated that about 3/4 of Cairo's population was sewered (Bedding, 1989). A 1991 analysis by AMBRIC based on flows through the sewerage system and estimates of per capita sewage generation rates found the sewered population in 1990 to be 8.3 million, or 72% relative to the Greater Cairo population of about 11.5 million. For the purposes of calculations later in this report, we will assume that 75% of the population of Greater Cairo is now sewered.

In unsewered areas, vaults and seepage pits are the most common means of collecting sanitary wastes. When these are filled or clogged they may be pumped out for a fee by a pump truck, or emptied manually using buckets. The unsanitary conditions surrounding this activity pose a substantial health threat to residents and to those making a living emptying the vaults (AMBRIC, 1987).

While most of the discharges to the sewage collection system are from domestic sources, industries in Greater Cairo discharge an estimated 56 million m^3/year to the collection system (Taylor Binnie, 1992). As the system is upgraded and the construction of secondary treatment completed, more industries are expected to wish to connect to the sewer system for wastewater disposal. Industries are required, however, to meet discharge limits for certain parameters before they can discharge into the sewer system. A 1992 survey of 48 industrial facilities found that 40%, representing 75% of the flow, had some type of effluent treatment. In some instances, though, it was evident that the treatment units had not been used for some time (Taylor Binnie, 1992).

These studies reported that most of the industrial discharges that could adversely affect the collection system or treatment plants are sufficiently diluted within the sewage system. However localized problems that threaten the health and safety of the workforce and integrity of the collection system were identified. GOSD data from 1992 showed that four pumping stations had levels of settleable and suspended solids high enough to increase the likelihood of blockage within the conveyance system and potentially interfere with treatment at the treatment plants. These pump stations also had levels of BOD and COD that were indicative of wastewaters that can deteriorate the collection system and overload treatment plant operations. Industrial discharges also impact the suitability of treated wastewater and sewage sludge for reuse. Heavy metals, in particular, concentrate in sewage sludge.

Though effluents from the wastewater treatment plants are periodically monitored, only limited data were obtained for this study. Six months of data on the quality of the effluent discharged from Abu Rawash was provided. This data provided analytical results for conventional parameters including temperature, pH, TSP, volatile solids, DO, and BOD. The effluent quality of Abu Rawash is indicative of a well operated primary treatment plant, achieving a 75% removal efficiency for suspended solids. However, no data was available on the concentrations of metals, pathogens, or persistent organic chemicals in the final effluent.

Industrial Waste Water

Cairo has been one of several industrial centers in Egypt since the early part of the 19th century. Industrial facilities vary greatly in age and operating condition. In Greater Cairo, 75% of the industries are owned by the public sector and 25% are privately owned (El Gohary, 1993). While 80% of the publicly owned facilities are under the jurisdiction of the Ministry of Industry, several other Ministries control the remaining 20%.

The public sector industries in Greater Cairo consist of 23 chemical, 27 textile, 7 metal, 23 food, 29 engineering, and 9 mining operations. These industries use a combined sum of 162 million m^3 of fresh water per year and discharge 129 million m^3 per year. Each day they discharge 0.75 tons of heavy metals, 93 tons of oils and lubricants, and 97 tons of suspended matter (El Gohary, 1993).

There are three major industrial zones on the periphery of Cairo City: Shoubra El-Kheima, Helwan, and Imbaba. Shoubra El-Kheima and Helwan have been studied extensively. There are also an estimated 800 small scale industrial facilities operating in and around Cairo, and many of them are located in residential areas (El-Gohary, 1993). In addition, industries are locating new facilities in the new satellite communities developing at the boundaries of the Greater Cairo area.

The Helwan area is a large industrial complex south of Cairo with most of the area's heavy industrial operations, including, iron and steel, metal working, smelting, and cement production. There are also some textile and chemical factories. Industries in Helwan discharge their effluents into drains, desert lagoons, or the Nile River. They will be allowed to discharge into the Helwan wastewater treatment plant after they achieve an acceptable degree of pretreatment.

Shoubra El-Kheima is a heavily industrialized area north of Cairo on the East Bank. Various factories located in the area include textiles, glass, wire cable, electric appliances, cement pipes, and metal foundries. Industries in Shoubra El-Kheima discharge to drains flowing to the Mediterranean to the northeast. These drains are heavily polluted. Sampling results reveal water quality characteristics closer to medium strength sewage than surface water.

Imbaba is the site of the largest concentration of industry on the West Bank. Industrial operations include textiles, metal products, print shops, paints, enameling, and a shipyard. These facilities discharge mostly to the sewer system. There is another large industrial complex on the West Bank south of Cairo in Hawamdia. This facility, formerly notorious for its high strength discharge, carried out a research and development program to identify saleable byproducts that would allow the elimination of wastewater discharges. Currently this sugar refining complex only discharges cooling water to the Nile River (Taylor Binnie, 1992).

Numerous smaller scale industries are located throughout Greater Cairo, on both sides of the Nile River. It is assumed that many of these discharge to the sewer system. These facilities include tanneries, gasoline stations, garages, bakeries, marble and tile factories, and weaving and dyeing operations. Discharges from some of these facilities are already impacting the sewer system. It has been suggested that the small facilities are responsible for 30% of the flooding in the city's streets (El Gohary, 1993).

Industrial discharges present a variety of problems which have been described in detail in the industrial effluent study commissioned by METAP and in the El-Gohary background paper. Examples of problems posing the greatest concern include (El-Gohary, 1993):

- Oil at 57,300 mg/l from the bus depot in Zeitoon;
- Suspended solids at 17,700 mg/l from a glue factory;
- Ammonia at 600 mg/l from a glue factory;
- BOD at 16,200 mg/l from a brewery in Giza;
- Chromium at 85 mg/l from the tanneries district;
- Grease at 327 mg/l from the tanneries district;
- Suspended solids at 3,700 mg/l from the tanneries;
- Detergent at 2,160 mg/l from a chemical factory;
- pH between 0.67 and 1.3 from iron & steel and galvanizing;
- pH at 12.6 from a concrete products facility; and
- Iron at 4,000 mg/l from a steel pipe and fitting factory.

Similarly as for the sewage treatment plants, the impact of Cairo's industrial discharges on health and the environment is substantially reduced by the fact that many of them are routed away from the Nile and away from the metropolitan area in industrial drains or domestic sewers.

HEALTH RISKS FROM DRINKING WATER

Nearly all residents of Greater Cairo receive treated drinking water in individual connections in their homes. The water utility serving Greater Cairo is the General Organization for Greater Cairo Water Supply (GOG), also known as the Cairo Water Authority (CWA). CWA operates 16 water treatment plants producing about 3.5 million cubic meters of potable water each day. Twelve plants serve the East Bank, which includes the City/Governorate of Cairo and the portion of Kaliobeya in Greater Cairo, and four plants serve Giza on the West Bank. Most of the water supply is withdrawn from intake points in the middle of the Nile, with additional ground water sources providing about 8 percent of the supply. Table 2-6 shows the volume of water treated at each plant and its source.

Table 2-6. Drinking Water Treatment Plants in Greater Cairo, 1992-93

NAME	QUANTITY OF WATER PRODUCED/YEAR (MILLION M^3)			AVERAGE QUANTITY OF WATER PRODUCED/DAY (THOUSAND M^3)
	SURFACE	WELL	TOTAL	
T. Elasmant	0.19	-	0.19	0.52
S. Elkhema	-	2.54	2.54	6.95
El Marg	0.00	19.00	19.00	52.06
El Maadi	20.87	-	20.87	57.17
K. El Elw	27.78	-	27.78	76.11
Helwan	28.72	-	28.72	78.67
Elltebben	35.48	-	35.48	97.20
Giza	48.78	-	48.78	133.65
Elroda	52.93	-	52.93	145.02
G. Eldahab	80.74	23.61	104.35	285.90
Warrak	113.20	-	113.20	310.14
Ameria	110.33	7.75	118.08	323.51
Fostat	121.56	-	121.56	333.04
Mostorod	237.84	40.38	278.22	762.24
Rod Elfarag	276.00	3.49	279.49	765.72
Total	1,154.23	96.77	1,251.00	3,427.92

Typical treatment at the CWA's plants begins with chlorination. Next, alum or other flocculants are sometimes added to remove iron and manganese, particularly where ground water is used. The water is then clarified, chlorinated again, passed through sand filters, and rechlorinated. The finished water then flows to storage or to pump stations for distribution. At this point, as it enters the distribution system, Cairo's drinking water is nearly always clean.

Problems in the water distribution system, however, lead to erratic water supplies and/or contamination entering the drinking water in some areas of the city.

Much of the system has inadequate capacity for storing water, reducing the opportunity to produce water during low demand periods and distribute it during peak demand. While the transmission main network is generally adequate, the distribution piping is often too small and poorly looped, resulting in excessive pressure loss in some areas before the water reaches the consumer. The distribution system is comprised of piping of numerous materials from a variety of sources and, in the older areas of the city, it has deteriorated significantly. These factors further limit the pressure at which water can be pumped through parts of the network. The result is erratic water pressure and occasionally unreliable supply to residences in various areas.

Leaky distribution mains in combination with low water pressure present an additional hazard. Pollution from contaminated ground water or sewage from leaking drains and sewers may enter the drinking water distribution system through damaged joints or pipe fissures when the water pressure drops (Abdel Gawaad, 1994).

To compensate for erratic water supply, many buildings have been equipped with pumps and holding tanks. Unfortunately, pumping water from the distribution system creates negative pressure, increasing the likelihood of infiltration of ground water and sewage into the drinking water pipes. In addition, many of the tanks are open and subject to atmospheric deposition, birds, and animals, providing another means for contamination to enter the water.

Ongoing system upgrades are improving the reliability of the system and reducing opportunities for contamination of the drinking water after treatment. Water leakage from the distribution system—a good indicator of the integrity of the system—has been reduced from an estimated 12% in 1987 to 11.5% in 1990, and is projected to decline to 9.5% in the year 2000 (CH2MHill, 1990). Increased supply capacity is being added, additional reservoirs are being planned, pump booster stations are being constructed to improve pressure, and new transmission systems are being installed to accommodate growth. Improvements that were planned or completed at the time of the 1990 Master Plan update are expected to provide enough capacity to meet current demands.

It is not known with certainty what fraction of Greater Cairo's population receives water in the home through this system. CWA officials cited an estimate of over 90 percent. A USAID water supply expert suggested 95 percent. A 1990 study estimated that a mere 1.4 percent (almost 100,000 people) of East Bank residents were served by public fountains rather than individual household connections (CH2MHill, 1990). El-Gamal (personal communication, 1994) believes that such figures may be accurate in showing more than 90% of the population with a water connection to their building, but that many buildings served may not have indoor plumbing that further distributes the water to individual apartments. He also notes that water service is often erratic and discontinuous in terms of pressure, hours of service, and volume. Interrupted service during peak hours is a common complaint. Many residents must store water in bathtubs in the evening for use in the morning when supplies are less reliable. Abdel Gawaad (1994) confirms this picture, and estimates that 23% of Greater Cairo inhabitants lack access to safe and adequate water supplies. He believes that:

> Official figures for the numbers of people adequately served often overstate the number actually served. For instance, they may assume that all those with water taps in their settlements are adequately served, but there are often so few communal water taps that people have to wait for a long time in queues and this tends to reduce water consumption to below what is needed for good health in some settlements in old Cairo. In some settlements where there is no piped water the people buy the water through unsafe containers at very high prices. Piped water systems in many settlements also function only intermittently for a few hours a day, which makes it especially difficult for households relying on communal taps.

For purposes of analysis associated with this project, we have assumed that 90% of the Greater Cairo population is served by in-home water connections.

Individuals relying on a neighborhood standpipe for water will typically use much less water than will individuals with a connection in their home. Water must be transported from the standpipe to the home (often by hand in buckets) and then stored. Per capita domestic consumption in 1990 was estimated at 56, 181, and 249 liters per day for low, medium, and high income groups with household connections to the distribution system. In contrast, individuals relying on standpipes used an average of only 40 liters per day (CH2MHill, 1990). Water vendors are also common in areas poorly served by piped water. Vendors might deliver 20 liters per day to a household at a cost of about one L.E., a cost sufficiently high to significantly deter water use (Dr. John Hoehn, consultant to USAID/Cairo, personal communication, 1994). Reduced availability of water for those without household connections reduces opportunities for cleaning, washing, bathing, and other sanitary practices. Transportation and storage of water also provide opportunities for contamination of the water. Reduced availability of water and increased likelihood of its contamination significantly increase the risks of many infectious diseases for residents without an in-home potable water connection. (See Annex F: Health Risks from Microbiological Diseases.)

Estimating Health Risks from Drinking Water Contamination

To estimate the health risks from drinking water contamination in Greater Cairo, we obtained and analyzed data on the chemical quality of surface water in the Nile at Cairo, finished water following treatment at the CWA plants, and samples of tap water in Cairo residences. Combining these data on chemical contaminants with Abdel Gawaad's estimate that the average Egyptian adult consumes 2.81 liters of water per day (Abdel Gawaad, 1994; Abdel Gawaad, 1989), we estimate the daily intake of each contaminant in drinking water. Then applying U.S. EPA dose-response information for each chemical to the estimated intake of the chemical, we can calculate the health risks from drinking water contamination. These calculations are summarized in Table 2-7 for all chemicals for which dose response information is available.

Risks From Metals in Drinking Water

Several sources provide data on concentrations of metals in drinking water in Greater Cairo. Abdel Gawaad (1992, for metals other than lead) and Zahran (1992, for lead) report the results from 116 samples of tap water in residences in various locations in Greater Cairo. The 1992 monitoring data from the CWA includes measurements of metals in treated water as it enters the water distribution system. In theory, the Abdel Gawaad/Zahran data set should differ from the CWA data set in reflecting any changes in water quality resulting from the water distribution system and household piping and fixtures. Experience from elsewhere suggests that treated water may accumulate moderate additional amounts of lead and copper before it is ultimately ingested by consumers. The two Cairo data sets, however, differ very sharply and, in our view, inexplicably.

Table 2-7. Health Risk Calculations for Water Pollutants in Cairo

Source	Pollutant	Concentration (ug/l)	Consumption (l/day)	Dose (ug/kg/day)	Reference Dose (ug/kg/day)	Hazard Index	Cancer Potency (mg/kg/day-1)	Individual Lifetime Cancer Risk	Annual Population Cancer Risk
Tap Water	Copper	185	2.81	7.41E+00	37	2.00E-01			
(Abdel Gawaad,	Lead	492	2.81	1.98E+01	1.4	1.41E+01			
Zahran; 1992)	Manganese	66	2.81	2.65E+00	5	5.30E-01			
	Zinc	1357	2.81	5.45E+01	200	2.72E-01			
	DDT	43	2.81	1.73E+00	0.5	3.45E+00	0.34	5.87E-04	101
	Dieldrin	3	2.81	1.20E-01	0.05	2.41E+00	16	1.93E-03	330
	Lindane	4	2.81	1.61E-01	0.3	5.35E-01	1.3	2.09E-04	36
	Endrin	10	2.81	4.01E-01	0.3	1.34E+00			
	DDT	0.043 *	2.81	1.73E-03	0.5	3.45E-03	0.34	5.87E-07	0.1
	Dieldrin	0.003 *	2.81	1.20E-04	0.05	2.41E-03	16	1.93E-06	0.3
	Lindane	0.004 *	2.81	1.61E-04	0.3	5.35E-04	1.3	2.09E-07	0.0
	Endrin	0.010 *	2.81	4.01E-04	0.3	1.34E-03			
Treated Water	Chloroform	19.84	2.81	7.96E-01	10	7.96E-02	0.0061	4.86E-06	0.8
(CWA, 1992)	Dichlorobromomethane	8.18	2.81	3.28E-01					
	Dibromochloromethane	2.82	2.81	1.13E-01	20	5.66E-03	0.084	9.51E-06	1.6
	Mercury	0.12	2.81	4.82E-03	0.3	1.61E-02			
	Copper	5.59	2.81	2.24E-01	37	6.06E-03			
	Lead	5.9	2.81	2.37E-01	1.4	1.69E-01			
	Chromium	0.73	2.81	2.93E-02	5	5.86E-03			
	Cadmium	0.27	2.81	1.08E-02	0.5	2.17E-02			
	Manganese	44.61	2.81	1.79E+00	5	3.58E-01			
	Nickel	1.05	2.81	4.22E-02	20	2.11E-03			
Nile Ambient Water	Mercury	0.17	2.81	6.82E-03	0.3	2.27E-02			
(CWA Intake	Copper	6.16	2.81	2.47E-01	37	6.68E-03			
Water, 1992)	Lead	5.85	2.81	2.35E-01	1.4	1.68E-01			
	Chromium	1.13	2.81	4.54E-02	5	9.07E-03			
	Cadmium	0.40	2.81	1.61E-02	0.5	3.21E-02			
	Manganese	79.43	2.81	3.19E+00	5	6.38E-01			
	Nickel	2.26	2.81	9.07E-02	20	4.54E-03			
Nile Ambient Water	Dursban	0.007	2.81	2.94E-04	3	9.81E-05			
(1979; Badawy,	Atrazine	0.287	2.81	1.15E-02	5	2.31E-03	0.222	2.56E-06	0.4
1982)	Lindane	0.002	2.81	6.66E-05	0.3	2.22E-04	1.3	8.65E-08	0.0
	Endrin	0.001	2.81	5.85E-05	0.3	1.95E-04			
	DDD	0.002	2.81	6.56E-05			0.24	1.57E-08	0.0

* These alternate concentration figures and corresponding risk calculations presume that the Abdel-Gawaad data for pesticides should be in nanograms/liter rather than micrograms/liter.

119

Average at the tap lead levels found by Abdel Gawaad/Zahran exceed those in CWA treated water by a factor of more than 80, while copper levels are apparently higher by a factor of more than 30. This discrepancy between the data sets is discussed at greater length in Annex D: Health Risks from Exposure to Lead.

Further investigation is needed to resolve this discrepancy. At this point, we have chosen in Table 2-7 to calculate risks based on each of the two alternative data sets. Table 2-7 shows that:

- (Assuming the Abdel Gawaad/Zahran data set to be accurate) Lead is present in tap water at levels sufficient to exceed its reference dose and threaten adverse non-cancer health impacts. Annex D details these impacts, which we believe are very significant. Metals other than lead are not present in tap water at levels exceeding their Reference Doses, and no adverse non-cancer health impacts are expected from them. None of the metals are carcinogens.

- (Assuming that the CWA treated water data also represent concentrations at the tap) None of the metals are present at levels exceeding their Reference Doses, and no adverse non-cancer health impacts are expected from them. None of the metals are carcinogens.

Risks From Disinfection By-Products in Drinking Water

Chlorination of drinking water that contains organic materials can produce a variety of chlorinated organic compounds that may be carcinogenic. Drinking water professionals in the U.S. regard modest levels of these by-products of disinfection as being a price well worth paying in return for the benefits of chlorination in killing microbiological contaminants in drinking water. The CWA treated water data included information on the three most prominent disinfection by-products, chloroform, dichlorobromomethane, and dibromochloromethane. The concentration of these contaminants in total is about 1/3 of the U.S. standards for total trihalomethanes of 100 ug/l. The risk calculations for these contaminants in Table 2-7 show:

- About 2.4 excess cancer cases per year from carcinogenic byproducts from chlorine disinfection. (As explained in Annex A, cancer case estimates using EPA methods are likely to be substantial overestimates, probably by 1 or 2 orders of magnitude.) No non-cancer health impacts are expected.

Risks From Pesticides in Drinking Water

Two data sets are available that provide useful information about the levels of pesticides in drinking water. Abdel Gawaad (1989) measured the levels of organochlorine insecticides in 50 tap water samples. Badawy (1982) reported the results of sampling the Nile at Cairo for three months in 1979 for organochlorine and other pesticides. Also, the CWA data for 1992 included monitoring results for pesticides in treated water, but pesticides were never detected. We have no information about the detection limit of the CWA's pesticide analysis procedure, so the CWA data are not useful.

The Badawy and Abdel Gawaad data differ sharply, with the levels of pesticides reported by Abdel Gawaad exceeding those found by Badawy in Nile water by factors of 1,000 or more. We believe this difference probably represents an error in Abdel Gawaad's reported units of measurement, perhaps involving a confusion in the abbreviation "ppm." In American English, "ppm" means "parts per million" or mg/kg or mg/l. Abdel Gawaad reported finding pesticides in tap water at 0.003 - 0.043 "ppm," meaning 3 - 43 ug/l. We believe he may have intended "ppm" to mean "parts per milliard," which in British English means "parts per billion" or ug/kg or ug/l. This supposition is prompted by another published version of the Abdel Gawaad tap water findings (Ezz, 1991) that reports finding pesticides in tap water at 0.000003 - 0.000043 mg/kg, meaning 3 - 43 nanograms/l, or exactly one thousandth of the level reported in Abdel Gawaad (1989). Badawy reports finding organochlorine pesticides at a similar nanogram per liter level. The risk calculations for these pesticides in Table 2-7 show:

- (Assuming that the Abdel Gawaad, 1989, results are reported correctly in ug/l. We doubt this to be the case.) Carcinogenic organochlorine pesticides contribute 467 excess cancer cases per year. (As explained in Annex A, such cancer case estimates using EPA methods are likely to be substantial overestimates.) For three of the four pesticides, doses also modestly exceed the Reference Doses for non-cancer health effects, and non-cancer impacts may be possible.

- (Assuming that the Abdel Gawaad, 1989, results are reported incorrectly and that they are actually in nanograms/l. We believe this to be more likely.) About 0.4 excess cancer cases per year from carcinogenic organochlorine pesticides. (As explained in Annex A, cancer case estimates using EPA methods are likely to be substantial overestimates.) Doses are well below the Reference Doses for non-cancer health effects, and no non-cancer impacts are expected.

- (Assuming that Badawy, 1982, results from Nile sampling are similar to what concentrations would be at the tap.[1]) About 0.4 excess cancer case per year from carcinogenic pesticides. Doses are well below the Reference Doses for non-cancer health effects, and no non-cancer impacts are expected.

Risks From Microbiological Contaminants in Drinking Water

The health risks from microbiological agents in drinking water cannot be quantified. Two factors prevent numerical estimation of these risks:

1. Levels of microbiological contaminants in drinking water vary widely over time and across locations, and cannot readily be assessed.

2. In contrast with chemical contaminants, dose response functions for microbiological contaminants and diseases are much less well developed.

---

[1] This is a reasonable assumption. Pesticide concentrations should be roughly similar in tap water and the raw water source, as pesticides are typically not removed from raw water by conventional treatment, nor added to treated water by infiltration in the distribution system.

The levels of microbiological agents in source water in the middle of the Nile and in treated water following chlorination are usually low. Concentrations may be much higher in other source water (e.g., shallow wells, irrigation canals, in the Nile near outfalls) and if these other sources are used for drinking without treatment, risks could be high. Even water that is thoroughly treated by the CWA can be contaminated subsequently in the distribution system or during storage. Annex F evaluates the risks of microbiological diseases in Cairo from environmental sources. It is very difficult to apportion the total incidence of microbiological diseases among specific causes such as contaminated drinking water, erratic water supplies, food contamination, poor personal hygiene practices, overcrowded housing, and other problems. The rate at which microbiological diseases are transmitted depends on a combination of many factors, and contaminated water is only one of them. In general, we believe that contaminated drinking water is probably one of the less important factors in the prevalence of these diseases.

HEALTH RISKS FROM DIRECT CONTACT WITH CONTAMINATED WATER

Working, swimming, bathing, or washing articles in the Nile and canals could cause microbiological disease among those doing so. Concentrations of bacteria in these waters undoubtedly vary widely with proximity to sources of human waste. Limited sampling data at various outfall locations on the Nile in Cairo suggest that fecal coliform concentrations are often in the range of 300 - 1,600 MPN/100 ml. Fecal contamination of many canals is probably higher, while most of the Nile itself that is well mixed would show much lower concentrations.

Hammer (1986) presents typical standards set by states in the U.S. for water contact recreation. The coliform bacteria standards suggest a mean of 1,000 (200 fecal) per 100 ml, with not more than 10% of the samples exceeding 2,000 (400 fecal). Most of the near-shore surface water in Cairo that people would be likely to be in contact with might exceed these coliform bacteria guidelines. Dissolved oxygen (DO) levels recommended by Hammer are 4 - 5 mg/l. (Higher levels of DO tend to enhance water quality due to increased degradation of organic contaminants and decreased odors.) Most surface water in Cairo is probably of substantially better quality than these DO levels.

Direct water contact standards based on coliform bacteria alone are controversial, since direct contact can lead to eye, skin, and respiratory diseases, in addition to the enteric diseases associated with coliforms. Studies have shown that the vast majority of diseases among recreational water users in the U.S. were eye, nose, throat, ear, and skin infections, not gastrointestinal disorders (Waite, 1984). The relationship between coliform bacteria, which indicate the possible presence of enteric pathogens that cause gastrointestinal disorders, and the onset of these other illnesses, is unclear. However, Waite describes studies that show that the rates of various illnesses among swimmers is related to water quality, and discusses correlations that indicate that the total incidence of illness decreases significantly when total coliforms are below 1,000 per 100 ml. Despite the evidence that a relationship between illness rate and the presence of coliform bacteria exists, there are no dose-response relationships from which numerical risk estimates can be made.

We conclude that those in frequent contact with surface water in Cairo are likely at risk of a variety of microbiological diseases. Risks of microbiological disease from direct contact, like those from pathogens entering water distribution systems, also cannot be estimated separately from those due to other causes of microbiological disease. We would guess that risks from direct contact are low to the general population of Cairo because most residents have little cause to be in the water.[2]

HEALTH RISKS FROM IRRIGATING CROPS WITH CONTAMINATED WATER

Crops irrigated with contaminated water may take up contaminants through the soil and roots, or may retain the contaminants on the crop surface after contact with irrigation water that subsequently evaporates. Table 2-8 compares the concentration of various pollutants in Nile water at Cairo and in water in agricultural drains (along the Rosetta Branch north of Cairo, the only location for which we found such data) with irrigation guidelines from the WHO and Eckenfelder (1980).[3] The irrigation guidelines represent levels of contaminants below which there should be no restriction on use of the water for irrigation purposes.

---

[2] We have not addressed schistosomiasis in this discussion. According to Dr. Mike Phillips (physician and consultant to USAID/Cairo on schistosomiasis, personal communication, 1993) the snails necessary for propagation of this disease have been nearly eradicated from waters in Greater Cairo. Although the disease is still common among residents of Cairo, this is through people having been infected elsewhere moving to Cairo.

[3] This comparison considers only pollutants of concern for health reasons. Many other pollutants not shown here are of concern in irrigation water for reasons associated with crop productivity. The data on water quality in agricultural drains is assumed to be similar to that for agricultural irrigation canals. The data shown in the table for the drains represent an average across three drains. The data source is El-Gamal, 1992. (El-Gamal's data are reported in "ppm," and we believe the same confusion between milliard and million may exist for these data as for Abdel Gawaad's data discussed earlier. We have assumed that El-Gamal's data are actually in parts per billion rather than million. This conclusion is suggested by El-Gamal's statement that the contaminant levels he found did not violate irrigation standards, which would be true only if his data were in parts per billion rather than million.)

Table 2-8. Comparison of Water Quality With Irrigation Guidelines (ug/l)

POLLUTANT	NILE CONCENTRATION	AGRICULTURAL DRAINS CONCENTRATION	IRRIGATION GUIDELINES
Copper	6.2	13.5	200
Lead	5.9	6.9	5,000
Chromium	1.1	3.7	10
Cadmium	0.4	0.8	100
Manganese	79.4	NA	200
Nickel	2.3	6.4	200
Zinc	NA	9.0	2,000
Fecal Coliform	up to 1,500/100 ml	NA	200/100 ml

Sources: Nile concentrations: Table 2-3; CWA intake data, 1992.
Agricultural drains: El-Gamal, 1992.
Irrigation guidelines: WHO, 1988; Eckenfelder, 1980.

With the exception of fecal coliform, the levels of contaminants in both Nile water and agricultural drains are well within guidelines for safe irrigation of food crops. It appears that sources of irrigation water in Greater Cairo may exceed desirable levels of bacteriological contamination. This pathway may contribute to bacteriological contamination of foods eaten in Cairo, particularly in the case of foods that are not washed, cooked or processed after being brought in from irrigated fields. This pathway probably contributes modestly to the overall incidence of microbiological diseases in Cairo.

HEALTH RISKS FROM CONSUMPTION OF CONTAMINATED FISH

Table 2-9 shows health risk calculations for consumption of fish from the Nile. We obtained three data sets on concentrations of pesticides in Nile fish: from Aly and Badawy (1982) for edible fish from the Nile at Cairo in 1979, and from Abdel Gawaad (1994) on Nile catfish and Bolti fish taken in 1985 from Beni Suef upstream of Cairo. We calculated average daily Egyptian consumption of fish from domestic sources by assuming that all domestic fish production (3.2 kg/capita/year in 1980, the most recent year for which such data were available—Abdel Gawaad, 1994) was consumed domestically. Annual consumption of 3.2 kg/year is equivalent to 9 g/day. The daily dose of contaminants received per kilogram of body weight is calculated by multiplying the concentration of contaminants in fish by the 9 gram daily consumption of fish and dividing by an assumed 70 kilogram adult body weight. We proceed to calculate health risks in Table 2-9 for each of the three fish contamination data sets. The calculated risks are those that would result if individuals consumed one of the three types of fish exclusively, for all 9 g/day.

Table 2-9. Health Risk Calculations for Pollutants in Fish in Cairo

Source	Pollutant	Concentration (ug/kg)	Consumption (kg/day)	Dose (ug/kg/day)	Reference Dose (ug/kg/day)	Hazard Index	Cancer Potency (mg/kg/day-1)	Individual Lifetime Cancer Risk	Annual Population Cancer Risk
Nile Fish	Lindane	8.9	0.009	1.14E-03	0.3	3.81E-03	1.3	1.49E-06	0
(1979: Aly, 1982)	Endrin	19.6	0.009	2.52E-03	0.3	8.40E-03			
	DDT	86.6	0.009	1.11E-02	0.5	2.23E-02	0.34	3.79E-06	1
Nile Catfish	Lindane	127	0.009	1.63E-02	0.3	5.44E-02	1.3	2.12E-05	4
(1985; Abdel	DDT	720	0.009	9.26E-02	0.5	1.85E-01	0.34	3.15E-05	5
Gawaad, 1994)	DDE	485	0.009	6.24E-02			0.34	2.12E-05	4
	DDD	460	0.009	5.91E-02			0.24	1.42E-05	2
	Heptachlor	122	0.009	1.57E-02	0.5	3.14E-02	4.5	7.06E-05	12
	Heptachlor epoxide	95	0.009	1.22E-02	0.013	9.40E-01	9.1	1.11E-04	19
	Aldrin	10	0.009	1.29E-03					
	Dieldrin	70	0.009	9.00E-03	0.05	1.80E-01	0.16	1.44E-06	0
Nile Bolti fish	Lindane	123	0.009	1.58E-02	0.3	5.27E-02	1.3	2.06E-05	4
(1985; Abdel	DDE	120	0.009	1.54E-02			0.34	5.25E-06	1
Gawaad, 1994)	DDD	440	0.009	5.66E-02			0.24	1.36E-05	2
	Heptachlor	263	0.009	3.38E-02	0.5	6.76E-02	4.5	1.52E-04	26
	Heptachlor epoxide	10	0.009	1.29E-03	0.013	9.89E-02	9.1	1.17E-05	2
	Dieldrin	590	0.009	7.59E-02	0.05	1.52E+00	0.16	1.21E-05	2

No contaminants in any of the three varieties of fish result in hazard indices exceeding one. Thus, non-cancer health effects are not expected from average consumption of Nile fish. Annual cancer risks among the population of Greater Cairo from fish consumption are estimated at a maximum of 1 case per year based on the Aly data, and a maximum of 46 or 37 cases per year based on the Abdel Gawaad data. Again, because of the way EPA estimates cancer potency factors, this projected number of cancer cases is likely a significant overestimate of the true risks.

ECOLOGICAL IMPACTS OF NILE WATER QUALITY IN CAIRO

Although such effects are not within the scope of this project, we nevertheless investigated this issue quickly. Ambient concentrations of pollutants in Nile River samples were compared with US water quality standards set to protect aquatic life. No exceedances of the standards for acute, short-term exposures were found. However, concentrations of lead in the Nile consistently exceeded the standards for long-term exposures, and occasional exceedances of the mercury and copper standards also occurred. It should be noted that the U.S. aquatic life standards were developed to protect aquatic species common in the U.S., and they may not be appropriate for species indigenous to the Nile. Other non-chemical factors (e.g., overfishing, destruction of marshes and riverside vegetation) can also harm the aquatic community in the Nile, and we did not investigate these factors.

REFERENCES . .

Abdel Gawaad, 1994. Abdel Gawaad, A.A. "Ranking Environmental Health Risks in Cairo, Egypt." Background paper for the Cairo CRA. January, 1994.

Abdel Gawaad, 1992. Abdel Gawaad, A.A., F.I. Zahran, Z.M. Seleim, and A. El-Mousallamy. "Monitoring of Heavy Metals Except Lead in the Tap Water." Journal of the Egyptian Society of Toxicology 9(1992):37-40.

Abdel Gawaad, 1989. Abdel Gawaad, A.A., and A. Shams El Dine. "Insecticides in Total Diet Samples." Journal of the Egyptian Society of Toxicology 4(1989):79-84.

AE/ECG, 1988. Associated Engineering International, Ltd., and Engineering Consultants Group. Prepared for the Canadian International Development Agency. "Water Supply & Sanitation, Governorate of Giza, Egypt—Vol. 2-A, Existing Conditions, Part A - Data Collection and Analysis." January, 1988.

Aly and Badawy, 1982. Aly, O.A., and M. Badawy. "Organochlorine Insecticides in Selected Agricultural Areas of Egypt." Presented at the International Symposium in Alexandria, March, 1981. Management of Industrial Wastewater in Developing Nations. 1982.

AMBRIC, 1993. American British Consultants, Moharram-Bakhoum (ACE) Sabbour Associates. Greater Cairo Wastewater Project, "West Bank Project Wastewater Collection System Monitoring 1992 Report." February, 1993.

AMBRIC, 1992. American British Consultants. "Greater Cairo Wastewater Project Review Statement, Second Quarter." 1992.

AMBRIC, 1987. American British Consultants. "Greater Cairo Wastewater Project Unsewered Areas Demonstration Project, Final Report," Arab Republic of Egypt - Ministry of Reconstruction, New Communities Housing and Utilities." 1987.

Badawy, 1982. Badawy, M. River Nile and Lake Nasser Project (internal report). Egyptian Academy of Scientific Research and Technology, Cairo. 1982.

Bedding, 1989. Bedding, James. "Money Down the Drains." New Scientist. April 15, 1989: 34-8.

CH2MHill, 1990. Warith, Ahmed Abdel, CH2MHill International. "Rod El Farag Distribution System, Volume I, East Bank Water System Master Plan Update." USAID Grant 263-0102. 1990.

D7

CWA, 1992. General Organization for Greater Cairo Water Supply (CWA, or Cairo Water Authority). Computer tables showing sampling results for the 12 months of 1992 for intake water and treated water at 12 water treatment plants.

DRI, 1989. Prepared by Environmental Studies Group (ESG), for Advisory Panel for Land Drainage in Egypt, Drainage Research Institute. "Environmental and Health Impact of Irrigation and Drainage System in Egypt." October, 1989.

Eckenfelder, 1980. Eckenfelder, W. Principles of Water Quality Management. Boston: CBI Publishing Co., 1980.

El-Gamal, 1992. El-Gamal, I.M. "Role of Micropollutants Residues on the Evaluation of Drainage Water in Rosetta Branch as a Source of Irrigation." Journal of the Egyptian Society of Toxicology 9(July, 1992):37-40.

El-Gohary, 1993. El-Gohary, Fatma. "Comparative Environmental Risks in Cairo," Water Pollution Problems. Report prepared for the Cairo CRA. December, 1993.

El-Gohary, 1992. El-Gohary, Fatma. "Environmental Assessment of Helwan Area." Water Pollution Control Dept., National Research Centre, Cairo. May, 1992.

Ezz, 1991. Ezz, A.E., Z.M. Seleim, and A.A. Abdel Gawaad. "Egyptian Infant Average Daily intake of Some Pesticide Residues During His First Year of Life." Journal of the Egyptian Society of Toxicology 7(1991):125-34.

Hammer, 1986. Hammer, M. Water and Wastewater Technology. Second edition. New York: J. Wiley and Sons, 1986.

Norconsult, 1992. Norconsult International, A.S. Prepared for the World Bank. "Environmental Assessment and Screening of the Helwan Area, Egypt, Draft Report." June, 1992.

Taylor Binnie, 1992. Taylor Binnie & Partners. Environmental Programme for the Mediterranean, European Investment Bank "METAP Cairo Industrial Effluent Control Study." July, 1992.

USAID, 1992. NE/DP and Program Office, USAID/Cairo. "U.S. Economic Assistance Program in Egypt, Program Accomplishments." October, 1992.

Waite, 1984. Waite, T. Principles of Water Quality. Orlando, Florida: Academic Press, 1984.

Welsh, 1992. Welsh, James L., and Khalil H. Mancy. Submitted by Project in Development and the Environment (PRIDE) to USAID. "Egypt Water Quality Impact Assessment:

Phase I." July, 1992.

WHO, 1988. World Health Organization. Global Freshwater Quality Assessment Report. Geneva, Switzerland: WHO Int. Report PEP/88.5.

Youssef, 1985. Youssef, Youssef Shafik. "A Study on Monitoring and Trends of Pollutants Along the River Nile," in Proceedings of the International Drinking Water Supply and Sanitation Decade, Second National Conference - Egypt Sector Progress and Needs, Volume III. Alexandria, April 16-18, 1985.

Zahran, 1992. Zahran, F.I., A. El-Mousallamy, N.A. Soliman, Z.M. Seleim, and A.A. Abdel Gawaad. "Toxicity and Monitoring of Lead in Tap Water." Journal of the Egyptian Society of Toxicology 9(July, 1992):55-8.

ANNEX C

HEALTH RISKS FROM SOLID AND HAZARDOUS WASTES

ANNEX C
HEALTH RISKS FROM SOLID AND HAZARDOUS WASTES

Solid waste generation and disposal is perceived to be a growing problem in Egypt, particularly in major urban areas like Cairo. Increases in the overall population and population density place continued pressure upon a waste collection and disposal infrastructure that is inadequate for current waste needs in Cairo. Problems occur at all levels of solid and hazardous waste management from collection to ultimate disposal. However, aside from the potential impact to the Zaballeen, we believe solid and hazardous wastes are likely to pose low health risks in Cairo.

This annex presents an overview of the solid and hazardous waste collection and disposal system in Cairo and highlights some of the problems with the system. The overview is followed by a qualitative discussion of the health risks derived from solid and hazardous waste in Cairo.

DEFINITION OF THE PROBLEM

Characterization of Solid Waste in Cairo

The generation rate of solid wastes in Egypt is typical of most developing countries, ranging from 0.2 to 0.8 kg per person per day. This rate varies for the most part with the standard of living; higher rates of generation occur in areas with a higher income. The generation rate for Cairo falls at the high end of this range at about 0.8 kg per person per day. (El-Halwagi, 1991) With a population of approximately 12 million in the greater Cairo area, the total daily volume of solid waste generated is nearly 10,000 tons or 3.5 million tons annually.

The typical constituents of Cairo's solid waste are shown below.

CONSTITUENT	% OF TOTAL WASTE
Food	46
Paper	21
Metals	2
Cloth	2
Glass	2
Plastics	4
Other	23

SOURCE: El-Halwagi, 1991.

This mix of wastes is very wet by U.S. standards, up to 50% moisture. In higher income areas, the percentage of paper, metals, plastics and other recyclables increases, while in low income areas, the percent of food waste increases. The composition of the solid waste also varies to some degree by season. The constituent mix influences the degree to which the waste is recyclable and has value to waste collectors. The disparity in the constituent mix and generation rate by income level is illustrated by the table below:

INCOME LEVEL	HOUSEHOLD QUANTITY (KG/CAPITA/DAY)	MOISTURE CONTENT
High	0.5 - 0.6	40 - 45
Medium	0.3 - 0.4	30 - 45
Low	0.2 - 0.3	20 - 30

SOURCE: El-Halwagi, 1991.

The sources of the waste are shown in the following table, with the majority of wastes coming from households.

SOURCE	% OF TOTAL WASTE
Households	64.30%
Street and Green Areas	12.30%
Commercial	14.90%
Industrial	2.30%
Educational	0.90%
Hotels	0.70%
Hospitals	0.09%
Others	4.51%

SOURCE: El-Halwagi, 1991

Solid Waste Collection in Cairo

Estimates of the fraction of solid waste collected in Cairo vary. Estimates have been generated through sample surveys in scattered neighborhoods and there is uncertainty about how to scale up to the city as a whole from the few surveyed areas. The official estimate is that approximately 68% of the solid waste generated in Cairo is collected (Env Action Plan, 1992). Another estimate is that 60 % is collected (Bouverie, 1991), while another places the figure at less than 50 % (El Gamal, 1994). In any case, the aggregate figure disguises a wide differential across areas within the city. Much lower fractions are collected in lower income areas, where many of the poorest areas have virtually no collection service (Schmertz, 1985, Abdel Gawaad, 1994).

The uncollected of the waste is dumped in streets, temporary dump sites, vacant areas, or canals, or is burned on-site or in the street. Collection rates vary by area primarily as a function of income level. Most middle and high income areas enjoy routine door-to-door service for a fee. Wastes from the higher income areas are valued for their high recyclable content so it is not difficult to entice collectors to service such areas; Cairo also has a well-developed recyclables market. Low income and squatter areas have irregular or nonexistent service due to limited access from narrow or nonexistent streets, and the low recyclable content of the waste. One estimate put the value of typical waste from high income areas at 26.15 L.E. per ton, while from low income areas the value was only 9.30 L.E. per ton (EQI, 1991). "Unplanned," unofficial, or squatter areas house 45% of Cairo's population and generally have very limited access to roads, water, sewer, and other public services, including waste collection (El-Gamal, 1994). More than 1/2 of Cairo households are without solid waste collection or are very poorly served. Some 300 tons per day of waste are simply left in the streets (Schmertz, 1985).

Incomplete waste collection can be attributed to a number of factors:

- Insufficient ability/willingness to pay and a low recyclable content combine to limit the interest of private waste collectors,
- Limited funding for public waste collection programs,
- Inadequate staffing, organization, and management,
- Inadequate and mismatched facilities for collection, transport, and disposal,
- Negative public attitudes and a general lack of awareness (El-Halwagi, 1991)

Recent efforts have focused on identifying problems with collection and developing solutions.

Three solid waste collection methods are currently employed in Greater Cairo.

- **Public Collection.** In Egypt, municipalities and special agencies (e.g., the Cairo Cleaning and Beautification Agency) are responsible for collecting street sweepings, commercial refuse, waste in communal municipal containers, and some limited domestic waste. Collection is performed using lift dumpers and side or rear loading compactors. Narrow or non-existent roads in some low income areas limit service by the collection vehicles. In many cases, residents near a communal municipal container resent the container and its associated odors and pests—which are exacerbated by infrequent municipal collection from the containers—and they destroy the containers, set fire to the contents, or otherwise disrupt regular use of the containers.

- **Private Collection Companies.** The Cairo government has been encouraging the development of private companies to provide waste collection services. Recently, the municipal government has introduced a competitive bidding process to distribute rights to collect waste in specific areas. By 1991, 85 companies had been licensed to collect waste in the Cairo area, and current estimates put the number near 100. (Env. Action Plan, 1992) The private companies find it most profitable to provide collection in high income areas where residents can afford collection fees, access is not a problem, and the waste has a high recyclable content. Private companies can dispose of their waste in municipal sites, most of which are a significant distance from the city. However, many private companies instead choose pay a fee to the Zaballeen for them to manage the waste at the Zaballeen settlements and thereby avoid the higher cost of transporting the waste to distant disposal sites. (Bouverie, 1991)

- **Private Collection by the Zaballeen.** The Zaballeen represent a class of people who have provided waste collection and recycling in Cairo for many decades. Most of the Zaballeen reside in seven settlements in the Greater Cairo area. Waste collection and recycling are a way of life for the Zaballeen and the entire family is involved in the process. The "Wahis" are a group who secure contracts from individual building owners for collection services in return for a monthly fee. They also determine specific collection routes. The "Zarabs" and other daily laborers participate in the actual collection and transport of wastes to the settlements. Donkey carts were traditionally used for collection. Though they are now illegal in Cairo, donkey carts are still used to some degree. Trucks are becoming more common.

The Zaballeen collect an estimated 1/3 (EQI, 1991) or 2/3 (Bouverie, 1991) of all waste collected in Cairo. They recycle 80% of what they collect (Bouverie, 1991). Waste is taken to the settlements and carefully separated for recycling. Paper, glass, plastic, metal, bone, and cloth are sent to manufacturers for re-use, re-processed on-site or sold in the second-hand market. Food waste is used to feed pigs raised in the settlement for sale to government slaughterhouses. Food waste may also be combined with collected pig manure to produce organic fertilizer. Many of the Zaballeen find the recycling business quite lucrative and are investing in more sophisticated means of processing the recycled materials themselves. (Bouverie, 1991) The waste remaining after valued recyclables are reclaimed is piled on vacant areas or burned. Clients of the Zaballeen are generally satisfied with the system, although a lack of coordination and control by municipal authorities has raised some concern.

Solid Waste Disposal in Cairo

Though several collection systems are operating successfully in Cairo, the disposal of the collected waste poses an additional problem. 95% of the waste collected by public agencies is dumped in one of a number of open dumps that are often outside the city limits (El-Halwagi, 1991). Private collection firms are often unwilling to transport the collected wastes to the dump sites, and often dump it illegally or transfer it to the Zaballeen. Solid industrial waste is usually handled by the industries as they maintain large dump sites near their facilities or transport the waste to municipal disposal sites.

Cairo's waste dump sites are unsanitary, generally poorly managed and spontaneous fires are common (El-Halwagi, 1991). A few of the landfills have been upgraded and are continuously covered and compacted. Sanitary landfills are not generally available for disposal. One sanitary landfill was constructed in 1986 in Cairo with a capacity of 1,000 tons per day, but it appears no longer to be operating in conformity with its planned standards.

The Greater Cairo area has at least three composting plants built since the mid 1980's. In total, though, the plants have daily capacity equal to only about 2 % of Cairo's volume of waste (El-Halwagi, 1991 and Bouverie, 1991). Several incinerators have also been built in Cairo. However, the process has proven unsuccessful due to unexpectedly high operating costs and a difficulty in providing maintenance and finding spare parts (Env. Action Plan, 1992). The high moisture content of the waste in Cairo poses additional difficulty in the use of incineration

Disposal capacity poses a problem in Cairo; even if the sanitary landfill, composting plants, and incinerators were all in operation, less than 25% of the waste collected could be managed in such safe, modern facilities.

Management of Hazardous Wastes

Egypt has no specific legislation governing the disposal of hazardous wastes and hazardous waste disposal is generally not perceived to be a specific problem. There is no formalized system in place to handle the 20,000 - 50,000 tons per year generated in the Greater Cairo area. The government controls about 75% of industrial production, particularly the largest plants. The principal industries in Greater Cairo are textiles, food, metal working, and chemicals. (Env. Action Plan, 1992) As these industries modernize and expand, the production of hazardous waste may increase.

The management of hazardous industrial waste varies from industry to industry. Industries with substantial waste generation generally dump their waste on vacant land nearby or in canals or drains near the industrial site. Smaller generators may transport it themselves or by contractor to municipal dump sites or simply dump the waste off-site near their property. Hazardous wastes from these industries are normally not identified as such and segregated; they are handled as normal solid waste. Several large toxic stockpiles have been created in heavy industrial areas such as Helwan, Shoubra El-Kheima, and Embaba. A detailed review of industrial waste disposal in the Helwan area showed 18 open dump sites along a 22 km stretch of the Helwan Highway. One of the sites contained a sanitary landfill that was rarely used.

Three sites handled household and municipal waste. The remaining 14 sites contained industrial wastes including asbestos, metals, and a variety of dusts and sludges (World Bank, 1992).

Agricultural hazardous waste is also unregulated. Pesticide containers and outdated pesticides and chemical fertilizer are disposed of as normal solid waste. A number of agricultural communities still exist in Greater Cairo despite the expansion of the urbanized area.

Hospital and laboratory waste is disposed of with other municipal waste, often falling into the hands of the Zaballeen who sort it along with the other municipal waste. Recovered medical waste can even find its way into the second hand market, e.g., selling used syringes. Hazardous waste from hospitals amounts to about 13,000 tons per year, less than 1% of the volume of municipal waste (Env. Action Plan, 1992). A few small incinerators have been built at university and private hospitals but are generally not in operation due to maintenance problems and a lack of spare parts. Public hospitals do not see waste disposal as a high priority concern (Env. Action Plan, 1992).

Health Risks from Solid and Hazardous Wastes

It is not possible to offer any quantitative assessment of the degree to which Cairo's system for managing solid and hazardous wastes produces health risks. No suitable data were available to estimate health risks. Only the most aggregated data was available for the constituents in and quantities of solid wastes in Cairo and potential populations exposed. The specifics of waste quantity, type and concentration of hazardous constituents; the volumes managed in different ways at different sites; the hydrogeological and meteorological characteristics for waste sites; patterns of use for surface and groundwater; and the exposed populations are generally not available.

Based on the limited data available and qualitative information on solid and hazardous waste management, we believe the health risks in Cairo are low. In higher income areas where most waste is collected, problems from solid waste are largely limited to aesthetics. However, lower income areas may face health effects in addition, from direct contact with wastes and the animals and insects it attracts. Specific populations who have more frequent and prolonged contact with wastes (e.g., Zaballeen, dump scavengers, municipal workers) face an increased risk from their exposure to accumulated and potentially toxic wastes. The general population of Cairo may also face some diffused risks from solid wastes due to air pollution from open burning and contaminants in drinking water. A qualitative discussion follows for each of the several mechanisms by which health risks might arise:

Uncollected Solid Waste

Large volumes of waste are either never collected or are left after collection and extraction of recyclables. These wastes are typically discarded near where people live and left to decompose. Wastes may also accumulate in public areas due to poorly designed, vandalized or improperly located collection containers, due to overflow from uncovered containers, and due to irregular or insufficiently frequent collection times. Uncovered collection vehicles may also contribute to the spread of uncollected waste.

Aside from the aesthetically unpleasant view of the waste and noxious odors, the waste piles attract and support rodent, insect, dog, and cat populations that contribute to the transmission of infectious diseases. Abdel-Gawaad (1994) presents information on the density of flies, and stray dogs and cats across the various districts of Cairo. The numbers of flies, dogs, and cats correlate clearly with low income areas and uncollected solid waste. Diseases such as infectious hepatitis, typhoid, paratyphoid and poliomyelitis are feared in areas where wastes accumulate and decompose, along with a concern for the entire range of diarrheal diseases, allergies and food poisoning. Health risks of this sort are discussed in the section on microbiological diseases. In general, though, we believe uncollected and discarded solid waste is probably a lesser contributor to infectious disease rates than are non-environmental factors (overcrowding, poor nutrition, etc.) and other environmental factors relating to sanitation, particularly a lack of water and sewer services in some neighborhoods.

Zaballeen Direct Contact with Solid Waste (may also apply to other scavengers in low income areas)

The very close and frequent contact between the Zaballeen and solid wastes undoubtedly raises the importance of solid waste as a contributor to health effects in the Zaballeen settlements. Residents of the settlements, like other areas of unofficial or squatter housing, face significant public health problems associated with inadequate sanitation. The municipalities generally have no control over the development of these areas and rarely are able to provide full public services like water, electricity, sewer, and waste collection. The crowded Zaballeen settlements themselves include an assortment of shacks and some permanent brick housing, often on stilts, with waste spread in, around and below the housing for sorting purposes. Fires are an ever-present danger given the density of the housing and the spread of a variety of wastes throughout the settlement.

All members of the Zaballeen family participate in the waste sorting and processing and may have long periods of exposure to the waste surrounding their home. Children play and livestock are raised in the same area where the waste is accumulated and sorted. Adequate drainage is lacking, and electricity and municipal drinking water are available sporadically at best. Access to these areas is often difficult given the sprawl of the development, the density of activity and limited roads. Sanitary and health care facilities are often lacking and compound the risks from the accumulated wastes.

Direct contact with hazardous waste in the settlements is always possible given that hazardous waste (including medical waste) is disposed of in the same manner as other solid waste. Toxic and infectious materials pose a hazard for direct human contact, contamination of food through the livestock, and contamination of local water supplies (by infiltration through leaky pipes, by accumulation of waste near commercial stand pipes, or by contaminating buckets, barrels, and tanks used for water transport and storage). Fires are easily ignited in the waste areas and the presence of hazardous waste may intensify the ill effects of open burning.

On a positive note, improvements have been made in some Zaballeen settlements where the infrastructure has been upgraded with access to water and electricity, road construction, and programs instituted to improve housing and schools. In some areas, cleansing programs have been developed to remove residual waste that had been left to accumulate in open piles. In addition, collection facilities are being upgraded. Because of success in the market for recyclables, the Zaballeen are often not as poor as other low income residents in Cairo and are often able to provide basic necessities and luxuries often not available in other squatter areas. In fact, some aid agencies have bypassed the Zaballeen community because of their financial success in the reclamation business (Bouverie, 1991).

At least seven areas of Zaballeen settlements are present in the Greater Cairo area. The table below shows the population of these settlements. This is the population that may be at risk for health effects from the presence of significant volumes of solid and hazardous wastes in their neighborhoods and from prolonged direct contact with it.

SITE	# ZERIBAS	POPULATION
Manshiet Nasser	1,000	10,000
Moatemedia	300	700
Baragil	35	300
Ezbat El Nakhl	500	4,000
Ein El Sira	40	350
Helwan	30	200
Tora	165	820

SOURCE: El-Halwagi, 1991.

We expect this issue of health effects could be investigated through epidemiological studies comparing health in Zaballeen communities with that in other socioeconomically similar communities that are not so closely involved with solid waste.

Open Burning of Solid Waste

Discarded or dumped wastes are often open-burned when they accumulate to unwanted quantities in any location. Fires may arise spontaneously at open dump sites or in waste areas at Zaballeen settlements. Residents in other areas may ignite collection containers or waste piles that have accumulated or infringed upon their property in protest of their location or the lack of collection in the area. Industrial waste (including hazardous waste) may be openly burned as a means of disposal. Such open burning contributes to air pollution with particulate matter and toxic pollutants. Limited information suggests that open burning of waste is a modest contributor to problems of particulate matter in air. (See Air Pollution)

Pollution of Surface and Ground Water from Solid Waste

The lack of sanitary landfills in Cairo and the continuing problem of uncontrolled open dumping (particularly dumping directly into the Nile and canals) may lead to pollution of surface or ground waters and cause risks through drinking water contamination. We doubt that this pathway presents significant health risks. Nearly all pathogens from solid waste that find their way into a source of drinking water will be eliminated by chlorination at Cairo's drinking water treatment plants. It is very unlikely that there will be chemical contaminants in solid wastes at sufficient concentration to threaten chemical-related risks in drinking water. In addition, the generally dry conditions found in Cairo and the surrounding areas limits leachate generation and migration to water sources.

REFERENCES

Abdel Gawaad, 1994. Abdel Gawaad, A.A. "Ranking Environmental Health Risks in Cairo, Egypt." Background paper for the Cairo Comparative Risk Analysis. January, 1994.

Bouverie, 1991. Bouverie, Jasper. "Recycling in Cairo: a tale of rags to riches." New Scientist, June 29, 1991, pp. 52-55.

EQI, 1991. Environmental Quality International. "Assessment of Environmental Problems in Egypt." Submitted by EQI to Japan International Cooperation Agency, 1991.

El-Gamal, 1994. El-Gamal, Amin. "Comparative Environmental Risk Analysis in the Greater Cairo Area." Background paper for the Cairo Comparative Risk Analysis. January 1994.

El-Halwagi, 1991. El-Halwagi, M.M., Chairman, "A Proposed National Strategy for Solid Waste Management in Egypt." Egyptian Environmental Affairs Agency, Arab Republic of Egypt, December, 1991.

Env. Action Plan, 1992. Government of the Arab Republic of Egypt, Egyptian Environmental Affairs Agency. Environmental Action Plan. May, 1992.

Schmertz, 1985. Schmertz, Mildred F. "Coping with Cairo: A Study in Urban Decline." Architectural Record, v. 173, May 1985, pp. 91-93.

World Bank, 1992. Norconsult International. Environmental Assessment and Screening of the Helwan Area, Egypt. Draft Report for the World Bank. June 1992.

ANNEX D

HEALTH RISKS FROM EXPOSURE TO LEAD

ANNEX D
HEALTH RISKS FROM EXPOSURE TO LEAD

INTRODUCTION

This annex addresses the pollutant lead in all of Cairo's environmental media. It unites information on sources, environmental pathways, human exposures, and health effects of lead. Although lead is a pollutant that contributes to health risks associated with most of the other environmental problems discussed in this report (air pollution, water pollution, food contamination, solid waste), we assemble the information on lead here in a single place in order to provide a comprehensive overview of its effects.

All the typical sources of lead contribute to the problem in Cairo: leaded gasoline, lead smelters, water supply pipes and fittings, food and soil contamination, lead paint, and occupational sources. Cairo has had some of the highest gasoline lead levels in the world, and the city's lead smelters operate amidst densely populated areas without particulate control technologies. The resulting concentrations of airborne lead are quite high, even for the developing world. Lead components in the drinking water supply system (pumps, pipes, storage tanks, and fittings) contribute to potentially significant levels of lead in drinking water. High levels of lead have been found in Cairo's food supply, most likely deriving from numerous sources: crop production using soil, irrigation water, and fertilizer containing lead; deposition of airborne lead on foodstuffs as they are grown, transported, or displayed for sale; and lead solder used in canning. Cairenes can be exposed directly to lead in soil as children eat it (pica behavior) or indirectly when soil gets on an individual's hands and subsequently on food he holds and eats. Occupational exposures (e.g., smelter workers, traffic policemen) provide another means by which workers (and their families, as the workers bring lead home on their clothes or possessions) come in contact with lead. As for most other environmental pollutants in Cairo, though, lead levels have not been systematically monitored in these different pathways. We are left with inferring the sources of human exposure to lead through numerous scattered and sometimes inconsistent studies.

A rapidly increasing body of research has linked human exposure to lead to a wide range of serious adverse health effects involving mental development, blood chemistry, the kidneys, and the nervous, reproductive, and cardiovascular systems. Adverse effects have been documented among infants, children, and adult men and women. Researchers have linked these adverse health effects to ever-lower levels of lead. In both developing and developed countries, the levels of lead to which large fractions of the population are exposed are now believed to result in significant health problems. There is essentially no margin of safety between the level of lead exposure for the general population in developing countries, including Egypt, and the level at which adverse human health effects are observed. Particularly in a developing country context, lead has tragic effects on the health of the population, on mental development, on health care costs, and on the productivity of the labor force.

In this annex, we describe the sources of lead in Greater Cairo, the pathways for human exposure, the resulting levels of exposure, and the estimated numbers of ensuing health effects.

SOURCES OF LEAD AND PATHWAYS OF EXPOSURE

Lead in Air

The concentration of lead in Cairo's ambient air varies with location, as shown in Table 4-1.

Table 4-1. Lead in Cairo's Ambient Air

MONITORING SITE, YEAR	MEAN CONCENTRATION (UG/M^3)
City Center, 1983	3.0
City Center, 1990	3.0
Residential/Commercial, 1990	1.9
Residential (North), 1983	1.4
Residential (Northeast), 1983	0.6
Residential (Northeast), 1990	0.5
Residential/Commercial (Southeast), 1983	2.2
Residential/Industrial (Shoubra El-Kheima), 1983	1.3
Residential/Industrial (Helwan), 1990	10.0

Sources: Nasralla, 1993a; Ali, 1986.

For comparison, the U.S. ambient standard for lead is 1.5 ug/m^3, while the WHO guideline is 0.5 - 1.0 ug/m^3. It is apparent that the ambient concentration of lead exceeds health-based standards throughout much of Cairo.

This range of ambient lead concentrations of 0.5 - 10.0 ug/m^3 in Cairo is generally higher than that in other large cities in developing countries. Comparative data for nine other cities is shown below (WHO/UNEP, 1992):

- Bangkok 0.2 - 2.5
- Buenos Aires 0.3 - 3.9
- Jakarta 0.3 - 3.6
- Manila 0.3 - 4.4
- Sao Paolo 1.0 - 1.1
- Bombay 0.25 - 0.33
- Calcutta 0.73
- Karachi 1 - 3
- Mexico City 0.5 - 3.5

Ambient lead concentrations vary spatially even more than is shown in Table 4-1. Areas downwind of lead smelters suffer extremely high localized concentrations. The 10 ug/m^3 figure cited above for Helwan reflects several metal industries in the area. Concentrations exceeding 50 ug/m^3 have been measured at two sites 500 meters downwind of the General Metals lead smelter in Helwan (World Bank, 1992). Heavy automobile traffic also causes high ambient lead concentrations; lower than those caused by smelters, but affecting much larger areas. For example, a concentration exceeding 10 ug/m^3 was observed in a heavily-trafficked location in central Cairo unaffected by smelters (Nasralla, 1984). Ambient lead monitoring at two primary schools found a clear relationship between traffic density and lead concentrations. At a school on a street with an average of 15 vehicles passing per hour, the concentration of lead was 0.7 ug/m^3, while at a school on a street with 500 vehicles/hour the concentration was 2.2 ug/m^3 (Massaoud, 1988).

Lead concentrations in ambient air also vary seasonally to some degree. Concentrations are generally somewhat higher in the summer than winter, especially in central Cairo. This is probably a result of higher traffic flow and lower wind speeds in the summer (Ali, 1986).

Probably the most important source of lead emissions to the air in Cairo is the combustion of gasoline containing tetraethyl- and tetramethyl-lead as anti-knock additives. In the U.S., this source of the metal contributed 90% of lead in the air prior to production of unleaded gasoline. Throughout the 1980s, the gasoline used in Egypt contained about 0.9 g of lead per liter (Ali, 1986 and WHO/UNEP, 1992). The Government of Egypt then undertook reductions in the maximum allowable lead content of gasoline sold in Cairo, resulting in an average lead concentration in 1991 of 0.5 g/L.[1] Further reductions led to an official 1993 figure of 0.34 to 0.36 g/L. According to the Egyptian Environmental Action Plan, refineries will eventually be required to produce gasoline with no more than 0.15 g/L of lead by the year 1995. At that time unleaded gasoline (in addition to the presumably lead-free diesel fuel) should also be available (Rhoda and Krause, 1993).

There is uncertainty as to whether this projected reduction of lead in gasoline is occurring as planned. Informal testing in the fall of 1993 reportedly found that the actual lead concentration in gasoline was still between 0.5 and 0.8 g/L.

The lead content of gasoline in Egypt has been higher than that in most other countries throughout the world (OECD, 1993; WHO/UNEP, 1992). All OECD countries rely on unleaded gasoline for between a majority and virtually all of their gasoline use. In these countries, the leaded gasoline that is used has a maximum lead content of 0.15 g/L and typically has a lower concentration than this. As of 1991, only two of the 20 largest cities in the world, Karachi and Manila, used gasoline with higher lead content than Cairo.

Use of leaded gasoline appears to be the largest source of lead emissions to Cairo's atmosphere. Assuming there were 900,000 automobiles in Greater Cairo in 1991, lead

---

[1] Twenty percent of cars used 90 octane high-test gasoline, with 0.9 g/L of lead. Eighty percent of the cars used 80 octane gasoline, with 0.4 g/L of lead. The average lead content of all the gasoline used was 0.5 g/L. (EEAA, 1993; USAID, 1993)

emissions from gasoline were estimated at 1000 to 2000 metric tons per year (WHO/UNEP, 1992). Under current conditions, if 1.20 x 10^6 metric tons of leaded gasoline is consumed per year in Cairo (M. M. Nasralla, personal communication) with an average lead content of 0.5 g/L, then an estimated 620 metric tons of lead are emitted from automobiles each year.

Industrial emissions of lead are also significant in Greater Cairo. For example, the General Metals Company in Helwan-Tebbin that includes a secondary lead smelter and a lead oxide production unit emits 150 tons/year of lead (World Bank, 1992). This results in lead concentrations in the ambient air around the plant many times higher than health-based standards. The World Bank Environmental Assessment of Helwan stated that anyone seeing the facility would conclude that it must be shut down as soon as possible (World Bank, 1992). Indeed, the total emissions of lead from smelters in the Cairo area are estimated at 300 - 500 tons/year (Nasralla, 1993a). There may be roughly a dozen secondary lead smelters scattered throughout Cairo, as well as numerous workshops and foundries processing other metals, armament factories, and ceramic and glass plants that emit smaller quantities of lead.

Although the amount of lead emitted from automobile exhaust may be similar to that from industrial sources, the impact on the average resident of Greater Cairo will be far greater from auto emissions. The few smelters affect relatively small areas severely, while auto exhaust is distributed widely throughout the city. In addition, lead from automobile exhaust is typically in the form of smaller particles than lead from smelters. The small particles in areas subject to auto emissions (particularly central Cairo) stay suspended for extended periods and are therefore available for inhalation longer than the larger particles in the areas affected by smelters (Ali, 1986).

Other processes that may contribute to lead in the air include the burning and weathering of lead-painted surfaces and the burning of solid waste. Little is known about how much these sources contribute to human exposure to lead in the Greater Cairo area.

Lead in Water

Human exposure to lead may also come from drinking water. Data available on the levels of lead in tap water in Cairo are contradictory, and we are unable to determine the extent to which this possible route of exposure is significant in our study area.

The largest and most comprehensive study on lead in tap water involved 116 samples taken from a variety of residences in eight governorates, including the three comprising Greater Cairo (Cairo, Giza, and Qualiobia) (Zahran et al., 1992). Samples taken from Greater Cairo contained lead at concentrations between 197 and 709 ug/L, with an average of 480 ug/L These levels of lead are very high, with all samples exceeding the U.S. (15 ug/L), WHO (50 ug/L), and Egyptian government (100 ug/L) standards. Table 4-2, taken from this study, illustrates some of the factors that influenced the concentration of lead in tap water. The maximum levels were found in very old homes, with water storage tanks (which are often lead-lined) also contributing to higher levels. Within the Greater Cairo area, concentrations in urban areas were higher than in the rural portions of Giza and Qualiobia. Furthermore, having a lead connection between the water meters and pipes in the home proved to increase exposure.

Table 4-2. Levels of Lead Found in Tap Water in Greater Cairo

SITE		LEVEL (MG/L)	MEAN
Urban area New houses without tanks	* maximum	0.433	0.4216 ± 0.1052
	* minimum	0.236	
	** maximum	0.591	
	** minimum	0.473	
New houses with tanks	* maximum	0.473	0.4843 ± 0.049
	* minimum	0.433	
	** maximum	0.551	
	** minimum	0.512	
Very old houses	* maximum	0.551	0.5711 ± 0.083
	* minimum	0.512	
	** maximum	0.709	
	** minimum	0.603	
Rural area Giza	maximum	0.394	0.3256 ± 0.107
	minimum	0.197	
Qualiobia	maximum	0.473	0.2314 ± 0.068
	minimum	0.197	

* From houses without a lead connector between network and meter.
** From houses with a lead connector between network and meter.
Source: Zahran, 1992.

The findings of this relatively large study contrast sharply with other data.

We were provided with the monitoring data for 1992 by the Cairo Water Authority (CWA) for raw water and treated water for the 12 major water treatment plants serving Greater Cairo (providing more than 95% of the drinking water for the metropolis). These data showed mean lead concentrations over the twelve months in intake water (mostly Nile water, with a small amount of ground water) to be 6.4 ug/L. Treated water as it left the treatment plants had an average lead concentration of 6.2 ug/L These values are very low, at roughly 1% of the values as measured in the Zahran study in homes. There were no treatment plants showing measurements particularly different from the system-wide mean.

These Zahran and CWA data sets together suggest quite low concentrations of lead in source water for drinking water supplies and subsequently in the treated water, but then very high additions of lead to Cairo's drinking water in the water distribution system and/or homes. This is certainly possible, as lead is widely present in Cairo's drinking water systems: in some pumps used to lift water in the distribution system, in some distribution pipes, in some water storage tanks, in the connecting pieces between a water meter and home plumbing, in some home water pipes and solder, and in many fittings and faucets in homes (Zahran et al., 1992; Abdel-Gawaad, personal communication). Water that has a low concentration of lead as it enters the distribution system can leach lead from any of these sources, resulting in high lead levels at the tap. This process of plumbosolvency is most pronounced for water that is corrosive—either soft and/or acidic.

Despite the apparent widespread existence of lead available for leaching in Cairo, we find such a large increase in lead between the treatment plant and the tap difficult to understand. The lead levels found in the Zahran study (197-709 ug/L) substantially exceed those found elsewhere (OECD, 1993). The highest at-the-tap lead concentrations observed in the U.S. for a group of at least several homes in a single geographic area (i.e., excepting unusual findings at single homes that are not replicated in the same geographic area) has been 380 ug/L (USEPA, 1989). Typical levels were much lower, between 10 and 30 ug/L, even before the U.S. began its efforts several years ago to reduce lead in drinking water. In both Great Britain and the U.S., "first draw" water samples (i.e., water that has stood in the pipe overnight, thereby providing the greatest opportunity for leaching lead) have very rarely shown a lead concentration exceeding 100 ug/L.

The Zahran tap water data are contradicted by two less extensive studies that found much lower levels of lead. M. M. Nasralla of the National Research Center analyzed several dozen samples of tap water from Cairo, and found no samples in which lead exceeded the Egyptian standard of 100 ug/L (personal communication, 1994). Another sampling effort found similarly low concentrations of lead in tap water. In 1991, sampling of the Cairo Centre office building and the residences of seven American Embassy employees where there was known to be lead piping provided a maximum measurement of 8.9 ug/L (U.S. Embassy, 1993).

These data are even further different than data from a masters thesis suggesting that lead concentrations in tap water are over an order of magnitude higher than those reported in Zahran et al. (1992), ranging from 3,780 to 20,520 ug/L (Mahmoud, 1992). We find the Mahmoud figures not believable, as: 1) they are far higher than any figures for lead in drinking water that we have seen reported elsewhere in the world, and 2) if consumed regularly, drinking water with such a lead concentration would result in levels of blood lead far beyond those actually observed.[2] It is possible that the units of measurement were wrongly reported or translated in this thesis. We have chosen to exclude the Mahmoud figures from further analysis in this report.

---

[2] As will be discussed later in this section, the estimated slope relating the concentration of lead in drinking water (in ug/L) to the resulting level of lead in the blood (in ug/L of blood) of those consuming the water is 0.06. If lead is present in tap water at 10,000 ug/L, then, consumers would be expected to have lead in their blood at a level of about 600 ug/dL. We have never heard of an individual having such a level of blood lead, and it would probably be quickly fatal.

We are unable at this point to resolve the conflicts among data regarding the levels of lead in tap water in Greater Cairo. It is odd that the 116 samples of Zahran et al. (1992) did not include a measurement as low as the highest of the CWA, Nasralla, or U.S. Embassy figures. We would think it likely that at least some of the residences in Cairo would actually have lead concentrations similar to those at the water treatment plants—at least some residences probably have no or minimal sources from which lead can leach between the treatment plant and the tap. We believe it more likely that one or the other data set (Zahran or CWA) is inaccurate than that both data sets are accurate and there is a very large and universal increase in lead concentrations between the treatment plant and the tap. Such a wide discrepancy between data sets is unlikely to be explainable by sampling protocols (e.g., sampling the first draw rather than after the water has run for several minutes might typically make a difference of a factor of 10, but not 100) or by choice of residences to sample.

Further insight into the discrepancy between the Zahran and CWA data sets may be obtained by considering metals other than lead that were also measured in each data set. Abdel Gawaad (1992) reports data for 5 additional metals from the 116 tap water samples that are also covered in the 1992 CWA monitoring at treatment plants. A comparison of the data sets for these five metals and for lead is shown below in Table 4-3.

Table 4-3. Comparison of Two Data Sets on Metals in Tap Water Concentrations in mg/L

METAL	ZAHRAN/ABDEL GAWAAD	CAIRO WATER AUTHORITY
Lead	0.492	0.0059
Copper	0.185	0.0056
Manganese	0.066	0.0450
Iron	0.038	0.1100
Potassium	8.100	5.8000
Sodium	10.800	28.0000

We cannot draw any conclusions from this further information. Lead is the only metal for which the Zahran/Abdel Gawaad data on concentrations at the tap are so far in excess of the CWA data at the treatment plants. Copper shows a similar pattern, though not to the same degree as lead. This lends some credence to the suggestion that large amounts of lead are being leached from the water supply system after the treatment plants, as copper would be expected to show the same pattern. The comparison for the other metals, though, is confusing. We can think of no reason why potassium in water should appear to increase after treatment, while sodium and iron would decrease.

Whether the Zahran figures for lead in tap water (mean of 480 ug/L) or the CWA/Nasralla/U.S. Embassy figures for lead (mean probably less than 20 ug/L) are more representative is of great importance in judging the relative contribution of different environmental pathways to human exposure. If tap water in Greater Cairo contains approximately 480 ug/L of lead, then tap water is responsible for nearly 70% of total lead intake by a Cairo resident. If, in contrast, tap water contains only about 20 ug/L of lead, this source is responsible for only about 8% of total lead intake. Further investigation to clarify the levels of lead in Cairo's tap water would be useful.

Lead in Soil

Soil may be both a direct and an indirect source of human exposure to lead. Children often ingest soil intentionally (pica behavior), and both children and adults may ingest soil unintentionally as they mouth things that have been in contact with soil. Health risk assessments for lead or other chemicals often consider this direct exposure route, as well as indirect routes involving the consumption of foods grown in soil contaminated with lead. Although soil is potentially a significant source of lead exposure in Cairo, an attempt to assess risks from this pathway is limited by:

1. The absence of information specific to Cairo or Egypt about the extent of pica behavior; and

2. The widely varying levels at which lead is present in Cairo's soils or surface dust.

The most likely source of lead in soils near highways in Cairo is air deposition from leaded gasoline. Several studies show that the lead content of surface soil decreases consistently with distance from roadways. For example, proceeding from 5 to 100 m from the Cairo-Benha Road, the lead in soil declined from 282 to 36 ug/g (Ali, 1992). Similarly, proceeding from 2 to 8.5 m from the El-Moukattam Highway, the lead in soil declined from 256 to 89 ug/g (El-Gamal, 1992a).

However, industrial activities are also major contributors to the lead in soil. For example, near metallurgical and other industrial plants in Shoubra El-Kheima, the soil concentrations ranged from 160 to 547 ug/g, compared with 15 ug/g in a rural area of the Sharkia governorate used as a control site for comparison (Nasralla, 1993b). For comparison again, native soils in the U.S. exhibit lead concentrations ranging from 2 to 200 ug/g, with 10 ug/g being an average figure (USEPA, 1983).

Nasralla (1993a) provides data on rates of dustfall over various districts of Greater Cairo, ranging from moderate levels in suburban areas to heavy in typical urban areas and extremely heavy in the city center, Shoubra El-Kheima, and Helwan. Lead has been measured as a constituent of this dustfall at very high levels, often over 1,000 ug/g in the city center, Shoubra El-Kheima, and Helwan. This can result in extremely high rates of air deposition of lead. In one study of eight diverse sites in the Helwan area, atmospheric deposition of lead ranged from 15-75 mg/m^2/month (Ali, 1992b).

Of specific concern for children, the concentrations of lead in dust on streets and in playgrounds can be high (Ali, 1985). In central Cairo, measured lead concentrations in small-size-fraction (<50 um) street dust have been as high as 6,740 ug/g, with a mean value of 2,850 ug/g for the sampling area. In urban playgrounds, the mean lead content of fine dust was 1,250 ug/g, with an extreme of 2,310 ug/g. Such levels are not atypical of those in cities in the U.S. or the U.K. before widespread adoption of unleaded gasoline (OECD, 1993). In the U.S., guidance regarding cleanup at hazardous waste sites requires remediation of soils when the lead concentration exceeds 500 to 1,000 ug/g. Clearly, the movement of dust from ground to hands to mouth would be a common route of exposure to lead for children in Cairo.

Lead in Food

For many people throughout the world, food is the main route of exposure to lead (Goyer, 1986). Abdel Gawaad et al. (199?) combined data from sampling the lead content of numerous Egyptian foods with data on typical Egyptian daily consumption of each food and estimated the total Egyptian daily intake of lead through food as 0.592 mg/person. Assuming that lead levels and food consumption are the same in Cairo as in the entire country[3], this intake through food would constitute a very significant source of exposure to lead for the average resident of Cairo. Whether or not food is the most important source depends on the concentration of lead in tap water, as discussed above. Assuming the high lead levels found in tap water by Zahran, et al., lead from food would contribute about 30% of the average Egyptian's daily intake of lead. Assuming lower lead levels in tap water, lead from food might contribute about 87% of total daily intake.

The estimated average Egyptian lead intake from food of 592 ug/day is relatively high compared with other countries around the world, as shown in Table 4-4.

[3] In fact, we speculate that lead intake through food would be higher for the average Cairene than for the average Egyptian. Average daily food consumption is higher in Cairo for most food groups than for the remainder of the country, because of the higher average income of Cairenes (Abdel Gawaad, 1994). Also, most foods are probably more highly contaminated with lead in Cairo than they are elsewhere in Egypt.

Table 4-4. Average Daily Intake of Lead in Food (ug/kg of body weight)

COUNTRY	AMOUNT	YEAR	DATA SOURCE
Egypt	8.5	1980s	d
Australia	3.0	1985	c
Canada	0.8	1980 - 1988	b
China	0.8	1980 - 1988	b
Cuba	9.0	1980 - 1988	b
Finland	0.7	1992	c
France	2.8	1983	a
Germany, F.R.	2.0	1987	a
Guatemala	4.6	1980 - 1988	b
Hungary	1.6	1980 - 1988	b
India	8.6	1980 - 1988	b
Japan	1.4	1980 - 1988	b
New Zealand	3.6	1980 - 1988	b
Thailand	6.9	1980 - 1988	b
U.K.	0.7	1985	c
U.S.	0.5	1985	c

Sources: a -- UNEP, 1989-90. b -- UNEP, 1991-92. c -- OECD, 1993. d -- Abdel Gawaad, 199?.

The sources of this lead in the Egyptian diet cannot be pinpointed. The two important questions are: 1) Which foods are contributing most of the lead? and 2) How is lead getting into these foods?

Samples of a variety of vegetables taken from markets throughout Greater Cairo showed variable concentrations of lead, ranging from about 2 ppm to 40 ppm. One type of vegetable, spearmint, showed higher levels, at nearly 100 ppm (Abdel Gawaad, 1994; Mahmoud, 1992). Buffalo and cow milk showed much lower levels of lead, at about 20-100 ppb (Abdel Gawaad, 1994). One hundred samples of bread from street vendors throughout Cairo showed even lower ranges of lead, at 0.4-2.7 ppb (Abdel Gawaad, 1994). For comparison, reports from OECD countries show concentrations of lead in foods are typically less than 100 ppb, though certain foods can reach much higher concentrations (OECD, 1993). In Britain in the 1980s, the majority of foods contained less than 50 ppb of lead. A survey of foods in France in 1978-79 showed lead concentrations ranging from 25 ppb (sugar) to 731 ppb (fresh celery).

Relative to data from other countries, the Egyptian data appear to show exceptionally high levels of lead in vegetables, and exceptionally low levels in breads, which constitute about half of the average Egyptian diet (Abdel Gawaad, 1994). These unusual findings may be accurate, or they may reflect a problem in reporting the units of measurement. The term "milliard" is sometimes used by British and Egyptian speakers to signify a thousand million (a billion, in U.S. parlance) and ppm may be written in Egypt as an abbreviation for what would be expressed as parts per billion in the U.S.

Potential sources for the lead found in Egyptian food may include:

- **Air deposition to agricultural fields.** Lead may deposit from the atmosphere on the crop as it is grown or on the soil the crop is grown in. Some plants take up lead from soil efficiently, some do not. Several researchers have found the lead content of grains, fruits, and vegetables to fall by an order of magnitude or more as the crop is grown at increasing distances from a heavily trafficked highway (e.g., Ali, 1992; Ali, 1991; Nasralla, 1993a). This suggests that air deposition is an important source of lead in food that is grown in areas with high concentrations of lead in ambient air. We do not know what fraction of Cairo's food is grown in or near the metropolitan area where lead concentrations in ambient air may be high, and what fraction is grown further into the Nile Delta where such concentrations are likely much lower. Despite the growth of the urban area, there are still extensive agricultural fields in and near Greater Cairo; often even directly adjacent to major point sources of lead emissions and to major highways.

- **Use of crop fertilizers containing lead.** Abdel Gawaad believes this is one of the primary sources of lead in crops throughout Egypt (personal communication, 1994). The nitrate fertilizer used extensively in Egypt contains lead at about 60 ppb (60 ug/kg).

- **Irrigation with water containing high levels of lead.** This potential source of lead is difficult to evaluate. The ultimate source of irrigation water is the Nile, which, based on the CWA intake water data cited earlier, contains lead at a low average concentration of about 6 ug/L (6 ppb). Such a level is probably less than the concentration of lead in most native soils, and should be low enough to cause no significant addition of lead to crops. However, the immediate source of irrigation water is usually water pumped from canals rather than directly from the Nile—most often irrigation canals, often drainage canals from other agricultural fields, and occasionally industrial and municipal drains. The concentration of lead in the canals may be higher than in the Nile itself (particularly for industrial and municipal drains), while pumps and pipes may also be a source of lead. Abdel Gawaad (personal communication) indicates that many submersible pumps used in Egypt involve a lead "rope" as a sealant. A study of the Nile and three agricultural drains along the Rosetta branch confirms that lead (as well as other metals) occur at higher concentrations in drain water than in Nile source water (El-Gamal, 1992b). In monitoring four sites over the course of nearly a year, El-Gamal found the average lead concentration in the Nile to be 5.1 ppm, while it averaged 6.3, 6.9, and 7.3 ppm in three drains. (We find it difficult to believe that these monitored concentrations are truly in ppm (mg/L). Again, we believe that there may be an error in units/translation, and that the concentrations are actually in ppb. This supposition is corroborated by El-Gamal's finding that the concentrations of lead and other metals in drainage water were less than the U.S. National Academy of Science irrigation water quality criteria for metals—which in the case of lead is 5 ppm.) Assuming that the El-Gamal data are actually in ppb, use of these three agricultural drains for irrigation should not cause an appreciable increase in the lead concentration of crops.

- **Air deposition as foods are being transported, stored or displayed for sale.** Dust particles, to which lead from automobile exhaust or industrial sources may adsorb or settle on foods that are outdoors and uncovered, particularly those being sold at roadside shops or stands. Abdel Gawaad's study of street bread from vendors throughout Greater Cairo showed bread sold in heavily trafficked areas as having higher lead levels than bread in less trafficked areas (Abdel Gawaad, 1994, p. 333).

- **Lead in cans.** Additional exposure to lead in food may come from packaging. Until the mid-1980's, most cans used throughout the world for food packaging were constructed in three pieces joined by lead solder. Such cans were phased out in most OECD countries beginning in the mid or late 1980's, but they are still used in Egypt. U.S. findings in the mid-1980's were that foods packed in lead soldered cans often had lead levels from 100 to 400 ug/kg, or from five to thirty times the lead content of frozen or fresh foods. Forty-two percent of the lead in food in the U.S. was estimated to come from lead soldered cans (OECD, 1993). Data on a variety of canned foods in four OECD countries showed that the lead content of foods in soldered cans was about three to twenty times higher than the lead content of the same food in a modern one-piece, non-soldered can (UNEP, 1988). Sampling for lead in Egyptian canned tomatoes and oranges during 1977-80 showed levels between 390 and 3,600 ug/kg, far above the levels found for the same canned produce in other countries at this time (UNEP, 1988/1989).

- **Other sources of lead.** Lead-glazed ceramics used in the home may also contribute to lead in the Cairene diet. Release of lead from both packaging and pottery will be facilitated when they are used to hold acidic contents. Cooking food in lead-contaminated water can elevate lead concentrations in food. Sherlock (1987) reported that every 10 ug/L in water increased the lead concentration in cooked vegetables by about 6 ug/kg. If tap water in Cairo contains lead at the high levels found in the Zahran study, cooking in water could be a significant route of exposure.

There is insufficient data available to confidently ascertain the major contributors to lead in food in Cairo. The leading possibilities include air deposition on crops or on food stored or displayed for sale, use of leaded fertilizer, and canning. Further research is recommended to clarify the contributions of different sources of lead. Studies of the lead content of foods at each of the different points between crop production and ultimate consumption could pinpoint the steps at which significant amounts of lead are added.

Lead-Based Paint

In the U.S., one of the most significant current remaining sources of exposure to lead is consumption of peeling or flaking lead-based paint. Although lead-based paint was essentially banned in the U.S. in 1977, in 1991 over 20 million older housing units still contained lead paint (OECD, 1993). As such paint deteriorates, it can flake off and be eaten directly by children, or be ground into dust on floors and be ingested by several means. We have no information bearing on the importance of this pathway for lead exposure in Cairo.

Occupational Sources of Lead

The final important source of exposure to lead for Cairo residents is occupational. Workers can be exposed to lead on the job site, then bring the lead home on their bodies, clothes, or possessions and expose others. There are inadequate data to assess the importance to the general population of such secondary occupational exposures. We do not know the number of workers significantly occupationally exposed to lead, nor their degree of exposure, nor the extent to which their activities away from the job site are likely to expose others. We expect, though, that this route of exposure would be significant only for the workers themselves and their families. They likely constitute a very small fraction of Cairo's population. Several studies document the extremely high levels of lead exposure for smelter workers and traffic policemen in Cairo and, to a lesser degree, garage mechanics and bus drivers (El-Samra, ?a; Emara, ?; Nasralla, 1984b; Shakour, 1992).

MEASUREMENTS OF EXPOSURE TO LEAD

Because of the large uncertainties in estimating the amount of lead to which people are exposed through each individual pathway, many investigations of human exposure to lead have focused on the total amount of lead in an individual's body without regard to the pathways by which the exposure occurred.

Only a fraction of the lead that is ingested or inhaled is actually absorbed into body tissues. The fraction absorbed depends on the mode of exposure, the chemical species of lead, the degree of previous and recent exposure to lead, the age of the subject, nutritional status, diet, and numerous other factors. Absorbed lead is transported rapidly through the body in blood, and can then accumulate in many other body tissues. Eventually much of the absorbed lead moves into the bone, where it can accumulate over a lifetime. Lead in blood and soft tissues (e.g., liver, brain, kidneys) can be eliminated fairly rapidly in urine or feces, with a half-life of about one month. Lead in bone, though, is released extremely slowly, and bone can serve as a source of lead to the rest of the body long after exogenous exposure to lead has ceased. Transfer of lead occurs easily to a fetus during pregnancy.

An individual's total exposure to lead can be gauged by sampling any of several biological tissues, including blood, urine, semen, hair, tooth, or bone. Sampling teeth or bone will indicate the individual's long-term exposure to lead; the soft tissues will indicate more recent exposure. As a matter of convenience in obtaining samples, blood has been the tissue most frequently chosen for investigation. Numerous investigations have been conducted in most countries throughout the world of the levels of lead in the blood of various populations—children, men, women, smokers, workers of various sorts, etc.. Numerous other studies have subsequently investigated the frequency of different adverse health effects in relation to the levels of blood lead in the studied population. We will use this information in estimating the magnitude of adverse health impacts from lead in Cairo by: 1) reviewing the available information on blood lead levels of Cairo residents; and then 2) applying dose-response functions developed in other countries to project the health effects resulting from the lead concentrations in the blood of Cairo's population.

Lead in blood

Concentrations of lead in blood (PbB) are usually measured in terms of micrograms of lead per deciliter of whole blood (ug/dL). Table 4-5 shows data collected on blood lead levels in Cairo. Data come from many sources and often represent small sample sizes. In some cases we have obtained the range of values and in others only the means.

Table 4-5. Blood Lead Levels in Cairo—Actual Measurements

GROUP	CONC. (UG/DL)	REFERENCE
Greater Cairo adults	29.69	El-Samra, et al., year?b
Greater Cairo children (age 7-12)	22.203	El-Samra, et al., year?b
Rural farmers (adults)	26.73	El-Samra, et al., year?b
Rural residents (60 km from Cairo)	12.14±6.2 (SD)	
Urban residents	30	GOE, 1992
Urban residents (low work exposure)	30.5 (13-41.3)	Nasralla, et al., 1984
Urban males (low work exposure)	29.7	Ali, 1988
Urban females (low work exposure)	27.5	Ali, 1988
Traffic policemen (moderate exposure)[a]	39.6±11.2 (SD)	Nasralla, et al., 1984b
Traffic policemen (high exposure)[b]	62.8±16.6 (SD)	Nasralla, et al., 1984b
Bus drivers	34.6±3.0 (SD)	Emara (year?)
Garage mechanics	36.6±3.3 (SD)	Emara (year?)
Smelter workers	80.2±5.3 (SD)	Shakour, et al., 1992
controls	30.3±1.8 (SD)	Shakour, et al., 1992
Primary school children (2.2 ug/m^3 lead in air)	23.8	Massaoud, et al., 1988
Primary school children (0.7 ug/m^3 lead in air)	13.23	Massaoud, et al., 1988
Children near smelters (Hadayek El-Qubba)[c]	> 60	Al-Ahram Weekly, 1992
15-year olds (Helwan, Shoubra el-Kheima)[d]	40 to 50	Lewnes, 1992
European children[e] (age 0-6)	11.3 (7.2-15.8)	German Embassy, 1993
European children (age > 6)	12.2 (9.7-16.5)	German Embassy, 1993
American children (age ≤ 3)	7.75	U.S. Embassy, 1993
American children (age 3-6)	9	U.S. Embassy, 1993
American children (age > 6)	3.5	U.S. Embassy, 1993

[a] Moderate exposure refers to 1,200 to 2,500 vehicles per hour passing the policemen

[b] High exposure refers to more than 2,500 vehicles per hour passing the policemen

[c] This is not an average, since these children were those chosen to be tested for lead poisoning.

[d] Lewnes cites as the source a study by Dr. Rifky Faris, chairman of Community, Environmental and Occupational Medicine at Ain Shams University.

[e] All children from Dokki/Giza and Garden City had blood lead levels above 10 ug/dL. Children from Maadi had the lowest blood lead levels.

Among these studies, the most extensive investigation of blood lead in Cairo is a 1993 study by El-Samra, et. al., the results from which are reported in Abdel Gawaad (1994). El-Samra, et al. tested 825 subjects and found the mean blood lead level for non-occupationally exposed adults in the Greater Cairo area to be 29.69 ug/dL. The same study looked at blood lead in rural farmers; the mean blood lead level for them was lower, at 26.73 ug/dL. Children (age 7-12) showed a similar pattern, with urban children having an average blood lead level of 22.20 ug/dL and rural children having 19.57 ug/dL. Men showed higher blood lead levels than women, at 29.46 ug/dL in comparison to 27.50 ug/dL for women. In three other independent studies, the average blood lead concentration in adults or adult men was also about 30 ug/dL (Nasralla, 1984; Ali, 1988; Shakour, 1992). Thus, we have chosen to use this figure as the mean blood lead level for men and 27.5 (Ali, 1988; El-Samra, 1993) as the mean level for women.

These blood lead values for adult residents of Cairo are well above the WHO 98th percentile blood lead guideline of 20 ug/dL (WHO/UNEP, 1992). El-Samra's mean blood lead level for children in the Greater Cairo area, 22.20 ug/dL, also far exceeds the U.S. Centers for Disease Control's recently (1991) established action level for blood lead in children of 10 ug/dL (OECD, 1993). U.S. EPA and the U.S. Agency for Toxic Substance Disease Registry have identified the same level of concern for children.

For comparison with these figures for Cairo, the mean blood lead level for adults in the U.S. is currently about 4 ug/dL and about 5 ug/dL for children (Firley, personal communication, 1994; OECD, 1993). Blood lead levels in the U.S. have been declining steadily for the past fifty years. The U.S. population last had an average blood lead level of about 30 ug/dL, the current level in Cairo, in the late 1930's. The populations of other large cities throughout the world have lower levels of blood lead than in Cairo, as shown in Table 4-6.

The mean blood lead concentrations shown in Table 4-5 are generally lower for children than for adults, with children living near smelters an exception. The apparent lower level of blood lead in children than in adults contrasts with the pattern in much of the rest of the world, where children are typically subject to more exposure pathways for lead than are adults (notably soil and paint) and have higher blood lead levels (OECD, 1993). The blood lead concentrations found for children in Cairo also appear more variable from study to study than the findings for adults. This is probably a result of the small sample sizes and episodic nature of the studies addressing children. In fact, we have not found any very comprehensive attempt to look at the blood lead levels of children, particularly young children, in Cairo. This limited knowledge is unfortunate, as young children are regarded as the group most subject to severe health risks from lead. The data in Table 4-5 for children are sufficiently variable that we are not confident in determining a mean blood lead level for children in Cairo, though for the purpose of health risk calculations we will assume the level found in the El-Samra study of 22.2 ug/dL.

Table 4-6. Average Blood Lead Levels (ug/dl)

City	Adults	Children	Year	Source
Cairo	29.7	22.2	mid 1980s	c
Ahmedabad	13.8	-	1981	a
Baltimore	7.5	-	1981	a
Bangalore	17.9	-	1981	a
Beijing	6.4	-	1981	a
Brussels	15.0	-	1981	a
Calcutta	10.7	-	1981	a
Christchurch	9.7	6.6	1985	b
France (8 cities)	16.7 / 11.9	-	male/female, 1982	b
Frankfurt am M.	14.2 / 10.8	-	male/female, 1977	b
Glasgow	0.4	-	1980	b
Jerusalem	8.2	-	1981	a
Liege, Belgium	13.0		1981	b
Lima	9.6	-	1981	a
Malta	23.2	-	1983	b
Mexico City	22.5	-	1981	a
New York		15.1 - 19.1	1976	b
Stockholm	4.8	-	1984	b
Tokyo	6.0	5.3 - 7.5	1981, 1980	a
U.K. (urban)		7.3	1987	b
Zagreb	9.2	-	1981	a

a UNEP. Environmental Data Report. 1987-88.
b UNEP. Environmental Data Report. 1989-90.
c Abdel Gawaad, 1994. (El Samra, et al., 1993)

Several other impressions from Table 4-5 are worth noting:

- The El-Samra study shows Cairo residents with only modestly higher levels of blood lead than rural farmers. In contrast, another study shows rural residents (60 km from Cairo) having much lower levels of blood lead. This uncertainty regarding blood lead levels for rural Egyptians would be worth resolving through further investigation, as doing so would shed light on the relative importance of different pathways for lead exposure. Assuming that diet and drinking water are roughly similar in urban and rural areas, the major urban to rural difference in exposure conditions probably involves lead in air. The more different urban and rural blood lead levels are, the more important lead in air and air deposition would seem to be.

- Several studies show extremely high blood lead levels for workers in highly exposed occupations—traffic policemen and smelter workers. Such blood lead levels would be expected to involve very serious adverse health effects (see the next section). For adults in the workplace in the U.S., blood lead levels exceeding 50 ug/dL trigger medical removals. A worker is allowed to return to work only when his or her blood lead level falls below 40 ug/dL (OECD, 1993). Although it is not one of the problems within the purview of this study, occupational exposures to lead and other toxic chemicals may be a significant public health threat in Cairo.

- Blood lead levels among residents near smelters and industrial areas are very high compared with those for the general population.

- Studies of German and U.S. embassy children suggested lower mean blood lead levels for them (about 4-12 ug/dL) than for Egyptian children. Assuming the samples were equally reliable, the difference may be explained by the length of residence in Cairo, with the embassy children likely to have been in Cairo for much less time. Perhaps also there is some correlation between lead exposure and socioeconomic status. In the U.S., for example, the soil and lead paint pathways affect lower income children more than they do upper income children, and lower income children therefore have higher blood lead levels on average (OECD, 1993).

Sources of Lead in Blood

Table 4-7 summarizes calculations aimed at evaluating the relative contribution of different exposure pathways to the levels of lead in Cairo residents. The second column shows the typical ambient concentration of lead to which Cairenes are exposed for each pathway. Note that two possible concentration ranges are given for lead in drinking water, to reflect the two contradictory ranges suggested by the Zahran and CWA data sets. The third and fifth columns provide "slopes" or coefficients that relate blood lead levels in adults and young children to ambient lead concentrations in each of the exposure pathways. The slope for a pathway represents a combination of three factors:

1. The daily intake through the pathway. For example, the average adult is assumed to inhale 20 m^3 of air each day, drink 2.81 (Abdel Gawaad, 1989) liters of water per day, consume about 1 kg of food per day distributed among specific food groups (Abdel Gawaad, 1989, derived from data from the Egyptian Nutrition Institute), and ingest no soil per day. Different intake amounts are assumed for young children. Some of these assumed intake amounts are specific to Egypt, and where Egyptian data are absent, U.S. assumptions are used. Knowing the ambient concentration of lead in an intake medium and the amount of the medium taken in each day, one can calculate the average daily intake of lead through each pathway.

2. The fraction of lead taken in through the pathway that is absorbed. In general, a high fraction of the lead that is inhaled is absorbed. A lesser fraction of lead in ingested drinking water is absorbed, while still less of the lead ingested in food is absorbed. For all pathways, the absorption fraction is higher for children than for adults (Rhoda, 1993).

3. The relationship between the amount of absorbed lead and the resulting increase in blood lead concentration. This is constant across pathways, but is affected by the body mass and metabolic characteristics of individuals. In general, a microgram of absorbed lead will have a greater effect on the blood lead level of a small child than a large adult.

The slopes are therefore different for each pathway and for adults and children. The fourth and sixth columns of Table 4-7 show the contribution to total blood lead from each pathway. This is the product of the concentration of lead in each exposure pathway and the slope for that pathway.

Table 4-7. Estimated Contribution of Individual Exposure Pathways to Blood Lead Levels in Cairo

Pathway		Concentration of Lead in Pathway	Slope for Adults (ug/dL per unit concentration)	Resulting Blood Lead (Adults) (ug/dL)	Slope for Children (ug/dL per unit Concentration)	Resulting Blood Lead (Children) (ug/dL)
Inhalation		0.5 to 3.0 ug/m^3	1.6[a,c]	1 to 5	1.9[e]	2 to 10
Water	Zahran[d]	300 to 600 ug/l	.06[e]	18 to 36	0.043[e]	13 to 26
	CWA[d]	6 to 20 ug/l		0 to 1		0 to 1
Food		Adults: 592 ug/day[f] Children: 120 ug/day[g]	0.04[b]	24	0.16[e]	19
Soil & Dust		50 to 500 ug/g	0[h]	0	0.032[i]	2 to 16
Total				25 to 65		23 to 71

a Source: OECD, 1993.
b Source: USEPA, 1986.
c In occupational settings, the relationship between lead in air and blood may have slopes as low as 0.02 to 0.08 ug/dL per ug/m^3 of air (OECD, 1993). Thus, at high ambient levels of lead in air, we may have overestimated the contribution of lead from air to blood lead.
d Zahran and CWA data sets show contradictory levels.
e Source: Marcus, 1989.
f It is assumed that this datum, from Abdel Gawaad, et al., represents adult exposure.
g Assuming child's dietary lead intake bears the same proportional relationship to adult's dietary intake as child's body weight to adult's body weight.
h Assuming no ingestion of soil by adults.
i Assuming the same rate of absorption as for food, and ingestion of 0.2 g/day (USEPA, 1990).

Numerous assumptions are involved in these calculations. Many are derived from research about behavior in the U.S. that may be different than behavior in Cairo. For example, one assumption based on U.S. research is that the average child ingests 2 grams/day of soil and/or dust. Children in Cairo may act in ways that lead them to ingest more or less than this assumed amount. Nevertheless, the average blood lead levels in Cairo projected from these calculations are reasonably close to the blood lead levels apparently prevailing in the city, lending credence to the calculations. We conclude from these calculations that:

- The relative importance of the different pathways in contributing to blood lead in Cairo is similar to the relative importance of the pathways in contributing to lead intake. For adults, food is the most important pathway if the Zahran data on lead in tap water are assumed to be incorrect. If the Zahran data are assumed to be correct, water and food are roughly equally important. For children, food is the most important pathway, but air and soil are also significant if the Zahran data are assumed to be incorrect. If the Zahran data are assumed to be correct, water and food are roughly equally important, with food and soil also significant.

- Assuming the Zahran data to be correct yields projected blood lead levels well in excess of the apparent actual levels. Assuming the Zahran data to be incorrect yields projected blood lead levels very close to the apparent actual levels. This adds more weight to a suspicion that the Zahran data are somehow not representative.

Note that these conclusions about the relative importance of different exposure pathways to lead refer to the pathways by which individuals are ultimately affected by lead, and not necessarily to the means by which lead initially enters the environment. Food may be the most important exposure pathway, but, as discussed earlier, there are a variety of ways that lead may get into the food consumed by Cairo residents including air deposition, fertilizer use, etc.. Further studies are needed to better understand the movement of lead among different environmental media in Cairo. With the completion of such studies, one can assess which sources releasing lead to the environment must be addressed in order to reduce Cairenes' exposure to lead.

HEALTH RISKS FROM LEAD IN CAIRO

A large body of research exists relating blood lead to numerous adverse health effects. Much of this research has been conducted in the U.S. and other developed countries, and little has been conducted in Egypt. Because of the lack of locally-derived dose-response relationships, in this annex we use primarily U.S. studies to link blood lead levels to anticipated health effects. Although these are the best estimates available for this study, they are only as accurate as: 1) the equations from which they are derived (which have been validated for blood lead levels that are generally lower than the range observed in Cairo) and 2) the degree to which residents of Cairo respond to lead like the populations in developed countries that were the subjects of the studies.

Tables 4-8 and 4-9 summarize some of the more important health effects in children and adults that are observed at various blood lead levels. The lower levels at which effects are observed may be related to real thresholds or to levels at which enough people exhibit the health

Table 4-8.

Summary of Lowest Observed Effect Levels for Key Lead-Induced Health Effects in Children

Lowest observed effect level (PbB)*	Heme synthesis and hematological effects	Neurological effects	Renal system effects	Gastrointestinal effects
80-100 μg/dl		Encephalopathic signs and symptoms	Chronic nephropathy (aminoaciduria, etc.)	Colic, other overt gastrointestinal symptoms ↓
70 μg/dl	Frank anemia			
60 μg/dl		Peripheral neuropathies ↓		
50 μg/dl		?		
40 μg/dl	Reduced hemoglobin synthesis Elevated coproporphyria Increased urinary ALA	Peripheral nerve dysfunction (slowed NCV's) CNS cognitive effects (IQ deficits, etc.) ↓		
30 μg/dl		? ↓	Vitamin D metabolism interference ↓	
15 μg/dl	Erythrocyte protoporphyia elevation ↓	Altered CNS electrophysio-logical responses ↓		
10 μg/dl	ALA-D inhibition PY-5-N** activity inhibition ↓ ?	?	?	

* PbB = blood lead concentrations.

** PY-5-N = pyrimidine-5'-nucleotidase.

Source: U.S. EPA (1986a)

163

Table 4-9.

Summary of Lowest Observed Effect Levels for Key Lead-Induced Health Effects in Adults

Lowest observed effect level (PbB)*	Heme synthesis and hematological effects	Neurological effects	Effects on the kidney	Reproductive function effects	Cardiovascula effects
100-120 µg/dl		Encephalopathic signs and symptoms	Chronic neuropathy ↓		
80 µg/dl	Frank anemia				
60 µg/dl		— ↑		Female reproductive effects	
50 µg/dl	Reduced hemoglobin production	Overt subencephalopathic neurological symptoms ↓		Altered testicular function ↓	
40 µg/dl	Increased urinary ALA and elevated coproporphyrins	Peripheral nerve dysfunction (slowed nerve conduction) ↓	↓	↓	
30 µg/dl		—			Elevated bloo pressure (white males) aged 40-59 ↓
25-30 µg/dl	Erythrocyte protoporphyrin (EP) elevation in males				
15-20 µg/dl	Erythrocyte protoporphyrin (EP) elevation in females				
<10 µg/dl	ALA-D inhibition				↓ ?

* PbB = blood lead concentrations.

Source: U.S. EPA (1986a)

effect to be noticeable. The wide range of impacts, including those on the cardiovascular, nervous, reproductive, excretory, and digestive systems, are notable. Also remarkable are the low blood levels at which impacts begin to occur. There is little margin of safety between even the current low American blood lead levels and the levels at which health effects begin to occur. In Cairo, workers in smelters and traffic policemen, with mean blood lead levels above 60 and 80 ug/dL, respectively, would be at high risk of almost all of the conditions in Table 4-9.

Numerous large epidemiological studies have quantified the relationship between blood lead levels and the frequency with which various of these health impacts are observed. Experimentation with animals has provided additional understanding of some of the physiological impacts and has established causality for some of the effects. We have selected several of the more confident of these quantitative relationships to use in estimating the health impacts from the levels of blood lead prevailing in Cairo. The quantitative relationships we use are described in Annex D-1 following this paper—a review of dose-response functions associated with blood lead by Mr. Brad Firley of Abt Associates, Inc. Mr. Firley is a consultant to the U.S. EPA on the health effects of lead, and he prepared his review paper specifically to summarize the current state of knowledge about blood lead dose-response functions for the Cairo CRA.

Using the data cited previously on blood lead levels in Cairo, the quantitative dose-response relationships shown in Annex D-1, and demographic data about Cairo's population that is necessary for using the dose-response relationships (e.g., population in various age groups, birth rate), we can calculate the health effects from lead in Cairo. Since natural sources make it unlikely that lead exposure could be completely eliminated, we calculate specifically the health effects that would be avoided if blood lead levels in Cairo could be reduced to levels comparable to those in the U.S. now (about 4 ug/dL for adults and 5 ug/dL for children). These health effects involve mental development in children, infant mortality, and cardiovascular illness. Additional suspected, but less certain, effects of lead are not estimated.

Loss of Intelligence in Children

The most significant effects of lead exposure on children relate to the sensitivity of the developing nervous system. A widely publicized impact of lead is on the IQ of children. Analysis of seven different epidemiological studies suggests that for a 1 ug/dL increase in blood lead, a decrease of 0.25 IQ points is likely. If the mean concentration of lead in the blood of children in Cairo is about 22 ug/dL, then children in Cairo would have a mean IQ of 4.25 points less than American counterparts with a mean blood lead concentration of 5 ug/dL.[4] For Cairo children with blood lead levels closer to 10 ug/dL, an IQ decrease averaging 1.25 points is probable. If children living near smelters have blood lead concentrations closer to 60 ug/dL, their IQs are likely to be around 14 points lower than American children. It is important to

[4] The estimated IQ points lost represents an average across the population, and only applies to an individual child in a probabilistic manner.

note, however, that the relationship between blood lead concentration and IQ has not been linearized for values above 20 ug/dL. The relationship between blood lead and IQ at blood lead levels higher than this may be different (OECD, 1993).

The implications of such a reduction in IQ for the productivity and earning potential of Cairo's population are very large. Assuming that childhood reductions in IQ persist into adulthood, a 4.25 point average loss in IQ might decrease the fraction of Cairo's population with IQ's over 120 (popularly thought of as "geniuses") by nearly 1/2, and increase the fraction of the population with IQ's less than 80 by nearly 1/2. Several years ago in the U.S., it was estimated that for each decrease in IQ of 1 point there would be a loss in lifetime income of $500 on a present value basis (USEPA, 1989b).

Infant Mortality

Infant mortality may also be linked to the lead exposure of the mother. High blood lead levels in pregnant women correlate with reduced gestational age for newborns, and reduced gestational age increases infant mortality. There is a decreased risk of infant mortality of 10^{-4} for each 1 ug/dL decrease in maternal blood lead level during pregnancy. That is, for every 10,000 infants born to mothers whose blood lead decreases by 1 ug/dL during pregnancy, there will be one fewer infant mortality.

There are about 350,000 births annually to the population of Greater Cairo.[5] If blood lead for women in Cairo were to decrease from an average of 27.5 ug/dL currently to 4 ug/dL, the risk of mortality for each of these births would decline by 23.5×10^{-4}. Infant mortality would decrease by about 820 per year.

Cardiovascular Illnesses and Death

Elevated blood lead has been linked to elevated blood pressure in both adult males and females. In turn, high blood pressure is a significant risk factor in cardiovascular illnesses. Both of these relationships have been quantified through large epidemiological studies in the U.S. and elsewhere. To project cardiovascular illnesses from lead in Cairo, we use the two-step procedure recommended by Firley in Annex D-1: 1) relate blood lead to blood pressure, and then 2) relate illnesses to blood pressure. We use the equations provided by Firley with one exception described below.

Numerous studies have been conducted to determine mathematical relationships between blood lead and blood pressure. Most of these studies involved individuals with blood lead levels

---

[5] Assuming that the birth rate in Cairo is the same as for all of Egypt, a crude birth rate of 29.2 per 1,000 population (CAPMAS, 1993) results in 350,000 births among an estimated population of 12 million in Greater Cairo.

lower than those in Cairo now. The relationships estimated in the studies are most applicable and most confident for blood lead levels between 5 ug/dL and 15 ug/dL, and there is a great deal of uncertainty about how to extrapolate for blood lead levels much higher than this. We have chosen to reflect the uncertainty about how to extrapolate for the higher blood lead levels in Cairo by using a range of relationships rather than the single one recommended by Firley:

1. Firley (p.2) suggests that a 1.4 mm change in blood pressure in adult men is expected for a one ug/dL change in their blood lead. This is based on Schwartz (1992). Applying this relationship to Cairo, a decline in the average adult male blood lead from 30 ug/dL to 4 ug/dL would reduce blood pressure by 36.4 mm. Such a massive decrease is not plausible.

2. Firley (p.5) also suggests an alternate interpretation of the Schwartz conclusions: a decrease of blood lead from 10 ug/dL to 5 ug/dL would decrease blood pressure by 1 mm. Applying this relationship to Cairo, the decline from 30 ug/dL to 4 ug/dL would reduce blood pressure by 5.2 mm.

3. In an extensive review of dose-response information for air pollutants for the World Bank, Ostro (1994) chooses a non-linear functional form predicting the change in blood pressure resulting from a change in blood lead from one level to another:

$$\text{Change in blood pressure} = 2.74 (\ln PbB_1 - \ln PbB_2)$$

   Applying this relationship, the decline from Cairo to U.S. blood lead levels would reduce average blood pressure in Cairo by 5.5 mm.

4. An OECD Task Group on human health risks from lead reviewed most of the same studies as Firley, Schwartz and Ostro and concluded that "...for any two-fold increase in PbB level there is a mean 1 mmHg increase in...blood pressure" (OECD, 1993, p. 174). Applying this relationship, a decline of blood lead from 30 ug/dL to 4 ug/dL would constitute roughly 3 halvings, for a decrease in average blood pressure of about 3 mm.

The differences between these various estimates result largely from the assumption of different functional forms for the relationship between blood lead and blood pressure in the range of 5-15 ug/dL. When subsequently extrapolating to 30 ug/dL, the choice of functional form proves very important.

We have chosen to estimate health effects using a range for the relationship between blood lead and blood pressure formed by the Ostro (#3 above, for the high end of the range) and OECD (#4 above, for the low end of the range) approaches. Firley's second approach (#2 above) is bracketed by Ostro and OECD, while we eliminate Firley's first approach (#1 above) as yielding implausible results. Thus, for adult men in Cairo, we assume that reducing blood lead to U.S. levels would reduce blood pressure by between 3 mm (low estimate) and 5.5 mm (high estimate). For women, we use Firley's recommendation that the effect in adult women is 0.6 times the effect in adult men and apply the Ostro and OECD approaches. This yields estimates that reducing the blood lead of Cairo women from 27.5 ug/dL to the current U.S. level of 4 ug/dL would reduce blood pressure by between 1.8 mm (low estimate) and 3.2 mm (high estimate).

To estimate numbers of cardiovascular illnesses, we then apply the various equations in Annex D-1 relating health effects to blood pressure for the high and low estimates of blood pressure changes. Table 4-10 shows the results of applying the equations—the decrease in the probability of various cardiovascular health effects among different age/sex groups in Cairo that would result from lowering blood lead to U.S. levels.

Table 4-10. Reduced Probability of Cardiovascular Health Effects From Reduction in Blood Lead

Health Effect		Sex	Age	Reduction in Annual Probability (low)	Reduction in Annual Probability (high)
Initial Heart Attack		Men	40 - 59	0.00580	0.01030
			60 - 64	0.00231	0.00412
			65 - 74	0.00207	0.00370
		Women	45 - 74	0.00097	0.00172
Stroke	Cerebrovascular Accident	Men		0.00027	0.00048
		Women	45 - 74	0.00021	0.00037
	Brain Infarction	Men		0.00015	0.00027
		Women	45 - 74	0.00014	0.00023
Premature Mortality		Men	40 - 54	0.00705	0.01246
			55 - 64	0.00170	0.00305
			65 - 74	0.00103	0.00188
		Women	45 - 74	0.00065	0.00117

Applying these changes in probabilities of health effects to the numbers of individuals in Cairo in different age/sex groups, we estimate the following reductions in cardiovascular health effects from a reduction in blood lead in Cairo to U.S. levels:

- 6,500 - 11,600 heart attacks annually;
- 800 - 1,400 strokes annually;
- 6,300 - 11,100 premature deaths from cardiovascular illness annually.

Although highly uncertain, these estimates suggest a very significant adverse impact of lead on the cardiovascular health of Cairo's residents.

Other Possible Health Effects From Lead

We have chosen not to estimate any additional sorts of adverse health effects from lead in Cairo. Firley in Annex D-1 suggests several additional ways in which lead has been shown to affect humans adversely. Lead compounds have been found to be carcinogenic and mutagenic in animal studies, and similar effects in humans are suspected. Lead stored in women's bones may be mobilized into blood during conditions of bone demineralization associated with pregnancy, lactation, and osteoporosis. High blood lead levels during pregnancy thus appear to affect not only the health and survival of live infants (as quantified earlier), but also rates of miscarriage and stillbirth. In post-menopausal women, high blood lead levels may aggravate the course of osteoporosis, since lead is known to inhibit activation of vitamin D, uptake of dietary calcium, and several regulatory aspects of bone cell formation. Because any dose-response functions for these additional possible effects of lead are quite speculative, however, we have not developed quantitative estimates for them.

SUMMARY AND LIMITATIONS OF THIS STUDY

We conclude that lead causes significant adverse health effects at the levels to which Cairo's population is exposed. If blood lead levels in Cairo were reduced to those in the U.S. now, we estimate that the following health effects would be avoided:

Table 4-11. Summary of Health Effects From Lead in Cairo

TYPE OF EFFECT	ESTIMATE
Intelligence loss in children	Average of 4.25 IQ points lost per child
Infant mortality	820 deaths per year
Cardiovascular illness in older adults	-
Heart attacks	6,500 - 11,600 per year
Strokes	800 - 1,400 per year
Premature deaths	6,300 - 11,100 per year

Although these numerical estimates should be regarded as highly uncertain, we are quite confident that the health effects of lead in Cairo are very significant. In contrast to that for most other environmental pollutants, risk assessment for lead is based on actual measurements of the body burden of the pollutant (lead in blood), rather than modeled estimates of human exposure based upon limited ambient monitoring of the pollutant. And again in contrast to other pollutants, the health effects of lead have been studied extensively—in humans as well as in animals—and for levels of exposure similar to those prevailing in the environment.

The numerical estimates of the adverse health effects from lead in Cairo are uncertain for several reasons having to do both with the quality of the exposure data on lead in Cairo and the dose-response relationships that are applied to the exposure data.

- The exposure estimates depend on several studies of the levels of lead in the blood of Cairo residents. We know little about the statistical sampling, measurement, and quality control procedures used in these studies. The studies are not sufficiently comprehensive to provide a picture of the spatial, demographic, or socioeconomic variability of blood lead levels across Cairo. Children are not well covered by the studies. In most cases, we do not know when the blood lead sampling programs were undertaken. This may be important if Cairo, with recent efforts to reduce lead in gasoline, shows similarly declining levels of lead in blood as many other cities throughout the world.

- Studies investigating the dose-response relationship between blood lead and blood pressure have focused on populations with blood lead levels typically significantly lower than those in Cairo. Several functional forms have been fit to data in the range of 5-15 ug/dL of blood lead, and these produce significantly different estimates of resulting health effects when extrapolating to the higher levels of blood lead in Cairo.

- The epidemiological studies themselves have arrived at mixed conclusions, even within the range of blood lead levels they have focused on. In general, the understanding of lead's effects on childhood intelligence are most certain, with impacts on cardiovascular illness and infant mortality less so. Dose-response relationships associated with suspected other health effects from lead are so uncertain as to prevent quantification.

The situation is further complicated when one seeks to understand what sources of lead exposure in Cairo are most responsible for the projected adverse health impacts. Knowledge about the levels of lead in each environmental medium are limited. There are major uncertainties about the concentrations of lead in drinking water as a result of conflicting studies on this issue. Data regarding the lead content of different foods consumed in Cairo are also conflicting.

Future efforts to reduce the adverse health effects due to lead in Cairo will require better knowledge about the direct sources of human exposure to lead (e.g., amounts inhaled vs. ingested from various sources) and—in order to design effective control programs—about the sources responsible for putting lead into the environment. Once it is in the environment, lead is a persistent pollutant that undergoes numerous complicated processes moving it from one place and environmental medium to another: deposition from the air, re-entrainment to the air, binding to soils, crop uptake, etc.. Our knowledge is particularly limited and speculative about the diverse means by which lead enters the environment in general and then reaches the environmental media to which people are exposed. Further studies to pinpoint the sources of lead to the environment and to understand its movement and fate would be valuable.

REFERENCES

Abdel Gawaad, 1994. Abdel Gawaad, A.A. "Ranking Environmental Health Risks in Cairo, Egypt." Background paper for the Cairo CRA. January, 1994.

Abdel Gawaad, 1992. Abdel Gawaad, A.A., F.I. Zahran, Z.M. Seleim, and A. El Mousallamy. "Monitoring of Heavy Metals Except Lead in the Tap Water." Journal of the Egyptian Society of Toxicology 9(July, 1992):33-36.

Abdel Gawaad, 199?. Abdel Gawaad, A.A., N.A. Soliman, F.I. Zahran, F. Seleim, and A. El Mousallamy. "The Daily Intake of Lead by the Egyptian People." Journal of the Egyptian Society of Toxicology .

Abdel Gawaad, 1989. Abdel Gawaad, A.A. and A.S. El Dine. "Insecticide Residues in Total Diet Samples," Journal of the Egyptian Society of Toxicology 4(1989):79-84.

Al-Ahram, 1992. "Something has to be done." Al-Ahram Weekly (17-23 Sept. 1992).

Ali, 1992. Ali, E.A. " Toxic effects of autoexhaust on vegetation and the use of soluble protein and chlorophyll as pollution indicators." Journal of the Egyptian Society of Toxicology 8(1992):89-93.

Ali, 1992b. Ali, E.A., Y.H. Ibrahim, and M.M. Nasralla. "Solubility and Rates of Heavy Metals Dry Deposition Over the Complex Industrial District, South of Cairo." Egyptian Journal of Occupational Medicine 16(1992):67-71.

Ali, 1991. Ali, E.A. "Accumulation of toxic metals in orange fruits and the toxic effects of autoexhaust on orange trees grown around traffic roads." Journal of the Egyptian Society of Toxicology 7(1991):107-114.

Ali, 1990. Ali, E.A. and M.M. Nasralla. "Using hair as a bioindicator for the exposure to heavy metals in the Egyptian environment." Egyptian Journal of Occupational Medicine 14.2(1990):287-292.

Ali, 1988. Ali, F.A. "Determination of normal levels of some metals in blood of non-exposed Egyptian subjects." M. D. thesis. Occupational Medicine, Cairo University. 1988.

Ali, 1986. Ali, E.A., M.M. Nasralla, and A. A. Shakour. "Spatial and seasonal variation of lead in Cairo atmosphere." Environmental Pollution (Series B) 11(1986):205-210.

Ali, 1986a. Ali, E.A. and M.M. Nasralla. "Impact of motor vehicle exhaust on the cadmium and lead contents of clover plants grown around Egyptian traffic roads." International Journal of Environmental Studies 28(1986):157-161.

Ali, 1985. Ali, E.A. and M.M. Nasralla. "An investigation of heavy metals in urban soil and Cairo street dust," pp. 559-561. In T.D. Lekkas (ed.). Heavy Metals in the Environment, Vol. 2. Conference, Athens, Sept. 1985.

CAPMAS, 1993. Central Agency for Public Mobilization and Statistics. Statistical Year Book, June 1993. Cairo.

CWA, 1992. Cairo Water Authority (General Organization for Greater Cairo Water Supply). "Heavy metals monthly report." Central Lab, Giza. 1992.

EEAA, 1993. Egyptian Environmental Affairs Agency, Technical Cooperation Office for the Environment. Project Proposal: "Vehicle Inspection Centers and Licensing System." Submitted to the World Bank, February 25, 1993.

El-Gamal, 1992a. El-Gamal, Ibrahim M. "Distribution patterns of some heavy metals in soil and plants along el-Moukattam highway." Journal of the Egyptian Society of Toxicology 9(1992):51-53.

El-Gamal, 1992b. El-Gamal, Ibrahim M. "Role of Micropollutants Residues on the Evaluation of Drainage Water in Rosetta Branch as a Source of Irrigation." Journal of the Egyptian Society of Toxicology 9(1992):37-40.

El-Samra, ?a. El-Samra, G.H., A.M. Zaghloul, M.M. Amr, M.M. El-Batanouni, A.N. Abou-Ali, and B. Ananian. "Health effects of the environmental pollution by automobile exhaust in different cities in Egypt." Supreme Council of Universities. FRCU Grant No. 82033, Progress Report No. 3. year??

El-Samra, ?b. Reported in Abdel Gawaad, 1994.

Emara, ?. Emara, A.M. "Health effects of the environmental pollution by automobile exhaust in different cities in Egypt." Supreme Council of Universities, FRCU Grant No. 82033, Progress Report No. 4. year??

German Embassy, 1993. Embassy of the Federal Republic of Germany, the Regional Medical Officer, Cairo. Report: Lead levels in children in Cairo, May 1993. June 15, 1993.

GOE, 1992. Government of the Arab Republic of Egypt, Egyptian Environmental Affairs Agency. Environmental Action Plan. May 1992.

Goyer, 1986. Goyer, R.A. "Toxic effects of metals," pp. 582-635. In Klaassen, C.D., M.O. Amdur, and J. Doull (eds.) Casarett and Doull's Toxicology: The Basic Science of Poisons. New York: Macmillan. 1986.

Lewnes, 1992. Lewnes, A. "Heavy breathing." Cairo Today 114-118. October 1992.

Mahaffey, 1982. Mahaffey, K.R., J.L. Annest, J. Roberts, and R.S. Murphy. "Estimates of blood lead levels: United States 1976-1980. Association with selected demographic and socioeconomic factors." New England Journal of Medicine 307(1982):573-579.

Mahmoud, 1992. Mahmoud, M.A. "Biochemical studies on lead pollution." Masters thesis. Cairo University. 1992.

Marcus, 1989. Marcus, A. "Contribution to a risk assessment for lead in drinking water." Draft final report to U. S. EPA. Battelle/Columbus Division, Arlington, MD. 1989.

Massaoud, 1988. Massaoud, A.A., A.-A.M. Kamal, and H.I. Fahim. "Association of traffic flow and the blood lead level of children of 5 to 10 years old." The Egyptian Society of Basic Medical Science, Cairo. 1988.

Nasralla, 1993a. Nasralla, M.M. Air Pollution in Greater Cairo. Background Paper for the Cairo CRA. December, 1993.

Nasralla, 1993b. Nasralla, M.M. "Air pollution." In Rouchdy Saleh, editor. Egyptian Environment...An Overview. Cairo: Embassy of Canada. April, 1993.

Nasralla, 1984. Nasralla, M.M. and E.A. Ali. "Lead, cadmium, and zinc pollution around Egypt traffic roads." Egyptian Journal of Occupational Medicine 8(1984):197-210.

Nasralla, 1984a. Nasralla, M.M. "Lead in Urban Environment." Egyptian Journal of Occupational Medicine 8(1984):53-64.

Nasralla, 1984b. Nasralla, M.M., A.A. Shakour, and E.A. Said. "Effect of lead exposure on traffic policemen." Egyptian Journal of Industrial Medicine 8.1(1984):87-104.

OECD, 1993. Organization for Economic Co-operation and Development, Environment Directorate. Risk Reduction Monograph No. 1: Lead. Background and Experience with Reducing Risk. Paris, 1993.

Ostro, 1994. Ostro, Bart. "Estimating Health Effects of Air Pollution. A Methodology With an Application to Jakarta." Paper for the World Bank, March, 1994.

Rhoda and Krause, 1993. Rhoda, R. and K. Krause. "Lead pollution in Cairo: review of available information." USAID/Cairo, Office of Environment Report, 1993.

Schwartz, 1992. Schwartz, Joel. "Blood Lead and Blood Pressure: a Meta-Analysis." Presented at the Annual Meeting of Collegium Ramazzini. November, 1992.

Shakour, 1992. Shakour, A., M.M. Nasralla, M.I. Mohamed, and M.A. Hassanien. "Effects of long-term exposure of lead and cadmium on cholinergic enzymes." International Journal of Environmental, Health Resources 2(1992):138-146.

Sherlock, 1987. Sherlock, J. "Lead in Food and the Diet." Environmental Geochemistry and Health 9.2(1987):43-47.

"Study for Replacing the Existing Lead Processing Plant at General Metals Company, Helwan-Tebbin." 1993 (draft).

UNEP, 1988. United Nations Environment Programme/FAO/WHO. Assessment of Chemical Contaminants in Food. 1988.

UNEP, 1988/1989. United Nations Environment Programme. Environmental Data Report. First Edition, 1988/1989.

UNEP, 1989/1990. United Nations Environment Programme. Environmental Data Report. Second Edition, 1989/1990.

UNEP, 1991/1992. United Nations Environment Programme. Environmental Data Report. Third Edition, 1991/1992.

USAID, 1993. U.S. Agency for International Development/Cairo. "Core Program for Environmental Development and Protection in Egypt—Pilot Project For Improving Transport Air Quality Management in Greater Cairo Area." Draft, April, 1993.

U.S. Embassy, 1993. American Embassy in Cairo. Staff announcement. "Blood Lead and Air Pollution." February 2, 1993.

USEPA, 1990. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment. Exposure Factors Handbook. EPA/600/8-89/043. March, 1990.

USEPA, 1989. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Review of the National Ambient Air Quality Standards for Lead: Exposure Analysis Methodology and Validation. Research Triangle Park, North Carolina. June, 1989.

USEPA, 1989b. Monetized Health Benefits of Regulating Sewage Sludge Use and Disposal. Prepared by Abt Associates, Inc. for the Office of Policy Analysis and the Office of Water Regulations and Standards, Washington, DC, May, 1989.

USEPA, 1986. U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office. Air quality criteria for lead, Vols. I-IV. Cincinnati, OH. EPA 600/8-83/028dF. June, 1986.

USEPA, 1983. U.S. Environmental Protection Agency, Office of Research and Development. Hazardous Waste Land Treatment. PB89-179014, April 1983, page 273.

WHO, 1984. World Health Organization. Guidelines for drinking water quality. Geneva, 1984.

WHO/UNEP, 1992. World Health Organization and United Nations Environment Programme. Urban Air Pollution in Megacities of the World. (Earthwatch, Global Environment Monitoring System) Blackwell Reference. 1992.

World Bank, 1992. Norconsult International. "Environmental assessment and screening of the Helwan area, Egypt." Draft report for the World Bank, 1992.

Zahran, 1992. Zahran, F.I., A. El-Mousallamy, N.A. Soliman, Z.M. Seleim, and A.A. Abdel Gawaad. "Toxicity and monitoring of lead in tap water." Journal of the Egyptian Society of Toxicology 9(1992):55-58.

Infant Mortality

The Centers for Disease Control (CDC, 1991) presents a method to estimate changes in infant mortality due to changes in maternal blood lead levels during pregnancy[1]. The analysis links two relationships. The first relationship, between maternal blood lead level and gestational age of the newborn, was estimated by Dietrich et al. (1987). CDC then estimated infant mortality as a function of gestational age, using data from the Linked Birth and Infant Death Record Project from the National Center for Health Statistics. The resulting association is a decreased risk of infant mortality of 10^{-4} (or 0.0001) for each 1 μg/dL decrease in maternal blood lead level during pregnancy.

Measuring Changes in IQ

A dose-response relationship for IQ decrements has been estimated by a meta-analysis of seven research studies (Schwartz, 1993). Regression coefficients for each study were used to determine a weighted average linear regression coefficient for the relationship between PbB and IQ. Each regression coefficient was weighted by the inverse of the variance of each estimate. To determine an overall coefficient, the regression coefficients for studies that used natural logarithms of PbB as the exposure index were linearized. In general, the coefficient was linearized in the PbB range of 10 to 20 μg/dL. However, in one study (Bellinger et al. 1991), 70 percent of the data was below 10 μg/dL; thus, the data was linearized in the 5 to 15 μg/dL range. For the studies that did not transform PbB concentrations, the regression coefficients were used directly. Given the typical uncertainty within individual studies, the variation in the regression coefficients among studies was not more than would be expected. The relationship determined by Schwartz (1993) suggests that for a 1 μg/dL increase in PbB, a decrease of 0.25 IQ points can be expected. The p-value (< 0.0001) indicates that this relationship is highly significant.

Health Benefits to Men

Elevated blood lead has been linked to elevated blood pressure in adult males, especially men aged 40-59 years (Pirkle et al. 1985). Further studies have demonstrated a dose response relationship for hypertension (defined as diastolic blood pressure above 90 mm Hg for this model) in males aged 20-74 years (Schwartz 1988). This relationship is:

$$\Delta Pr(HYP) = \frac{1}{1 + e^{2.744 - .793 \cdot (\ln PbB_1)}} - \frac{1}{1 + e^{2.744 - 0.793 \cdot (\ln PbB_2)}} \qquad \textbf{Equation A.1}$$

where,

+ΔPr(HYP) = the change in the probability of hypertension;

[1] The estimated change in infant mortality due to change in birthweight was not modeled because the data relating prenatal lead exposure to birth weight is not as strong as data relating lead exposure and gestational age.

PbB_1	=	blood lead level in the factual scenario; and
PbB_2	=	blood lead level in the counterfactual scenario.

Because blood pressure has been identified as a risk factor in a number of cardiovascular illnesses (Shurtleff 1974, McGee and Gordon 1976, Pooling Project 1978), it is useful to quantify the effect of changes in blood lead levels on changes in blood pressure for reasons other than predicting the probability of hypertension. A meta-analysis of several studies (Schwartz, 1992) estimated that a 1.4 mm Hg change in blood pressure is expected for a one μg/dL change in PbB. The following equation based on this relationship is used in this benefits model:

$$\Delta BP_{men} = 1.4*(PbB_1 - PbB_2) \qquad \text{Equation A.2}$$

where,

ΔBP_{men}	=	the change in men's blood pressure expected from a change in PbB;
PbB_1	=	blood lead level in the factual scenario; and
PbB_2	=	blood lead level in the counterfactual scenario.

The relationship between blood pressure and other health effects can be used to predict increased probabilities of the initial occurrence of heart attack and stroke (USEPA 1987). Increased blood pressure would also increase the probability of reoccurrences of heart attacks and strokes, but these quantified relationships are not available. First-time heart attacks (coronary heart disease events) in men can be predicted using an equation with different **coefficients and intercepts?** for each of three age groups. For men between 40 and 59 years old, information from McGee and Gordon (1976) is used. McGee and Gordon (1976) developed a multivariate model (controlling for smoking and serum cholesterol) that relates the probability of coronary heart disease to blood pressure. The model used data from the Framingham Study, a large general-population study that tracked a sample of men and women (initially between the ages of 30 and 59) living in Framingham, Mass. for a period of 18 years. The equation for men between 40 and 59 years old is taken from the study by McGee and Gordon (1976). Since the relationship in McGee and Gordon (1976) estimated the 10-year probability of occurrence of CHD, the equation presented below divides the change in probability by ten, assuming the probability of occurrence is the same for each year during a ten year period:

$$\Delta Pr(CHD_{40-59}) = \frac{1}{1 + e^{4.996 - 0.030365 \cdot BP_1}} - \frac{1}{1 + e^{4.996 - 0.030365 \cdot BP_2}} \qquad \text{Equation A.3}$$

where,

$\Delta Pr(CHD_{40-59})$	=	change in annual probability of occurrence of CHD event for men between 40-59 years old,
BP_1	=	mean diastolic blood pressure in the factual scenario; and
BP_2	=	mean diastolic blood pressure in the counterfactual scenario.

The relationship between BP and first time heart attacks in older men was determined from information presented in Shurtleff (1974). This study also uses data from the Framingham Study to estimate univariate relationships between BP and a variety of health effects by sex and for each of the following age ranges: 45-54, 55-64, and 65-74 years. Single composite analyses for ages 45-74 were also performed for each sex. For every equation, t-statistics on the variable blood pressure are significant at the 99th percent confidence interval. For men aged 60 to 64 years old, first-time heart attacks can be predicted from the following equation:

$$\Delta Pr(CHD_{60-64}) = \frac{1}{1 + e^{5.19676 - 0.02351 \cdot BP_1}} - \frac{1}{1 + e^{5.19676 - 0.02351 \cdot BP_2}} \qquad \textbf{Equation A.4}$$

where,

$\Delta Pr(CHD_{60-64})$ = change in annual probability of occurrence of CHD event for men from 60 to 64 years old;
BP_1 = mean diastolic blood pressure in the factual scenario; and
BP_2 = mean diastolic blood pressure in the counterfactual scenario.

For men aged 65 to 74 years old, the following equation uses data from Shurtleff (1974) to predict the probability of first-time heart attacks:

$$\Delta Pr(CHD_{65-74}) = \frac{1}{1 + e^{4.90723 - 0.02031 \cdot BP_1}} - \frac{1}{1 + e^{4.90723 - 0.02031 \cdot BP_2}} \qquad \textbf{Equation A.5}$$

where,

$\Delta Pr(CHD_{65-74})$ = change in annual probability of occurrence of CHD event for men from 65 to 74 years old;
BP_1 = mean diastolic blood pressure in the factual scenario; and
BP_2 = mean diastolic blood pressure in the counterfactual scenario.

Two types of health events are categorized as strokes: initial cerebrovascular accidents (CA) and initial atherothrombotic brain infarctions (BI). The risk has been quantified for the male population between 45 and 74 years old (Shurtleff 1974). For initial cerebrovascular accidents, the logistic equation is:

$$\Delta Pr(CA) = \frac{1}{1 + e^{8.58889 - 0.04066 \cdot DBP_1}} - \frac{1}{1 + e^{8.58889 - 0.04066 \cdot DBP_2}} \qquad \textbf{Equation A.6}$$

where,

$\Delta Pr(CA_{men})$ = change in 2 year probability of cerebrovascular accident in men;
DBP_1 = mean diastolic blood pressure in the factual scenario; and
DBP_2 = mean diastolic blood pressure in the counterfactual scenario.

For initial atherothrombotic brain infarctions, the logistic equation is:

$$\Delta Pr(BI) = \frac{1}{1 + e^{9.9516 - 0.04840 \cdot DBP_1}} - \frac{1}{1 + e^{9.9516 - 0.04840 \cdot DBP_2}} \qquad \text{Equation A.7}$$

where,

$\Delta Pr(BI_{men})$	=	change in 2 year probability of brain infarction in men;
DBP_1	=	mean diastolic blood pressure in the factual scenario; and
DBP_2	=	mean diastolic blood pressure in the counterfactual scenario.

Information also exists to predict the increased probability of premature death from all causes as a function of elevated blood pressure. USEPA (1987) used population mean values for serum cholesterol and smoking to reduce results from a 12 year follow-up of men aged 40-54 in the Framingham Study (McGee and Gordon 1976) to an equation in one explanatory variable:

$$\Delta Pr(MORT_{45-54}) = \frac{1}{1 + e^{5.3158 - 0.03516 \cdot DBP_1}} - \frac{1}{1 + e^{5.3158 - 0.03516 \cdot DBP_2}} \qquad \text{Equation A.8}$$

where,

$\Delta Pr(MORT_{40-54})$	=	the change in annual probability of death for men aged 40-54;
DBP_1	=	mean diastolic blood pressure in the factual scenario; and
DBP_2	=	mean diastolic blood pressure in the counterfactual scenario.

Information from Shurtleff (1974) can be used to estimate the probability of premature death in men older than 54 years old. For men aged 55 to 64 years old, mortality can be predicted by the following equation:

$$\Delta Pr(MORT_{55-64}) = \frac{1}{1 + e^{4.89528 - 0.01866 \cdot DBP_1}} - \frac{1}{1 + e^{4.89528 - 0.01866 \cdot DBP_2}} \qquad \text{Equation A.9}$$

where,

$\Delta Pr(MORT_{55-64})$	=	the annual change in probability of death in men aged 55-64;
DBP_1	=	mean diastolic blood pressure in the factual scenario; and
DBP_2	=	mean diastolic blood pressure in the counterfactual scenario.

For men aged 65 to 74 years old, premature mortality can be predicted by the following equation:

$$\Delta Pr(MORT_{65-74}) = \frac{1}{1 + e^{3.05723 - 0.00547 \cdot DBP_1}} - \frac{1}{1 + e^{3.05723 - 0.00547 \cdot DBP_2}} \quad \text{Equation A.10}$$

where,

$\Delta Pr(MORT_{65-74})$	=	the annual change in probability of death in men aged 55-64;
DBP_1	=	mean diastolic blood pressure in the factual scenario; and
DBP_2	=	mean diastolic blood pressure in the counterfactual scenario.

Citing laboratory studies with rodents, USEPA (1990) also presents evidence of the genotoxicity and/or carcinogenicity of lead compounds. While such animal toxicological evidence suggests that human cancer effects are possible, dose-response relationships are not currently available.

Health Benefits to Women

Available evidence suggests the possibility of health benefits from reducing women's exposure to lead. Recent expanded analysis of data from the second National Health and Nutrition Examination Survey[2] (NHANES II) by Schwartz (1990) indicates a significant association between blood pressure and blood lead in women. Another study, by Rabinowitz et al. (1987), found a small but demonstrable association between maternal blood lead and pregnancy hypertension and blood pressure at time of delivery.

A quantitative estimate of female blood pressure related to PbB can be estimated from a recent review of ten published studies (Schwartz, 1992). All of the reviewed studies included data for men, and some included data for women. A concordance procedure was used to combine data from each study to predict the decrease in diastolic BP associated with a decrease from 10 μg/dL to 5 μg/dL PbB. The results suggest that this decrease in PbB would decrease diastolic BP by 1 mm Hg in adult males, and about 0.6 mm Hg in adult females. Thus, lead's effect on BP in women is estimated to be 60% of the effect seen in men. Applying this value to Equation A.2 for men, the resulting equation is:

$$\Delta BP_{women} = (0.6*1.4)(PbB_1 - PbB_2) \quad \text{(A.11)}$$

where,

ΔBP_{women}	=	the change in women's blood pressure expected from a change in PbB;
PbB_1	=	blood lead level in the factual scenario; and
PbB_2	=	blood lead level in the counterfactual scenario.

Elevated blood pressure in women results in the same effects as for men (the occurrence of heart attack, two types of stroke, and premature death). However, the general relationships

[2] The Second National Health and Nutrition Examination Survey (NHANES II) was conducted by the U.S. Department of Health and Human Services from 1976 to 1980 and provides researchers with a comprehensive set of nutritional, demographic and health data for the U.S. population.

1861

between BP and these health effects are not identical to the dose-response functions estimated for men. All relationships presented here have been estimated for women aged 45 to 74 years old using information from Shurtleff (1974). First-time heart attacks in women can be estimated from the following equation:

$$\Delta Pr(CHD_{women}) = \frac{1}{1 + e^{6.9401 - 0.03072 \cdot BP_1}} - \frac{1}{1 + e^{6.9401 - 0.03072 \cdot BP_2}} \qquad \textbf{Equation A.11}$$

where,

$\Delta Pr(CHD_{women})$	=	change in annual probability of occurrence of CHD event for women aged 45-74;
BP_1	=	mean diastolic blood pressure in the factual scenario; and
BP_2	=	mean diastolic blood pressure in the counterfactual scenario.

The relationship between BP and initial cerebrovascular accidents can be predicted by the following logistic equation:

$$\Delta Pr(CA_{women}) = \frac{1}{1 + e^{9.07737 - 0.04287 \cdot DBP_1}} - \frac{1}{1 + e^{9.07737 - 0.04287 \cdot DBP_2}} \qquad \textbf{Equation A.12}$$

where,

$\Delta Pr(CA_{women})$	=	change in 2 year probability of cerebrovascular accident in women aged 45-74;
DBP_1	=	mean diastolic blood pressure in the factual scenario; and
DBP_2	=	mean diastolic blood pressure in the counterfactual scenario.

182

For initial atherothrombotic brain infarctions in women, the logistic equation is:

$$\Delta Pr(BI_{women}) = \frac{1}{1 + e^{10.6716 - 0.0544 \cdot DBP_1}} - \frac{1}{1 + e^{10.6716 - 0.0544 \cdot DBP_2}} \qquad \textbf{Equation A.13}$$

where,

$\Delta Pr(BI_{women})$	=	change in 2 year probability of brain infarction in women aged 45-74;
DBP_1	=	mean diastolic blood pressure in the factual scenario; and
DBP_2	=	mean diastolic blood pressure in the counterfactual scenario.

The risk of premature mortality in women can be estimated by the following equation:

$$\Delta Pr(MORT_{women}) = \frac{1}{1 + e^{5.40374 - 0.01511 \cdot DBP_1}} - \frac{1}{1 + e^{5.40374 - 0.01511 \cdot DBP_2}} \qquad \textbf{Equation A.14}$$

where,

$\Delta Pr(MORT_{women})$	=	the change in annual probability of death for women aged 45-74;
DBP_1	=	mean diastolic blood pressure in the factual scenario; and
DBP_2	=	mean diastolic blood pressure in the counterfactual scenario.

Lead toxicity is also believed to have reproductive effects through increased rates of miscarriage and stillbirth (Oliver 1911 as cited in USEPA 1990). A study of NHANES II data by Silbergeld et al. (1988) suggests that accumulated lead stores in the bone tissues of women may be mobilized into blood during conditions of bone demineralization associated with pregnancy, lactation and osteoporosis. The authors note that "lead may interact with other factors in the course of postmenopausal osteoporosis, to aggravate the course of the disease, since lead is known to inhibit activation of vitamin D, uptake of dietary calcium, and several regulatory aspects of bone cell function." No quantitative relationship has yet been established, however, between lead stores in women and postmenopausal health endpoints. Increased cancer risk in women of elevated lead exposure is also possible based on animal toxicology studies.

REFERENCES CITED IN ANNEX D-1

Abt Associates (1992). *The Medical Costs of Five Illnesses Related to Exposure to Pollutants.* Prepared for U.S. EPA, Office of Pollution Prevention and Toxics. June.

Bellinger, D. Sloman, J., Leviton, A., Rabinowitz, M., Needleman, H.L., and Waternaux, C. (1991). Low-level lead exposure and children's cognitive function in the preschool years. *Pediatrics*. Vol 87. No. 2:219-227. [Cited in Schwartz (1993).]

Centers for Disease Control (1991). *Strategic Plan for Elimination of Childhood Lead Poisoning*. February.

Dietrich, . 1987. [Cited in CDC, 1991.] **[From the CDC doc, can't tell which Dietrich citation the data is from]**

McGee and Gordon (1976). The Results of the Framingham Study Applied to Four Other U.S.-based Epidemiologic Studies of Coronary Heart Disease. *The Framingham Study: An Epidemiological Investigation of Cardiovascular Disease*. Section 31, April.

Oliver, T. (1911). Lead Poisoning and the Race. *British Medical Journal* 1(2628): 1096-1098. [Cited in USEPA (1990).]

Piomelli et al. (1984). Management of childhood lead poisoning. *Pediatrics*; 4:105.

Pirkle, J.L., J. Schwartz, J.R. Landis, and W.R. Harlan (1985). The relationship between blood lead levels and blood pressure and its cardiovascular risk implications. *American Journal of Epidemiology*. 121:246-258.

Pooling Project Research Group (1978). Relationship of blood pressure, serum cholesterol, smoking habit, relative weight and ECG abnormalities to incidence of major coronary events: final report of the Pooling Project. *Journal of Chronic Disease*. Vol. 31.

Rabinowitz, M., Bellinger, D., Leviton, A., Needleman, H., and Schoenbaum, S. (1987). Pregnancy hypertension, blood pressure during labor, and blood lead levels. *Hypertension*. Vol 10., No. 4, October.

Schwartz, J. (1988). The relationship between blood lead and blood pressure in the NHANES II Survey. *Environmental Health Perspectives*. Vol. 78:15-22.

Schwartz, J. (1990). Lead, blood pressure, and cardiovascular disease in men and women. *Environmental Health Perspectives*, in press.

Schwartz, J. (1992). Blood lead and blood pressure: a meta-analysis. Presented at the Annual Meeting of Collegium Ramazzini. November.

Schwartz, J. (1993). Beyond LOEL's, p values, and vote counting: methods for looking at the shapes and strengths of associations. *Neurotoxicology*. Vol. 14. No. 2/3. October.

Shurtleff, D. (1974). Some Characteristics Related to the Incidence of Cardiovascular Disease and Death. *The Framingham Study: An Epidemiological Investigation of Cardiovascular Disease*. Section 30, February.

Silbergeld, E.K., Schwartz, J., and K. Mahaffey (1988). Lead and osteoporosis: mobilization of lead from bone in postmenopausal women. *Environmental Research*. 47, 79-94.

U.S. Environmental Protection Agency (1985). *Costs and Benefits of Reducing Lead in Gasoline: Final Regulatory Impact Analysis*. Prepared by U.S. Environmental Protection Agency, Office of Policy Analysis, Economic Analysis Division. February.

U.S. Environmental Protection Agency (1986). *Reducing Lead in Drinking Water: A Benefit Analysis*. Prepared by U.S. Environmental Protection Agency, Office of Policy Planning and Evaluation, Draft Final Report. December.

U.S. Environmental Protection Agency (1987). *Methodology for Valuing Health Risks of Ambient Lead Exposure*. Prepared by Mathtech, Inc. for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Ambient Standards Branch, Contract No. 68-02-4323.

U.S. Environmental Protection Agency (1990). *Review of the National Ambient Air Quality Standards for Lead: Assessment of Scientific and Technical Information*. OAQPS Staff Paper, Air Quality Management Division, Research Triangle Park, N.C. December, 1990.

ANNEX E

HEALTH RISKS FROM FOOD CONTAMINATION

ANNEX E
HEALTH RISKS FROM FOOD CONTAMINATION

This annex addresses several important varieties of contaminants from environmental sources that may be found in the food consumed by Cairo residents. Much of the information on food contamination in Cairo used to prepare this annex derives from the CRA background paper on food, toxic substances, and environmental health issues prepared by Dr. A.A. Abdel Gawaad. Dr. Abdel Gawaad has been a professor in the Faculty of Agriculture at Zagazig University for more than 20 years, specializing in entomology, biochemistry, agricultural chemicals, and environmental health..

Food contaminants investigated in this annex fall into one of two categories: toxic chemicals, such as pesticides and metals, and microbiological agents. Toxic chemicals in food add to human exposures from other environmental media and can contribute to cancer, lead poisoning, and other chronic effects. Microbiological contaminants can lead to food-borne bacterial, viral, and helminthic (worm-related) infections. We exclude from consideration in this analysis some types of food contaminants that derive from non-environmental sources: food additives (saccharine, nitrite preservatives, food dyes), natural carcinogens (aflatoxin in legumes), and substances created in or added to foods as they are cooked (products of incomplete combustion as foods are grilled, baked, or seared; contaminants picked up from cookware or water used for boiling).

Pesticides may be found in foods for several reasons. Varying amounts of pesticides applied to crops in the field may remain on food surfaces or be incorporated systemically into the plant. Subsequent washing, processing, and cooking may remove some but not all of the pesticide residue. Pesticides may also be applied to crops after harvest to prevent spoilage during transport and storage. Pesticides may even appear in crops to which they were not applied when irrigation water that has been contaminated by upstream pesticide use is re-used for additional crops.

Metals may similarly be found in foods through many processes. Many plants will take up metals from soil and water. (The metals may be in the soil or water naturally or as a result of air deposition or contaminated irrigation water.) Metals can also derive from the application of pesticides and fertilizers containing metals, processing and canning of foods, and deposition of airborne metals on exposed foods in transport and storage or as they are displayed and sold in roadside markets.

Fish, livestock, and a some types of plants will bioaccumulate many pesticides and metals, concentrating them in their tissues to levels far beyond those at which they occur in air, water, soil, and the animals' food. This is particularly the case for lipophilic pesticides that concentrate preferentially in fatty tissues.

There are many varieties of microbiological contaminants found in food, including *Salmonella* spp., *Shigella* spp., *Staphylococcus* spp., *Clostridium perfringens*, *Bacillus cereus*, *E. coli* (signifying human fecal contamination), helminths, and many others. These agents are very widely distributed in the environment and can be kept out of foods only through sanitary procedures at all steps from crop production through food consumption. Some of the means by which these agents can get into foods include use of fecally contaminated water for crop irrigation; food handling by infected persons; contact with food by flies or rodents carrying the agents; use of contaminated food preparation surfaces, cooking vessels, and utensils; coughing on exposed food; and eating with unwashed hands. Most of these agents will multiply rapidly in food that is stored at inappropriate temperatures. In most cases refrigeration minimizes growth of these agents, and in some cases food needs to be kept sufficiently hot. Although cooking will kill many of these agents, cooked food can be quickly reinfected, and if not consumed promptly, colonies can multiply to dangerous levels.

Assessment of health risks from food contamination proceeds by different methods for chemical and microbiological contaminants.

HEALTH RISKS FROM CHEMICAL CONTAMINANTS IN FOOD

For chemical contaminants, standard risk assessment techniques can generally be used. A profile of the average diet should be obtained, indicating the quantities of different foods that are consumed. With sampling data on the levels of different contaminants in each food group, dietary exposure to each contaminant can then be estimated. Finally, standard dose-response relationships can be applied to the calculated doses of each contaminant to project health risks.

We were unable to acquire sufficient data to implement this approach fully for Greater Cairo. Abdel Gawaad (1989) and Ezz (1991) provide diet composition information, the first step in the risk assessment process for food contamination. The diets of two groups were evaluated: adults, and infants in the first year of their life. These data represent the average diets for people in all of Egypt, not just Greater Cairo, and are shown in Table 5-1. Most notable in the adult diet is the very high consumption of bread and low consumption of meat, fish, or poultry.

Abdel Gawaad (1994) provides information suggesting how the current diet for an average Cairene might differ from this country-wide profile in the late 1980's. The total consumption of food increases with income, particularly so for some food groups (animal proteins, milk). The higher average income in Cairo compared with the remainder of the country would thus result in a fuller average diet in Cairo. On the other hand, food prices in Egypt have increased faster than has income, thus likely resulting in reduced food consumption now relative to that in the 1980's.

Table 5-1. Average Composition of the Egyptian Daily Diet

FOOD GROUP	AVERAGE CONSUMPTION (G/DAY)	
	ADULTS	INFANTS < 1 YEAR
Drinking water	2810.0	900.0
Whole milk	83.3	477.5
Milk products	16.7	-
Meat, fish, or poultry	33.3	22.2
Bread (cereal grains)	480.0	24.1
Potatoes	100.0	25.8
Vegetables	116.7	49.9
Fruits and fruit juices	73.3	28.3
Oils and fats	13.3	-
Sugar and adjuncts	86.7	-

Source: Adults - Abdel Gawaad, 1989. (based on data from the Egyptian Nutrition Institute)
Infants - Ezz, 1991.

Estimation of Cairene's exposure to toxic chemicals through foods proceeds by combining these dietary profiles with sampling data on levels of toxic chemicals in these food groups.

Pesticides in Food

Unfortunately, information on pesticides in these food groups in Egypt was available only for one class of pesticides, organochlorines. These pesticides, including endrin, dieldrin, lindane, and DDT, were widely used in Egypt through the early 1980's, but have since been discontinued. They are very persistent in the environment and bioaccumulate in fatty tissues. The current risks from these pesticides result from agricultural practices of several decades ago.

Table 5-2 shows health risk calculations for organochlorine pesticides in the diet of the average Egyptian adult. Dose-response information from the U.S. EPA for each pesticide is applied to data on the estimated daily intake (EDI) of each (Abdel Gawaad, 1989). Most of the dose-response information has been peer-reviewed by a panel of U.S. health scientists and has subsequently been compiled in EPA's health effects data base, the Integrated Risk Information System (IRIS). EDIs for the pesticides are converted to a dose basis (per kilogram of body weight) by dividing the EDI by an assumed average Egyptian body weight of 70 kg (weight generally used in U.S. calculations). In the noncancer calculations, the dose is compared with U.S. EPA's noncancer reference doses. In the cancer calculations, the dose is multiplied by

U.S. EPA's cancer potency factor to estimate the average individual's lifetime excess cancer risk. The annual excess number of cancer cases among Cairo's population is then estimated by dividing the individual lifetime risk by an assumed 70 year lifetime and multiplying by the 12 million population of Cairo.

Table 5-2. Health Risk Calculations for Pesticides in Food in Cairo

	ENDRIN	DIELDRIN	LINDANE	DDT	TOTAL
Estimated Daily Intake (mg)	0.1671	0.0955	0.7018	0.9578	-
Dose (ug/kg/day)	2.4	1.4	10.0	13.7	-
Noncancer Reference Dose (ug/kg/day)[1]	0.3	0.05	0.3	0.5	-
Noncancer Hazard Index	7.96e+00	2.73e+01	3.34e+01	2.74e+01	
Cancer Potency $(mg/kg/day)^{-1}$	-	16	1.3	0.34	-
Individual Lifetime Cancer Risk	-	2.18e-02	1.30e-02	4.65e-03	3.95e-02
Annual Population Cancer Risk	-	3,742	2,234	798	6,774

Source: all Reference Doses and Cancer Potency factors are from the USEPA's IRIS.

This table shows that:

- Dieldrin, lindane, and DDT residues in food could result in very high lifetime excess cancer risks of about 4×10^{-2}. Among Cairo's total population, this could translate to nearly 6,800 excess cancer cases per year. (As explained in Annex A, cancer case estimates using EPA methods are likely to be substantial overestimates, probably by 1 or 2 orders of magnitude.)

- For all four of the pesticides, the doses exceed Reference Doses for non-cancer health effects and thus, non-cancer impacts may be possible.

Similar calculations are not performed to evaluate the possible health impacts of pesticides on infants, as the U.S. EPA dose-response information has been developed based on lifetime exposure to the chemicals. For infants, Ezz (1991) compares the doses instead with WHO values for the acceptable daily intake (ADI) for each pesticide. This comparison is shown in Table 5-3, which indicates that infants also are at some risk of non-cancer effects from pesticides (endrin and dieldrin) in food.

Table 5-3. Infant's Daily Intake of Pesticides Compared With Acceptable Amounts

	ENDRIN	DIELDRIN	LINDANE	DDT
Estimated Daily Intake (mg/kg)	0.00063	0.00219	0.00266	0.00294
Acceptable Daily Intake (mg/kg)	0.00020	0.00010	0.00800	0.02000
EDI / ADI ratio	3.1	21.9	0.3	0.1

Source: Ezz, 1991.

These estimated risks from pesticides in the Egyptian diet, particularly the excess lifetime individual cancer risks of nearly 4 x 10^{-2}, strike us as quite high. In our experience in the U.S. and other countries, cancer risks from pesticide residues have not exceeded 10^{-3}, and non-cancer hazard indices have rarely exceeded one. We suggest further investigation of why pesticides in Egypt are responsible for these unusually high projected risks.

To begin this investigation, we obtained data on dietary intake of DDT and aldrin/dieldrin in various other countries (UNEP, 1987/1988). The reported pesticide intake in Egypt is roughly 2 orders of magnitude higher than intake in the other countries for which data was available. Table 5-4 presents this information. The difference between intake in Egypt and that in other countries is even more dramatic than shown in this table, as intake in the other countries has likely declined significantly between the years when data were developed there and when the data were developed for Egypt. We conclude that either pesticide residues in Egyptian food are unusually high for some reason, or there is some problem in the Egyptian data.

Table 5-4. Dietary Intake of DDT and Aldrin/Dieldrin (ug/kg body weight/day)

COUNTRY	DDT	YEAR	ALDRIN / DIELDRIN	YEAR
Egypt	12.00	1980's	1.400	1980's
Australia	0.24	1980		
Canada	0.02	1977	0.002	1977
Guatemala	0.18	1984	0.009	1984
Hungary	0.15	1979		
Japan	0.04	1983	0.005	1983
New Zealand	0.34	1975		
U.K.	0.03	1981	0.010	1981
U.S.	0.03	1982	0.016	1982

Sources: Egypt - Abdel Gawaad, 1994. Other countries - UNEP, 1987/1988.

We are left with a great deal of uncertainty about the risks posed by pesticides in food in Cairo. Data questions are one source of uncertainty, while another uncertainty is caused by having information only on organochlorine pesticides. The pesticides that have been used in Egypt for the past decade (organophosphorus, carbamates, pyrethroids) are much less long-lived than organochlorines and most of them are not thought to be carcinogenic. Perhaps, therefore, they pose lower risks than the residues of the 20-year-old organochlorines. Without food residue data for the newer pesticides, though, we cannot be sure of this.

Lead in Food

For many people throughout the world, food is the main route of exposure to lead (Goyer 1986). Abdel Gawaad et al. (199?) combined data from sampling the lead content of numerous Egyptian foods with data on typical Egyptian daily consumption of each food and estimated the total Egyptian daily intake of lead through food as 0.592 mg/person.[1] Assuming that lead levels and food consumption are the same in Cairo as in the entire country,[2] this intake through food would constitute a very significant source of exposure to lead for the average resident of Cairo. Whether or not food is the most important source of lead depends on the concentration of lead in tap water. Assuming the high lead levels found in tap water by Zahran et al. (1992), lead from food would contribute about 30% of the average Egyptian's daily intake of lead. Assuming lower lead levels in tap water consistent with other data sources, lead from food might contribute about 87% of total daily intake.

The total Egyptian daily intake of lead through food of 0.592 mg/person, expressed in ug/kg body weight/day, is compared with dietary lead intake in other countries in Table 5-5. Egypt's daily dietary lead intake is comparable to that in several other countries at similar levels of economic development (Cuba, India, and Thailand), and much higher than that in developed countries. Annex D provides a discussion of the levels of lead in different foods in Egypt, the possible sources of lead in food, and the resulting serious health impacts.

---

[1] Average lead intake from food in Egypt appears similar to that in other developing countries for which such data are available, and far above that in developed countries. See Annex on lead for more information.

[2] In fact, we speculate that lead intake through food would be higher for the average Cairene than for the average Egyptian. Average daily food consumption is higher in Cairo for most food groups than for the remainder of the country, because of the higher average income of Cairenes (Abdel Gawaad, 1994). Also, most foods are probably more highly contaminated with lead in Cairo than they are elsewhere in Egypt.

Table E-5. Dietary Intake of Lead (ug/kg body weight/day)

COUNTRY	DIETARY LEAD INTAKE
Egypt	8.5
Australia	0.5
Canada	0.8
China	0.8
Cuba	9.0
Finland	0.7
France	2.8
Germany, F.R.	2.0
Guatemala	4.6
Hungary	1.6
India	8.6
Japan	1.4
New Zealand	3.6
Thailand	6.9
U.K.	1.0
U.S.	0.1

Sources: Egypt - Abdel Gawaad, 1994.
Finland - OECD, 1993.
France, Germany - UNEP, 1989/1990.
Other countries - UNEP, 1991/1992.

Other Metals in Food

We suspect that other heavy metals (in addition to lead) may also contribute to health risks through food. Other metals have been measured in significant concentrations in Cairo's atmosphere and dustfall, and local studies show cadmium as well as lead uptake by crops (Ali, 1992 a and b). Abdel Gawaad (1994) has sampled vegetables at markets throughout Cairo and found high concentrations of six metals (zinc, copper, nickel, lead, cadmium, iron). A study by El-Samra (1993) investigated heavy metals in non-occupationally-exposed Cairenes' blood and found cadmium and manganese at mean levels of 0.515 ug/dL and 2.436 ug/dL, respectively. A study of the blood of workers in a Belgian manganese chemical plant found manganese at levels ranging from 0.10 to 3.59 ug/dl; the controls in this study ranged from 0.04 to 1.31 (Roels et al., 1987). The fact that non-occupationally-exposed Cairenes exhibit blood manganese levels similar to Belgian manganese workers is unusual and should be investigated.

Unfortunately, these other metals have not been studied as extensively as lead, and dose-response relationships are not available to relate concentrations of other metals in human tissues to potential health effects. However, it is known that excessive exposure to any of these heavy metals can interfere with neurological functions. We do not know what role food plays in contributing to the levels of these other heavy metals in blood. in Cairo.

Several measures can effectively reduce concentrations of toxic chemicals, whether metals, pesticides or others, in food. Reducing use of pesticides and environmental releases of metals are obvious first steps. Where crops are grown also makes an important difference. Studies found that the concentration of metals dropped by roughly 70 - 90 % in crops that were grown 100 meters from heavily trafficked roads relative to those grown 5 meters from the roads (Ali, 1992a). Metal concentrations were also 90 % or more lower in crops grown in rural areas relative to those grown in the industrial area of Shoubra El-Kheima (Ali, 1992b). For today's degradable pesticides, the length of time between pesticide application and picking of fruits or vegetables significantly influenced residue levels. Washing, soaking, cooking, or processing food also reduced both pesticide and metal concentrations (Unknown, 1994).

HEALTH RISKS FROM MICROBIOLOGICAL AGENTS IN FOOD

For several reasons, it is not possible to project health risks from microbiological agents in food by applying dose-response functions to concentrations of the agents to which humans are exposed. First, there is no easily generalized infective dose, as age of the subject, extent of previous exposure, and current physical condition all affect the dose of a microbiological contaminant that will produce infection in a given individual. Second, the levels of microbiological contaminants vary so widely across different samples of food at different times that it is virtually impossible to estimate the dose of them to which an individual is exposed.

Instead, risk assessment for food-borne microbiological diseases typically involves collecting data on the actual incidence of these diseases. An approach we used previously involved four steps: 1) identify and describe relevant diseases, 2) estimate reported incidence (morbidity and mortality) for each of the selected diseases, 3) estimate the degree of under-reporting inherent in statistics on incidence of these diseases, and 4) estimate the degree to which environmental problems—as opposed to other causes—are responsible for the incidence of these diseases. Unfortunately we could not gain access to any sufficiently complete and reliable health statistics for the Greater Cairo area to attempt this type of analysis.

So, unable to reasonably estimate health risks to the Greater Cairo population from microbiologically contaminated food, we will discuss case studies which may suggest the extent of such contamination. We reviewed several recent case studies indicating that pathogenic organisms are commonly found in food in Cairo, often at high concentrations. These studies cover food served by street vendors; raw and cooked meat in factories, markets, restaurants, and hotels; weaning foods typically served to infants; and rice dishes prepared in different establishments (street vendors, markets, etc.). Table 5-6 summarizes some of this material. The studies found organisms that can cause several types of food poisoning in roughly 10-60% of the food samples analyzed. In general, food contamination was more likely in a lower income setting—for example, three- and four-star hotels showed lower rates of contamination than food from street vendors and in poorer homes. A consistent factor contributing to microbiological contamination was storing foods at inappropriate temperatures or for long periods of time. Salt and moisture content also affect microbiological growth. Salted fish showed relatively low levels of contamination, due to both its high salt and low moisture levels.

Table 5-6. Percentages of Sampled Foods Containing Microbiological Contaminants

FOOD TYPE	SHIGELLA	SALMONELLA	STAPHYLOCOCCUS	CLOSTRIDIUM PERFRINGENS	BACILLUS CEREUS	E. COLI
From street vendors	1%	0%	41%	18%	37%	75%
Meat - raw	2%	5%	63%	37%	-	-
Meat - cooked	0%	0%	13%	16%	-	-
Weaning foods						
Milk & products	0%	-	-	-	31%	54%
Rice & dishes	0%	-	-	-	33%	57%
Vegetables & beans	0%	-	-	-	18%	57%
Bread	0%	-	-	-	26%	32%
Rice dishes	1%	1%	19%	-	40%	-

Source: Compiled from El-Sherbeeny, 1985; Saddik, 1985; El-Rahman, year unknown; and El-Sherbeeny, year unknown.

Abdel Gawaad (1994) cites additional case studies providing further information on microbiological contamination of food in Cairo. A few points he notes include:

- An increasing proportion of the average Cairene's food is obtained from street vendors rather than from the home. Sanitary practices in preparation and storage of this "street food" appear to be deteriorating in recent years. In investigation of very commonly eaten bean dishes (medamis and tamiaa), it was found that the raw vegetables and other salad ingredients added to make sandwiches from the bean paste were the most common source of contamination by pathogenic bacteria, spores, yeasts, and molds. Contamination rates were higher in the summer than in the winter.

- Coshary is a dish prepared with rice, lentils, macaroni, or other starches, and is probably the second most commonly consumed variety of street food. It is commonly cooked early in the day in large quantities and sold throughout the day. Investigation of its quality revealed high levels of metals (from air deposition along the streets), sharply increasing levels of bacteriological contamination over the course of the day, worse contamination in squatter or slum areas, and worse contamination when sold by hawkers and peddlers than from shops.

- Mycotoxins that could produce illnesses were isolated from most stored grains tested in Egypt, and from most tested starchy foods. Other tested varieties of foods showed infrequent fungal contamination.

- Investigation of changing levels of microbiological contaminants in stored foods over time revealed the importance of storing each type of food under conditions of temperature, moisture, and ventilation that are specific to the type of food.

The varieties of food poisoning that can be caused by these organisms (generally bacteria) are typically mild, lasting usually less than 24 hours and including nausea and diarrhea and often no fever or vomiting. However, repeated or extended bouts of diarrhea or dysentery can lead to malnutrition, which in turn lowers resistance to other infections/diseases, hinders physical development in children, and lowers worker productivity. A 1989 study of industrial workers in Greater Cairo investigated the prevalence of parasitic infection and its relationship to worker productivity (Abdel Gawaad, 1994). The study found infected individuals to work less hours per month and receive lower hourly wages.

Limitations of the Food Contamination Risk Analysis

This assessment of health risks from contaminants in food is seriously incomplete. More research is needed to satisfactorily characterize the risks from contaminants in Cairo's food supply. Data collection in the following areas would be particularly useful:

- **Currently used pesticides.** The pesticides for which we have data include only organochlorines, which generally stopped being used in Egypt during the 1980's. The pesticides currently being used likely pose lower risks, but without comprehensive sampling for the newer pesticides we cannot be sure.

- **Metals other than lead, such as cadmium and mercury.** It would be useful to characterize the levels at which they occur in various food items, and to assemble dose-response information for them.

- **Health statistics.** In order to conduct an assessment of food-related microbiological infection, sufficiently complete and reliable health statistics for the Greater Cairo area are necessary.

REFERENCES

Abdel Gawaad, 1994. Abdel Gawaad, A.A. "Ranking Environmental Health Risks in Cairo, Egypt." Background paper for the Cairo CRA. January, 1994.

Abdel Gawaad, 1989. Abdel Gawaad, A.A., and A. Shams El Dine. "Insecticides in Total Diet Samples." Journal of the Egyptian Society of Toxicology 4(1989):79-84.

Abdel Gawaad, 199?. Abdel Gawaad, A.A., N.A. Soliman, F.I. Zahran, F. Seleim, and A. El Mousallamy. "The Daily Intake of Lead by the Egyptian People." Journal of the Egyptian Society of Toxicology.

Ali, 1992a. Ali, Esmat A. "Toxic Effects of Auto Exhaust on Vegetation and the Use of Soluble Protein and Chlorophyll as Bioindicators." Journal of the Egyptian Society of Toxicology 8(January, 1992): 89-93.

Ali, 1992b. Ali, Esmat A. "Toxic Effects of Industrial Pollution on Vegetation and Their Use as Bioindicators." Journal of the Egyptian Society of Toxicology 8(January, 1992): 107-112.

El-Rahman, ?. El-Rahman, Abd, M. Khalaf Allah, and M. Fahmi Saddik. "Microbiological Contamination of Some Traditional Weaning Foods."

El-Samra, 1993. El-Samra, et al. Reported in Abdel Gawaad, 1994.

El-Sherbeeny, 1985. El-Sherbeeny, M.R., et. al. "Microbiological Profiles of Foods Served by Street Vendors in Egypt." International Journal of Food Microbiology 2(1985): 355-364.

El-Sherbeeny, ?. El-Sherbeeny, M.R., et. al. "Microbiological Profile and Storage Temperatures of Egyptian Rice Dishes." Journal of Food Protection.

Ezz, 1991. Ezz, A.E., Z.M. Seleim, and A.A. Abdel Gawaad. "Egyptian Infant Average Daily Intake of Some Pesticide Residues During His First Year of Life." Journal of the Egyptian Society of Toxicology 7:125-34 (1991).

Goyer, 1986. Goyer, R.A. "Toxic Effects of Metals," pp. 582-635. In Klassen, C.D., M.O. Amdur, and J. Doull, eds. Casarett and Doull's Toxicology: The Basic Science of Poisons. New York: Macmillan, 1986.

OECD, 1993. Organization for Economic Co-operation and Development, Environment Directorate. Risk Reduction Monograph No. 1: Lead, Background and Experience with Reducing Risk. Paris. 1993.

Roels, 1987. Roels, H., R. Lauwerys, P. Genet, M.J. Srarhan, M. de Fays, I Hanotiau, and J.P. Buchet. "Relationship Between external and Internal Parameters of Exposure to Manganese in Workers from a Manganese Oxide and Salt Producing Plant." American Journal of Medicine 11,3:297-305 (1987).

Saddik, 1985. Saddik, M. Fahmi, et. al. "Mesophilic Aerobic Organisms and Certain Pathogens Associated with Raw and Cooked Meat." Journal of the Egyptian Public Health Association 60,3-4(1985):53-64.

UNEP, 1991/1992. United Nations Environment Programme. Environmental Data Report. Third Edition, 1991/1992.

UNEP, 1989/1990. United Nations Environment Programme. Environmental Data Report. Second Edition, 1989/1990.

UNEP, 1987/1988. United Nations Environment Programme. Environmental Data Report. First Edition, 1987/1988.

Unknown, 1994. Excerpts from Ph.D. thesis from Cairo University on dissipation rates of pesticides in Egyptian fruits and vegetables.

Zahran, 1992. Zahran, F.I., A. El-Mousallamy, N.A. Soliman, Z.M. Seleim, and A.A. Abdel Gawaad. "Toxicity and Monitoring of Lead in Tap Water." Journal of the Egyptian Society of Toxicology. 9:55-58, 1992.

ANNEX F

HEALTH RISKS FROM MICROBIOLOGICAL DISEASES

ANNEX F
HEALTH RISKS FROM MICROBIOLOGICAL DISEASES

This annex evaluates the health risks in Greater Cairo associated with a wide range of diseases that are related to environmental pollution and caused by microbiological agents. The diseases include acute diarrhea, dysentery, infectious hepatitis, typhoid fever, skin and eye infections, and many others. The agents responsible for the diseases include bacteria, protozoa, viruses, and helminths (worms).

These diseases are very prevalent in developing countries and warm climates. Their incidence is related to a broad set of intertwined factors: poverty, poor sanitation, poor housing, overcrowding, malnutrition, limited and impure water supplies, lack of sewage disposal and treatment, and inadequate health care and education. Some of these contributing factors are associated with environmental pollution and are thus relevant to this study (e.g., lack of sewage treatment). For this reason, we include some cases of some microbiological diseases among the health risks caused by environmental problems in Greater Cairo. However, many other factors contributing to these diseases are outside the scope of this project (e.g., malnutrition).

The symptoms from the great majority of cases of these diseases are relatively mild—uncomfortable but transient diarrhea, nausea, and often fevers and vomiting. Some rarer diseases cause more serious and occasionally even fatal effects. The diseases are generally easily treatable. Most of the diseases weaken their victims, making them more susceptible to other health problems. With dehydration from diarrhea, for example, individuals are less able to fight other infections. Chronic diarrhea or helminth infections contribute to long-term malnutrition and poor growth, and there is some evidence that they contribute to mental retardation also. Abdel Gawaad (1994) terms the interaction between these diseases and nutrition the "malnutrition/infection complex:"

> Infection influences nutritional status through its effects on the intake, absorption and utilization of nutrients and in some cases on the body's requirement for them. A child's rate of growth is retarded by too little food and/or too many infections or parasites. Malnutrition may result in lower immunity. Infection can lead to loss of appetite, decreased efficiency of food and nutrient utilization, increased energy requirements, and decreased growth. The relationship between diarrheal diseases and physical growth has been clearly shown. These interrelations produce the malnutrition and infection cycle so prevalent in Egypt.

Many of the diseases are more frequent and of more concern in infants and the elderly.

Egyptian data on mortality or morbidity for most of the diseases of interest to us here are not available. Data are reported only for a larger class of diseases"—infectious and parasitic diseases"—of which the environmentally related diseases constitute a large, but unknown,

fraction. Table 6-1 shows the broad categories of infectious and parasitic diseases as classified by WHO, and indicates which of them we consider to be "environmentally related."

Table 6-1. Infectious and Parasitic Diseases

ENVIRONMENTALLY RELATED	NOT ENVIRONMENTALLY RELATED
Diarrheal diseases	Tuberculosis
Polio	Sexually transmitted diseases
Tetanus	AIDS
Malaria	Pertussis
Encephalitis	Diphtheria
Hepatitis A	Measles
Schistosomiasis	Meningitis
Trachoma	Leishmaniasis
Intestinal helminths	Leprosy

Some aspects of our classification are probably arguable. We classify a disease as "environmentally related" if its transmission depends largely on contact with human feces (which can be closely related to water, sewer, and solid waste services) or on transmission by vectors (which relate closely to solid waste collection, sewage ponding, etc.). If neither human feces nor vectors are important in transmission of the disease, it is probably not environmentally related, as we define it. Measles and sexually transmitted diseases are two clear examples of diseases that are minimally influenced by water, sewer, sewage treatment, or solid waste measures. Infectious and parasitic diseases in total are responsible in Egypt for about 10% of the deaths in the general population and 30% of deaths among young children (MOH, 1993). In analyzing World Bank data for the Middle East as a whole on "Disability-Adjusted Life Years" for each disease, we estimate that the environmentally related diseases are responsible for slightly over 60% of the disease burden from infectious and parasitic diseases in total (World Bank, 1993).

Two of the consultants for this project contributed significantly to our understanding of environmental health issues generally in Cairo, and to an appreciation of the risks from microbiological diseases specifically—Dr. Amin El Gamal and Dr. A. A. Abdel Gawaad. Dr. El Gamal is a physician, former First Undersecretary of the Ministry of Health, and now an Advisor to the Egyptian Environmental Affairs Agency. Dr. Abdel Gawaad is an entomologist/biochemist who has been a professor of environmental pollution at Zagazig University for nearly 20 years. Their background papers for this project are reproduced later in Volume 3 as Annex I and Annex J, respectively.

Risk Assessment Approach for Microbiological Diseases

Risk assessment for these diseases is extremely difficult. Lack of data on the concentrations of disease agents to which people are actually exposed and poorly understood dose-response relationships prevent use of the predictive approach used for most environmental problems in which (dose) x (potency) = predicted risk. Instead, risk assessment for microbiological diseases typically proceeds by an opposite approach, in which data on the observed incidence of diseases is apportioned back to environmental and other causes. The ideal procedure would consist of four steps:

1. Identification and description of the diseases that are significantly related to environmental pollution;

2. Estimation of the reported incidence (morbidity and mortality) for each of the selected diseases;

3. Estimation of the degree of under-reporting inherent in the statistics on incidence of these diseases; and

4. Estimation of the degree to which the environmental problems covered by this study—as opposed to other causes—are responsible for the incidence of these diseases.

This procedure is very difficult to implement for Greater Cairo. El Gamal (1994) reviews some of the obstacles to pursuing this approach. Disease statistics in Egypt are very incomplete and unreliable. Diagnoses of diseases are often inaccurate, and (with the exception of a few notifiable diseases) the available statistics are aggregated to such a degree that statistics on diseases that are environmentally related cannot be distinguished from statistics on diseases that are not environmentally related. Private physicians and hospitals (which provide perhaps half the health care in Cairo) commonly do not report cases of even legally notifiable diseases. The stigma associated with notifiable diseases often prevents their being reported—often an infected person's home is required by the authorities to be fumigated, if the case is reported. Under-reporting of disease incidence is a major problem, both when individuals contract a disease without presenting themselves at a health care facility, and when health care facilities misdiagnose or do not report the cases that are presented. Difficulties are further compounded in using the limited available data on disease incidence in Cairo because of the national character of many of the health units there—statistics from these units reflect disease rates throughout the entire country rather than for Cairo alone.

Because of these data problems, we chose to analyze only two types of health damages from microbiological diseases: diarrhea and death. These are health effects for which more reliable data sets were available. Data on diarrhea incidence are available from the periodic nationwide "Demographic and Health Survey," a rigorous statistical sample interview survey of Egyptian households (NPC, 1993). Mortality data are available from the central statistical service (CAPMAS, 1992); data on deaths and their causes are presumably far more complete and accurate than morbidity data. Using data from these sources, we estimated the benefits if good water and sewer service were to be extended to all households in Greater Cairo. The benefits are measured as the reduction in: 1) annual morbidity from diarrheal diseases; and 2) annual mortality from all causes.

Numerous assumptions have been made to generate these estimates, including several key ones:

- The prevalence of diarrhea in the general population is about 1/5 that in young children of age 0-5. Table 6-2 shows that diarrhea incidence clearly decreases with age. Extrapolating the declining incidence observed across 1, 2, 3, 4, and 5 year-olds to the older population suggests something like the 1/5 ratio that we have assumed. The DHS data suggest that the average young child in Cairo has 16.1 days of diarrhea per year. This assumption then ascribes an average of 3.2 days of diarrhea per year to the remainder of the population.

Table 6-2. Prevalence of Diarrhea Among Children

Background Characteristic		Diarrhea in Preceding 2 Weeks: All Diarrhea	Diarrhea in Preceding 2 Weeks: Diarrhea with Blood	All Diarrhea in Preceding 24 Hours
Age	< 6 months	19.0%	3.0%	9.9%
	6 - 11 months	27.8%	1.2%	12.0%
	12 - 23 months	21.7%	1.2%	9.4%
	24 - 35 months	12.5%	0.8%	4.9%
	36 - 47 months	6.8%	0.8%	2.3%
	48 - 59 months	4.7%	0.3%	1.5%
Residence	Urban governorates	12.0%	0.4%	4.4%
	Lower Egypt	12.1%	0.6%	4.9%
	Urban	12.1%	0.5%	4.6%
	Rural	12.1%	0.7%	5.0%
	Upper Egypt	15.3%	1.1%	6.7%
	Urban	17.3%	0.8%	7.4%
	Rural	14.6%	1.2%	6.5%

Source: National Population Council. Egypt Demographic and Health Survey 1992.

- The effectiveness of upgraded water and sewer service in reducing morbidity and mortality in Cairo is represented by the median effectiveness figures found across two large literature reviews of studies throughout the developing world. This issue will be discussed later in this annex.

- Ninety percent of Greater Cairo's population is currently served with potable water of good quality and quantity and 75% of the population is adequately sewered. These estimates are discussed in Annex B in this volume. The health benefits we estimate are for extension of services to the assumed unserved 10% (for water) and 25% (for sewer) of the Cairo population.

- Greater Cairo shows similar population age distributions, diarrhea and mortality rates as the remainder of Egypt or other urban governorates. These assumptions are probably somewhat inaccurate, but the inaccuracies should not have a large effect on our conclusions. El Gamal (1994) provides information suggesting that the incidence of infectious diseases is more or less the same for the Greater Cairo area as for Egypt as a whole.

Risk Assessment Findings and Calculations

Using these assumptions and the two data sources on mortality and diarrheal morbidity, we estimate that completion of good water and sewerage service to Greater Cairo's entire population would abate these health damages:

- **About 6.1 million days of diarrhea each year.** This consists of about 2.9 million days of diarrhea that would be avoided among young children aged 0-5, and 3.2 million days among the remainder of the population.

- **About 1,700 - 5,500 deaths per year.**

These estimates should be regarded as approximate at best. The uncertainties associated with quantitative work in this area are very large. Our calculation procedures for developing these estimates are described below.

Diarrhea Morbidity Calculations

Objective: Determine the reduction in diarrhea mortality from extending water and sewer service to 100% of Greater Cairo.

<u>Assumptions</u>

A1. The diarrhea rate in Greater Cairo is identical to that for urban governorates in Egypt: 4.4% of children age 0-5 had episode within preceding 24 hours.
- Therefore the average young child had 0.044 x 365 = 16.1 days of diarrhea per year.

A2. Assume the remainder of the population has diarrhea at 1/5 the rate for children 0-5.
- Therefore the average other person in Greater Cairo had 3.2 days of diarrhea per year.

A3. Assume that:
a) communities without water and sewer experience a 40% decline in diarrhea morbidity when provided with full service and
b) communities with water only experience a 22% decline when provided with sewers also. (Esrey, 1985)

Calculation Procedures

1. F is the rate of morbidity in a community with full service
   W is the rate of morbidity in a community with water only
   N is the rate of morbidity in a community with no service

2. 75% of Greater Cairo population is in F
   15% of Greater Cairo population is in W
   10% of Greater Cairo population is in N (source: Annex B)

3. $0.75 \times F_C + 0.15 \times W_C + 0.1 \times N_C = 16.1$ for children age 0-5

   $0.75 \times F_D + 0.15 \times W_D + 0.1 \times N_D = 3.2$ for others

   The morbidity rates in each of the 3 types of communities in Greater Cairo, when weighted by the percent of the total population in each of the community types, must equal the overall community morbidity rates as given in A1. and A2.

4. Substituting the relationships described in A3. into the equations in 3., we get:

   $0.75 F_C + 0.15 [1/(1-0.22) \times F_C] + 0.1 [1/(1-0.4) \times F_C] = 16.1$

   Solving this equation: $F_C = 14.52$

   $0.75 F_D + 0.15 [1/(1-0.22) \times F_D] + 0.1 [1/(1-0.4) \times F_D] = 3.2$

   Solving this equation: $F_D = 2.89$

5. Thus,

Days of Diarrhea / Year

Community Type	Young Children (0-5)	Others
a) N: No service	24.20	4.82
b) W: Water only	18.61	3.70
c) F: Full service	14.52	2.89
All Greater Cairo	16.10	3.20

In essence, we have solved for the morbidity rates in community types N, W, and F that:

Add up to Greater Cairo rates of 16.1 and 3.2 when
10% of the population is in community type N,
15% of the population is in community type W, and

206

75% of the population is in community type F.

- Bear a relationship to each other as stated in A3.

6. Reduction in annual diarrhea days when service in the community is upgraded:

	Young Children	Others	
- Add water and sewer (N to F)	9.68	1.93	a) - c)
- Add sewer where water is already available (W to F)	4.09	0.81	b) - c)

7. Age distribution of population in Greater Cairo:

Children (age 0-5)	15.3%
Others	84.7%

8. If all of Cairo is to be fully served with water and sewer and Cairo's total population is 12 million, then

- # of individuals upgraded from N to F

0.1 x 0.153 x 12 million = 0.184 million children

0.1 x 0.847 x 12 million = 1.016 million others

- # of individuals upgraded from W to F

0.15 x 0.153 x 12 million = 0.276 million children

0.15 x 0.847 x 12 million = 1.524 million others

9. Number of days of diarrhea avoided:

0.184 million x 9.68 days = 1.78 million
1.016 million x 1.93 days = 1.96 million
0.276 million x 4.09 days = 1.13 million
1.524 million x 0.81 days = 1.23 million

Total: **6.1 million**

Mortality Calculations

Objective: Determine the reduction in mortality from extending water and sewer service to 100% of Greater Cairo.

1. Crude death rate nationally in 1992 was 7.4 / 1,000 (NPC, 1993).
   Assume same rate in Cairo.

2. Rate of death due to infectious and parasitic diseases:

   Males 9.1%
   Females 10.2%
   Average 9.6% (CAPMAS, 1992)

   Assume same rate in Cairo.

   Thus, death rate per 1,000 people in Cairo:

All causes	7.4	
Infectious/parasitic diseases only	7.4 x 0.096	= 0.72

3. Assume 75% of Cairo population has good sanitation (water and sewer)
   25% has bad sanitation (lack either sewer, water, or both)
   (see Annex B)

4. What percent reduction in mortality occurs when good sanitation is provided to a community formerly without it?

   Possibility #1: 21% reduction in total mortality from all causes (Esrey, 1985).
   or
   Possibility #2: 50% reduction in mortality from infectious/parasitic diseases specifically (Esrey, 1991).

   We will use these two different estimates to project a range of impacts from providing universal sanitation in Cairo.

5. Calculations for mortality from all causes:

   - Rate / 1,000 population = 7.4 for Cairo overall
   - Rate in good sanitation areas = 79% of the rate in bad sanitation areas
   - 75% of Cairo population has good sanitation; 25% has bad sanitation

Following the same calculation methods as for morbidity, we get:

Rate / 1,000 population in good areas = 6.94
Rate / 1,000 population in bad areas = 8.78
Rate / 1,000 population overall = 7.40

Reduction in mortality rate going from
bad to good sanitation = 1.84 / 1,000 population

25% of Cairenes (3 million people) assumed to have bad sanitation upgraded to good.

Reduction in mortality / year = $1.84 \times 10^{-3} \times 3 \times 10^{6}$
= 5.52×10^{3}
= 5,520

6. Calculation for mortality from infectious/parasitic diseases

- Rate / 1,000 population = 0.72 for Cairo overall
- Rate in good sanitation areas = 50% of the rate in bad sanitation areas
- 75% of Cairenes have good sanitation; 25% have bad

Following the same calculation methods as for morbidity, we get

Rate / 1,000 population in good areas = 0.576
Rate / 1,000 population in bad areas = 1.152
Rate / 1,000 population overall = 0.720

Reduction in mortality rate going from
bad to good sanitation = 0.576 /-1,000 population

25% of Cairenes (3 million people) assumed to have bad sanitation upgraded to good.

Reduction in mortality / year = $0.576 \times 10^{-3} \times 3 \times 10^{6}$
= 1.73×10^{3}
= 1,730

THE ROLE OF ENVIRONMENTAL FACTORS IN MICROBIOLOGICAL DISEASE

The quantitative estimates in the preceding section suggest that significant benefits in reducing microbiological disease would result from further progress in providing good water and sewer service to households in Cairo. These numerical estimates are highly uncertain, and a qualitative discussion of the impact of environmental factors on rates of microbiological diseases may also be helpful.

Most of the microbiological diseases we refer to as "environmentally related" involve disease agents that are spread through oral ingestion of human feces. An infected individual excretes the agent, which may live and (in some cases) multiply in the feces. Another individual can be infected through eventual ingestion of the fecal matter itself, or fecally contaminated water, food or soil. There are two steps in the infection via this pathway. First, fecal matter must be present in the individual's immediate environment. This can result from unsanitary use/care of latrines, indiscriminate defecation by children, overflows or backups from sewers, discharge of untreated domestic waste from sewers to water courses, etc. Then an individual must make the necessary type of contact with the source. Generally speaking, this would mean direct contact, with transfer of fecal matter from, for example, hands to mouth, or ingestion of fecally contaminated water or crops fertilized with sewage. The specific pathways are quite varied and do not lend themselves to generalization. They can range from a mother with fecal matter contaminated with a diarrheal agent under her fingernails infecting her infant while breast-feeding, to eating raw produce that has been freshened at the market by fecally contaminated water. Furthermore, the degree of importance of each pathway varies with each disease; for some, contaminated water may be a primary source of inoculation (bacterial diarrhea), whereas for another walking barefoot on insufficiently treated human waste may be the chief source (ascariasis).

Another group of diseases is transmitted by vectors such as insects (mosquitos, flies, lice), snails, arachnids (mites), and animals (rats, dogs, cats). Often, the agent is transmitted to the human through the bite of a vector, as is the case with malaria and rabies. Some agents require a vector as an intermediate host before infecting humans, as in the case of snails and schistosomiasis.

All of the diseases that are not formally vector-related can also be transmitted via vectors in the following fashion. Pathogens can be transported on the legs and bodies or in the digestive tracts of certain vectors, particularly flies, cockroaches, and other insects which breed in and/or eat feces. For example, a fly breeding near a latrine could pick up *Shigella* bacteria from infective feces, then land on uncovered human food, where this bacteria could multiply to a level high enough to infect those who eat the food. This pathway is normally a less significant route of transmission than direct fecal to oral.

In each of these pathways, what we think of as "environmental" factors (e.g., untreated sewage, uncollected garbage) significantly increase the amount of the infective agent in people's immediate surroundings, increase the prevalence of vectors, or both. In this sense we term the diseases that are transmitted in this manner "environmentally related microbiological diseases."

Environmental conditions in Cairo with which we are concerned in this project can contribute to the spread of these diseases in several ways:

- **Lack of water.** Having a reliable water supply available in the home sufficient for bathing, washing, drinking, and house cleaning is a key preventive measure for these diseases. Inadequate water supplies may exist in Cairo not only for homes not connected to the piped public water system, but also for homes affected by low water pressure, broken water mains, and other reasons for erratic water supplies.

- **Contaminated water.** Many of the microbiological agents can live in water and are commonly transmitted when contaminated water is used for drinking or bathing. Cairo's drinking water as it leaves the treatment plants is normally adequately disinfected, but microbiological contaminants may enter subsequently by infiltration through the distribution system or when water is stored.

- **Lack of sewage conveyance.** The bulk of the microbiological diseases of concern are transmitted by the fecal to oral pathway. This pathway can be broken by assuring that human excrement is conveyed away from where people are likely to come into contact with it. Toilets are most important in moving the waste out of the house; sewers are then important in moving it out of residential neighborhoods.

- **Lack of sewage treatment.** Appropriate treatment of sewage, in a sewage treatment plant or in septic tanks and cesspools under proper loading and soil conditions, will remove nearly all of the harmful microbiological agents from waste water. After such treatment, waste water can then be safely discharged into waterways to which humans and animals will be exposed.

- **Uncollected solid waste.** A significant fraction of Cairo's solid waste is not collected, and instead left in streets, canals, or vacant areas. Collected waste is typically picked over and then dumped. These discards can provide food and breeding ground for vectors such as rats, flies, and dogs involved in transmission of disease.

- **Food contamination.** We consider "environmental" food contamination to be that which occurs outside the home and is reasonably subject to governmental inspection and regulation. This includes contamination of food when commercially grown and during processing, packaging, storage, marketing, and preparation by restaurants and street vendors. Numerous studies document extensive microbiological contamination of food in Cairo through preventable inappropriate practices at each of these stages.

However, factors that we term "non-environmental," or beyond the scope of this study, are also important in transmission of these microbiological diseases. Critical non-environmental factors include:

- Poor personal and domestic hygiene. Cleaning, washing, wiping after defecating, keeping flies and mosquitos away, wearing shoes, etc. are all important. Keeping the home clean is similarly critical.

- Inadequate health care and education. Several of these diseases may be prevented by immunization, and all can be treated effectively. Better knowledge about which practices to avoid and which to emphasize would be very helpful.

- **Lack of/non-use of toilets.** Again, it is important to keep fecal material away from people. Lack of toilets or indiscriminate defecation, typically by children, either in the home or outside, can be a problem.

- **Overcrowding and poor housing.** Close living conditions increase person-to-person disease transmission. Lack of running water, toilets, screens on windows, refrigeration, and garbage disposal facilities will all increase disease incidence.

- Poor nutrition and food preparation in the home. Malnutrition may make individuals more susceptible to many of the microbiological diseases and increase the severity of the diseases once they are contracted. Improper food preparation—leaving foods out and exposed, insufficient cooking, use of unclean utensils or surfaces, etc.—can contribute to many problems.

Although the microbiological diseases each have a predominant pathway by which they are transmitted (e.g., fecal-oral, vector-related), wide variations are possible in the details of the pathways responsible for each case of disease. For example, shigella cause bacillary dysentery through the fecal-oral route. One case may arise when the feces of an infected individual reach an irrigation canal directly without treatment. A water supply pipe traversing the canal has corroded and allows the fecally-contaminated water to infiltrate, and an individual contracts shigellosis when he subsequently drinks the contaminated water. This case can clearly be attributed to environmental problems—lack of adequate human waste conveyance and treatment, and contaminated drinking water. Another case may arise, though, when feces from an infected individual are left on a toilet seat, and a child handles the toilet seat and then a kitchen counter on which food is being prepared. The shigella then multiply in the food, infecting other members of the family when the food is eaten. This case involves none of the environmental problems within the scope of this project.

In short, the pathways by which these diseases occur are so varied that it is not possible to attribute overall disease incidence to one or another cause. In most instances multiple factors—both environmental and non-environmental—probably contribute to disease incidence.

It is possible, though, to make some qualitative statements about the importance of different factors. By reviewing the characteristics of each disease (e.g., typical pathways, ability of the agent responsible to survive outside the host, minimum infective dose), it is possible to judge the likely relative contributions of the various environmental and non-environmental factors to transmission and persistence of the disease. Alternatively, by reviewing the literature on reductions in disease incidence after a variety of health-related interventions, one can judge the relative effectiveness of environmental and non-environmental measures. The conclusion is the same in either case: **non-environmental causes are as or more important than environmental causes for these diseases.** We summarize two major studies that provide an example of each approach:

1. Feachem et al. (1981) studied numerous infectious and parasitic diseases and assigned them to groups having similar modes of transmission. He then ranked each of several alternate control approaches according to its effectiveness in interrupting the primary

mode of transmission for each disease group. His list of control approaches includes improvements in: water quality, water availability, excreta disposal, excreta treatment, personal and domestic cleanliness, drainage and sullage disposal, and food hygiene. For each type of illness, alternate control approaches were ranked as being of no (0), little (1), moderate (2), or great (3) importance as elements of disease control strategies. Feachem's chart summarizing his judgments is shown as Table 6-3. Among the environmental factors, it is clear that water availability and excreta disposal are consistently more important than water quality and excreta treatment. Non-environmental factors—personal/domestic cleanliness and food hygiene—are very important also.

2. Esrey et al. (1985) reviewed 67 studies from 28 countries that analyzed the impact of several sorts of interventions on incidence of diarrhea. Esrey found the following median reductions in diarrheal morbidity from different types of control interventions:

Improvements in water quality	16%
Improvements in water availability	25%
Improvements in water quality and availability	37%
Improvements in excreta disposal	22%[1]

In further work, Esrey et al (1991) found that non-environmental hygiene interventions (e.g., health awareness education, handwashing campaigns) reduced morbidity by a median 33%. They also found that all interventions were likely to reduce mortality by a greater percentage than morbidity.

The conclusions of Feachem and Esrey, and evidence from other researchers (see Bradley et al., 1992 and Listorti, 1990 for summaries of other work) are generally consistent. Non-environmental causes are as or more important than environmental causes for microbiological diseases. In comparing the health risks posed by Cairo's different environmental problems, we should not count all of the incidence of environmentally related microbiological diseases as environmentally caused. The most important environmental factors in preventing these diseases are probably: (1) providing sufficient, reliable water to the population to support washing and other sanitary practices; and (2) providing means—toilets and sanitary sewers—to get human excrement away from the immediate human environment. These approaches are highly effective in reducing the incidence of a broad range of microbiological diseases.

Other environmental factors are less critical, though still important. The quality of the water supplied is less important than having a reliable water supply in the first place. Treating human excreta properly (e.g., in sewage treatment plants) is less important than conveying it away from people. Although water quality and sewage treatment are not vital in controlling most types of microbiological disease, they are of significant value in reducing the traditional water-borne bacterial diseases (cholera, typhoid, shigella) and some helminth-related diseases, respectively. In Cairo in particular, sewage treatment is less important as a disease prevention

[1] We use these percentages in our rough estimate of the reduction in diarrhea morbidity that might result in Cairo if good water and sewer service was extended to all residents.

Table 6-3. Importance of Alternate Control Measures for Environmentally Related Microbiological Diseases

Diseases and Agents	Water Quality	Water Availability	Excreta Disposal	Excreta Treatment	Personal/domestic Cleanliness	Drainage/sullage Disposal	Food Hygiene
Diarrheal diseases and enteric fevers							
Viral agents (e.g., enteroviruses, rotavirus)	2	3	2	1	3	0	2
Bacterial agents (e.g., Shigella, Salmonella)	3	3	2	1	3	0	3
Protazoal agents (e.g., Giardia lambia)	1	3	2	1	3	0	2
Poliomyelitis & Hepatitis A	1	3	2	1	3	0	1
Worms w/ no intermediate host							
Ascaris	0	1	3	2	1	1	2
Trichuris	0	1	3	2	1	1	2
Ancylostoma, Necator (Hookworm)	0	1	3	2	1	0	1
Beef & pork tapeworms	0	0	3	3	0	0	3
Worms w/ intermediate aquatic stages							
Schistosoma	1	1	3	2	1	0	0
Skin, eye, & louse-borne infections	0	3	0	0	3	0	0
Infections spread by water-related vectors							
Malaria	0	0	0	0	0	1	0
Dengue	0	0	0	0	0	1	0
Bancroftian filariasis	0	0	3	0	0	3	0
Encephalitis	0	0	0	0	0	1	0
Rabies a)	0	0	0	0	0	1	0
Tetanus a)	0	0	0	0	0	0	0
Leptospirosis	1	0	0	0	0	0	0
Typhus	0	1	0	0	1	0	0

a) Related somewhat to solid waste disposal.

Source: adapted from Feachem, 1981.

KEY: 3 of great importance in controlling disease
2 of moderate importance
1 of minor importance
0 of no importance

measure because most of Cairo's sewage (whether treated adequately or not) is conveyed away from the metropolitan area by drains, thereby minimizing human exposure to it.

More complete collection and better disposal of household refuse is another environmental factor that can be of value in reducing incidence of several vector-related diseases (those relating to rats and insects that can feed on garbage). We estimate this value as relatively low, because of the greater importance of sanitary measures indoors rather than outdoors.

REFERENCES . .

Abdel Gawaad, 1994. Abdel Gawaad, A.A. "Ranking Environmental Health Risks in Cairo, Egypt." Background paper for the Cairo CRA. January, 1994.

Bradley, et al., 1992. Bradley, David, Carolyn Stephens, Trudy Harpham, and Sandy Cairncross. A Review of Environmental Health Impacts in Developing Country Cities. Washington, DC: World Bank, 1992.

CAPMAS, 1992. Central Agency for Public Mobilization and Statistics. Births and Deaths Statistics 1989. Cairo: CAPMAS, 1992.

El Gamal, 1994. El Gamal, Amin. "Comparative Environmental Risk Analysis in the Greater Cairo Area." Background paper for the Cairo CRA. January, 1994.

Esrey, 1985. Esrey, S.A., R.G. Feachem, and J.M. Hughes. "Interventions for the Control of Diarrhoeal Diseases Among Young Children: Improving Water Supplies and Excreta Disposal Facilities" in Bulletin of the World Health Organization 63.4(1985):757-772.

Esrey, 1991. Esrey, S.A., J.B. Potash, L. Roberts, and C. Shiff. "Effects of Improved Water Supply and Sanitation on Ascariasis, Diarrhoea, Dracunculiasis, Hookworm Infection, Schistosomiasis, and Trachoma" in Bulletin of the World Health Organization 69.5(1991): 609-621.

Feachem, 1981. Feachem, Richard G., et al. Health Aspects of Excreta and Sullage Management: a State-of-the-art Review. Washington, DC: Transportation, Water, and Telecommunications Dept., World Bank, 1981.

Listorti, 1990. Listorti, James A. "Environmental Health Components for Water Supply, Sanitation, and Urban Projects." World Bank Technical Paper Number 121. Washington, D.C.: The World Bank, 1990.

MOH, 1993. Ministry of Health, Information and Documentation Center. Basic Health Statistical Data. Cairo, February, 1993.

NPC, 1993. National Population Council. Egypt Demographic and Health Survey 1992. Cairo, November, 1993.

World Bank, 1993. The World Bank. World Development Report 1993, Investing in Health. Oxford University Press, 1993.

PRIDE

Project in Development and the Environment

Comparing Environmental Health Risks in Cairo, Egypt

Volume Three: Technical Annexes
Reports by Egyptian Consultants

September 1994

Submitted to:
USAID/Egypt
Submitted by:
PRIDE

USAID Contract Number:
ANE-0178-Q-00-1047-00
USAID Project Number:
398-0365

Sponsored by:
USAID/NE/DR/ENR
Operated by:
Chemonics International
and its associates

2000 M Street, NW, Suite 200, Washington, DC 20036
Telephone: (202) 331-1860 • Fax: (202) 331-1871

TABLE OF CONTENTS

ANNEX G

AIR POLLUTION IN GREATER CAIRO

AIR POLLUTION IN GREATER CAIRO

By

Professor Dr. M.M.Nasralla

Background Information

Cairo is the Capital of Egypt. The City of Cairo is situated at an elevation of 74 m above mean sea level (Latitude 30° 08' N, Longititude 31° 34' E). The central urban area comprising thousands of small industries, workshops and bakeries. In 1950 Cairo had a population of 2.4 million increased to 5 millions on 1976. The U.N estimated the population of the 1990 at 9.08 million. The Greater Cairo consists of Cairo governorate, and parts of another two governorates, namely Giza and the area of Shoubra El Kheima which is a part of Kaliobia Governorate. Consequently, the populaton of the Greater Cairo exceeds 12 million.

Greater Cairo is fan shaped and lies in the Valley of the River Nile and extend along the sides of the river from north to south. The City is bordered from east by the chain of Mokattam hills. These hills seperate the city from the Eastern Desert. The western borders are surrounded by Abu-Roach Hills and Western desert and bounded by the Nile Delta to the north.

Climate

Cairo has a desert climate characterised by dry heat. Monthly mean temperature ranges from 14°C in January to 29°C in July. The maximum daily temperature in July may reach 43°C. Average relative humidity is 56 percent and reaches more than 70 percent as monthly average during both summer and winter months. Here it should be noted that several studies indicated that the combination of air pollutants with high air temperature and humidity causes more stress on human health than exposure at cold weather conditions.

Rain is very scarce. Annual mean rainfall is only 22 mm. Rains are only occur during 3-4 months per year, the monthly maximum (7 mm) occuring during December. In other words, the area of Greater Cairo is lacking one of the most important mechanisms of removing the pollution from the atmosphere (Washout). This leaves the pollutants hanging for long periods in the atmosphere increasing the bad effects of air pollutants and increasing the potentiality of the formation of secondary air pollutants such as ozone and PAN.

Furthermore, nights are generally cool and during winter quite damp, radiation cooling often leads to shallow stable inversions. A Nile breeze is also a characteristic of the night-time Climate. The area is generally characterised by low wind speeds averaging 2-4 m/s. On annual average the prevailing wind direction is northerly winds. The southern wind is only important during winter. Moreover, the variable and calim winds prevail over 5-10% of the time. Consequently, pollution is generally exacerbated by low wind speeds, lack of rain, tall buildings, narrow streets, traffic congestion in Cairo and the high rates of emissions from the industrial and combustion processes.

AIR POLLUTION SOURCES

A. Industry

Cairo houses 64% of Egypt's industries and accounts for 41% of the electricity generated from thermal power stations in the whole country. Industries are mainly located at Shoubra El Kheima, northern of Cairo, and Helwan area to the South of the City as well as adjacent to residential areas in some urban districts such as in Imbaba, Dar El Salam ... etc. These activities consume over 50% of the Egypt's energy. Table 1 shows the energy consumption in Greater Cairo during 1985 to 1990.

Table 1. Energy Usage in Greater Cairo, Consuption of Fuel, 10^3 Tons

Year	Fuel for Transportation		Fuel for houses			Mazout (heavy oil)
	Petrol	(Solar)	Natural gas	Kerosene	But. gas	
85/86	933.8	942.9	34	501.7	310.8	3158.1
86/87	965.2	1000.5	44	527.7	343.7	3626.3
87/88	985.5	1052.6	46	533.1	361.7	3483.7
88/89	987.8	1047.2	51	541.4	369.1	3647.0
89/90	1016.5	1078.2	56	521.9	282.7	3664.9

Helwan is the biggest industrial area in Egypt employing over 100,000 worker, the population of the area is about one million. This area houses 3 cement companies about 650 tons daily to the atmosphere of Helwan. In addition, it is also the site of iron and steel industries, lead and zinc smelting, foundries, ceramic industries, car industries, coke and firtelizers, textiles, bricks, chemical industries. Power for these industries is provided by 3 electricity power stations located in the area.

The northern industrial area, Shubra El Kheima consists of over 450 industrial units of various sizes and employs 87,000 people, most of whom are also residnts in the area. Industries include ferrous metallurgical work, foundries, lead smelters, ceramics, glass, bricks, textiles and plastics. There is also two power stations, one of them is a very large thermal power station producing 1.8 M W hr. These station are using heavy oil most of the time (Table 2). Conseqguntly emit excessive amounts of SO2.

Table 2. Fuel use in electric power stations in Greatenn Cairo (Units are 10^3 tonnes heavy fuel oil equivalents per annum)

Station name	1979/80	1988/89
West Cairo	378	446
South Cairo	414	506
North Cairo 1	179	207
North Cairo 2	16	--
East Cairo	23	11
Tebeen 1	77	51
Heliopolis	--	0.2
Helwan	25	214
Shoubra El-Khayma	--	1.809
Tebeen 2	22	16
Wadi Hoff	--	138
T o t a l	1.134	3.398.2

(Note: 52 percent of total is heavy oil and 46% is natural gas)

The industrial activities located in the urban area adjacent to the heavy populated residential areas include metallurgical work, bricks and food industries at Imbaba, limestone and lime work at Dar El Salam, food industries and chemical industries at El Amiria, lead smelters at El Wayli, bricks at El Basateen, leather work at Ein Elsira and many others. The urban districts houses.

Thousands of workshops, founderies and more than 1500 bakehouses.

B. Transportation

The number of vehicles increased significantly during the last 20 years from 100,000 in 1970 to 400,000 in 1980 reaching more than

900,000 in 1990. The problem with these vehicles is not only because of their number but also because of their age and condition. Table 3 shows the distribution of petrol cars according to age where 25% of cars are of more than 20 years old and 65% of them are more than 10 years old. These cars are, of course, a major source of air pollution which are sometimes can be seen and smelled.

Table 3. Distribution of petrol cars according to age (statistics for 1991)

Year of Manufacturing	%
Before 1970	23.00
1970 - 1975	15.00
1976 - 1980	28.00
1981 - 1985	23.00
1986 - 1990	9.50
1991	0.05

The number of motorized trips per day is projectd to rise from 3.9 million in 1980 to 12 million by the year 2000. These vehicles are one of the major sources of several air pollutants in Cairo atmosphere such as lead, CO and VOC. Table 4 shows the estimated emissions by cars and buses.

Table 4. Estimated emissions by cars in Cairo

Pollutant	1980 (ta-1)	1990 (ta-1)	Cars (%)	Busers (%)
CO	72,000	160,000	99	1
NOx	3,300	7,300	66	34
SO2	1,900	4,100	22	78
Smoke	600	1,300	88	12

AIR POLLUTION SITUATION

1. Sulphur Dioxide

There is no SO2 emission inventory available for Cairo. However from the data shown in table 2, it can be estimated that SO2 emissions from the heavy oil (Mazout) combustion in power stations, industry, workshops, bakeries ... etc, at the rate of 183,000 tonnes annualy. Calculating the amount of SO_2 emitted by only power stations from the data shown in table 1 (52% of the 3.4 million of fuel oil equavalent) it might be about 80,000 tonnes per annum. Another 4,000 tonnes per annum of SO_2 are emitted by cars and buses, which is more than a sevenfold increase compared with 1970 emissions. As the sulphur content of diesel is much higher than in petrol, nearly 80% of all motor vehicles emissions come from diesel - powered buses, the remainder from diesel cars (table 4). There are of course, several other sources for SO_2 emissions. Domestic emissions might be relatively small, but industrial sources such as iron and steel, fertilizers and chemical industries, coke plant, smelters ... etc certainly emit considerable additional amounts of SO_2. Here, it is recommended that a full and detailed SO_2 inventory for Greater Cairo be carried out as soon as possible.

Table 5. Sulphur dioxide Concentrations in Cairo City and Helwan (El Tebeen) Atmospheres 1991 / 1992

Season	Cairo City			Helwan (El Tebeen Ind area)
	Residential	City Center	Suburban	
Winter	44	65	38	71
Spring	52	72	40	79
Summer	66	112	46	150
Autumn	56	86	35	120
Mean	55	84	40	105
Monthy Max	76	127	54	171
24 hr Max	120	308	86	320

WHO Guidlines 40 - 60 ug/m3.

Table 6. Annual Sulphur dioxide concentrations in Shoubra El Kheima Atmoshere ug/m3

L o c a t i o n	1978	1983	1988	1990
Industrial Region (Close to Metall Work)	67	104	156	---
(Residential Close to power station)	---	---	---	96 (Autumn)

WHO Guidlines 40 - 60 ug/m3.

Monthly mean levels of SO2 in Cairo atmosphere were reported to be in the range of 100-300 ug/m3 at a number of sites (commins 1987). Table 5 shows that the annual mean concentrations of SO2 in the four stations of measurements during 1990/1992 were 40 ug/m3 in suburban area, 55 ug/m3 in residential area and 84 ug/m3 in the atmosphere of the city centre. The highest recorded monthly concentrations ranged between 54 to 127 ug/m3 in the air of the measurement locations. Table 5 also shows that the 24 hr concentrations in the air of the urban area may peaks to more than 300 ug/m3. Furthermore, the concentration of SO2 in the area of El Tebeen where lead smelter, iron and steel industrie, and coke plant are located reached 171 ug/m3 as annual mean peaking to 320 ug/m3 as a maximum for 24 h.

The concentration of sulphur dioxide in the air of Shoubra El Kheima is shown in Table 6. This table shows a steady increase in the concentration of SO2 in the industrial area from 67 ug/m3 during 1978 to 156 ug/m3 as annual mean on 1988.

The short measurements during autumn at the residential area close to Shoubra El Kheima power station revealed a concentraiton of 96 ug/m3 during Autumn 1990. Tables 5 and 6 show that, generally higher concentrations of SO2 were found in the summer months and the lowest concentration in winter. These data show that the WHO annual mean guidelines of 40-60 ug/m3 are exceeded by a factor of 2-3 in the city centre and the industrial areas.

The maximum 24 hr mean concentrations reported in tables 5 and 6 is more than 300 ug/m3. Furthermore at some Cairo sites (City Centre), commins (1987) reported over 1000 ug/m3 as a maximum over 24 hr. Such high level would posses a considerable risk to human health.

2. **Particulate Matter**

There is no SPM emission inventory available for Cairo. There are natural emission sources of particulate matter (such as wind-blown dusts) as well as anthropogenic sources (e.g. motor vehicle exhaust, industrial particulates). A large contributor to natural SPM levels are the north-easterly winds in spring and the fresh-to-strong hot "Khamasin" southerly wind which are usually loaded with high levels of natural sand and dust. However, there are no estimates of the contribution of natural SPM to total ambient SPM levels.

There are many anthropogenic SPM emission sources, especially from incomplete combustion processes, industry (iron and steel, cement, and so on), and traffic. Smoke emissions from cars and buses have been estimated to be 1,200 tonnes per annum in 1990. This is a more than sevenfold increase since 1970. About 88 per cent of these emissions come from cars. Traffic SPM sources are believed to be relatively small compared with other SPM sources, but their impact on SPM pollution at roadside locations is probably severe.

Particulate in Cairo atmosphere are monitored as total suspended matter (TSP), dustfall and black smoke (BS).

(a) Total suspended Matter (TSP)

Table 7. Annual mean concentrations of total suspended particulate matter (ug/m3) in Greater Cairo Atmosphere

Location	1989	1991
City centre	632	448
City centre (high traffic)	699	661
Residential	548	349
Residential (high traffic)	602	561
Industrial (Helwan)	1,100	857
Shoubra El Kheima	680(1988)	---

Annual mean TSP data are presented in table 7. The measured annual TSP levels of about 500-1100 ug/m3 are far in excess of the WHO guidline of 60-90 ug/m3. Moreover it may be noted that, the maximum 24 hr concentration sometimes peaked to more than 1000 ug/m3 in the urban districts and over 2000 ug/m3 in the industrial district of Helwan. Generally the concentrations of TSP in winter time is about 30% higher than those recorded in summer.

(b) Black Smoke

This sort of pollutant is mainly emitted from incomplete combustion processes and usually of finely devided small particle size and contains high levels of heavy metals and polycyclics (PAH). Moreover, because of their small sizes, they can easily penetrate to the lower respiratory tract causing a significant increase of SO2 bad effect on the respiratory system.

Because of the badly maintained vehicles, open burning, badly designed and operating combustion equipment, the emissions of black smoke can be noticed by necked eye. However, there is no source inventory for black smoke emissions in Cairo. This is an area which needs urgent assessment and control measures to reduce such emissions into Cairo's air.

Table 8. Concentratins of Smoke in Cairo Atmosphere, ug/m3 (1991)

D i s t r i c t	Concentration annual mean
City centre	130
Residential HT	102
Residential industrial	74
Residential	67
Residential	54
Industrial, Masara (Helwan)	96
Industrial, El Tebeen (Helwan)	67
Shoubra El Kheima	80
S u b u r b a n	39

Table 8 shows the annual mean concentrations of smoke in various sites of measurements during 1991. It may be seen from this table that the annual mean concentrations in urban and industrial areas ranged from 54 to 130 ug/m3. In other words the concentrations of smoke in all sites in 1991 are above the WHO annual guidline of 40-60 ug/m3 (except for suburban). Annual mean smoke levels in 1991 in the city centre even exceeded the WHO guidline of 125 ug/m3 for 24 hr. Here, it should be noted that the max 24 h concentration of smoke in 1991 was 450 ug/m3 which is more than 3 fold the WHO guidline of 125 ug/m3. These concentrations posses a high risk to human helath.

<u>Dustfall</u>

Dustfall which is a good indicator for particulate load in the atmosphere had been measured for several years in Cairo. Table 9 show the annual rates of dustfall over various districts. These rates of dustfall are much higher than those recorded in similar districts around the world and set all districts of Cairo except the suburban area in the categeory of heavy to very heavy polluted areas with dustfall according to Penselvania guidlines which set the different categeories of dustfall as follows:

> 35 g/m2. month, very heavy

14-35 g/m2. month, heavy

7-14 g/m2. month, moderate

0-7 g/m2. month, light

Dustfall over several districts such as city centre, Shoubra El Kheima, El Tebeen (Helwan) close to metallurgical work contain high levels of lead, Cd and Ni. Lead concentations in dustfull over these districts exceed 1000 ug/g.

Cadmiun and Ni concentrations reach over 100 ug/g. These are very high concentrations compared to those recorded in other countries and as compared to other Cairo districts. This is due to the high emission rates from vehicles and smelters located in Shoubra El Kheima and El Tebeen (Helwan). The concentrations of lead in particulate and its impact on health, soil and accumulation in vegetation is fully discussed in a seperate section.

Table 9. Dustfall Rates Over Various districts of Greater Cairo

L o c a t i o n	Rate of dustfall g/m2/month (Year)
City centre Residential	31 (1991) 13 - 28 (1991)
Averagem urban districts	23 (1991)
Suburban	10 (1991)
Helwan (Industrial)	38 - 261 (1989) (Mean 88)
Shoubra El Kheima (Industrial)	14 - 76 (Mean 45) (1988)

3. Carbon monoxide

An all-inclusive carbon monoxide (CO) emissions inventory has not yet been established for Cairo. Generally, in urban areas exhaust of petrol motor vehicles is the largest CO emission source. In Cairo, CO emissions from cars and buses have been estimated to be 160,000 tonnes per annum in 1990, more than a sevenfold increase from 1970. About 99 per cent of traffic CO emissions are from cars, as buses (and other diesel-powered vehicles) have very low CO emission rates.

Other CO emissions sources are probably relatively small compared with motor vehicles. A 1985 survey showed that the 20 major point sources in Greater Cairo had CO emissions of about 1,000 tonnes per annum with a single iron and steel plant accounting for more than 60 per cent of those emissions (Nasralla, 1990). Power stations generally have very efficient combustion systems and thus emit relatively low amounts of CO.

No long-term routine CO monitoring network exists in Cairo. However, some specific research studies on CO pollution from motor vehicles have been carried out over the past 20 years. For instance, measurements of CO during one day in 1984 at roof level at a city centre site with heavy traffic showed hourly CO concentrations of 7-19 ppm (about 8-22 mg m-3), and the WHO eight-hour guideline of 10 mg m-3 was exceeded during most hours of the afternoon and the evening (Nasralla, 1990). Since 1984, traffic CO emissions have grown by about 15 per cent, which had an influence on the ambient CO levels. The projected further increase in motor vehicle traffic without any emission control devices will lead to even higher levels of ambient CO in the future. These concentrations resulted in high levels of carboxyheamoglobine in traffic policemen reaching, sometimes more than 10%. In other words the blood of those who are exposed to CO in Cairo streets may have more than 10% impaired heamoglobine.

4. Oxides of Nitrogen

There is, no comprehensive emission inventory for oxides of nitrogen (NOx) in Cairo.

Oxides of nitrogen emissions from motor vehicles were estimated to be about 7,300 tonnes per annum in 1990, with two-thirds of its coming from cars and one-third from buses. This relatively low number is due to a relatively large number of cars with low-temperature, inefficient combustion engines.

A 1985 survey showed that the 20 major point sources (power stations and industry) in Greater Cairo had NOx emissions of about 24,700 tonnes per annum. Since then, one very large power plant (Shoubra El-Khayma) was opened, which has led to increased Nox emissions.

There has been only one major research study on NOx and photochemical oxidants (NO and NO2) which took place in 1979 (Nasralla and Shakour, 1981). During 1979, monthly mean NOx concentrations in the city centre location were 0.2 ppm (380 ug m-3) in January-March, 0.4-0.75 ppm (760-1,400 ug m-3) in April-July, and 0.3-0.4 ppm (570-760 ug m-3) in August-December. The marked maximum NOx concentrations during May and June are connected with increased traffic during that time and probably enhanced by temperature inversions during those months. These values are far above the WHO 24-hour guideline of 150 ug m-3 for NO2.

Similarly high values were reported from measurements of traffic-related NOx during one day in 1984 at roof level at a city centre site with heavy traffic. Results showed half-hourly NOx concentrations of 0.1-0.3 ppm (about 190-570 ug m-3). Measurements close to Shubra El Kheima power stations showed 36 to 204 ug/m3 NO2 as 24 hr average concentrations during Autumn 1990.

5. Ozone

Ozone (O3) is a secondary pollutant which is a product of complex atmospheric reactions of NO2 and reactive volatile organic compounds (VOC) under the influence of sunlight.

There is only a partial emission estimate for NO2 (see above), and no emission inventory for VOC. Volatile organic compound emissions result from a variety of sources including solvent and petrol evaporation, incomplete combustion processes, and natural sources. In the absence of statistical industrial data the amount of VOC emissions in Cairo cannot be estimated.

Photochemical oxidants are not monitored on a routine basis in Cairo. Some data on O3 concentrations are available from research studies.

During a 1979 study, photochemical oxidants were monitored on six to nine days per month. There was not a single month in which the WHO one hour guideline 150-200 ug m3 was not exceeded. However, during this study a method was used (neutral KI method), which has a rather poor reliability compared with modern UV absorption techniques.

A more recent study on O3 levels using UV absorption technique was performed between May and August 1989 at a residential site in Cairo. At this site, rather low O3 concentrations were recorded. Maximum half-hourly concentrations of 110-140 ug m-3 were monitored which are below the WHO hourly guideline (150-200 ug m-3). Concentrations of O3 recorded in the residential area close to the power station between September to December 1990 showed that the WHO guidline for one hour has been exceeded during 7 days out of the monitored 17 days. A clearer view of the ozone pollution situation in Cairo cannot be given unless a more thorough monitoring of O3 is intiated. This is under consideration in the time being through AST/NRC project (Professor Nasralla).

6. Lead

The major source for lead emissions are lead compounds added to petrol as antinock agents. It may be estimated that motor vehicles could give rise to lead emissions in the order of 700 to 1000 tonnes per annum. The other important sources of lead emission is lead smelting which may emit 300 to 500 tonnes per annum although the emission from this sort of industry is local but its impact on air quality and fod quality grown at these sites might be severe. Lead in petrol use to be 0.9 g/l. Official report mentioned that it is reduced to 0.36 g/l and projectioned to be free leaded gasoline by 1995.

Table 10 showed that lead levels exceed the WHO annual mean guideline of 1 ug/m3 in all sites, except the north-east residential area. Lead concentrations are highest in city centre and the maximum seasonal concentrations are usually found during summer months.

Table 10. Lead in Cairo Atmosphere, ugm-3.

	City Centre		Resident commertial	Resid. North	Resid N - E	Resid Ind. Tebeen
	(1983)	(1990)	(1990)	(1983)	1990	
Autumn	2.6	2.9	1.7	1.2	0.4	--
Winter	2.2	2.1	1.8	1.4	0.3	--
Spring	2.3	3.2	2.1	1.3	0.4	--
Summer	4.9	3.8	1.8	1.8	0.8	10.0*
Mean	3.0	3.0	1.9	1.4	0.5	

* Close to lead smelting opeation.

A survey of blood lead levels showed that mean Pb levels in blood of the urban population were about 31 ug dl/l compared to 12 ug/dl in rural population, and of heavily exposed policemen about 63 ug/dl, which is above the WHO 98 percentile blood Pb guidline of 20 ug/dl.

The emitted lead from smelters also polluted the cultivated soil in Helwan and Shoubra - El Khiema with levels of lead sometimes reaches more than 1000 ug/g soil. This resulted in accumulations of lead in edible portions of vegetation of levels more than the recommended level of 10 ug/g in food.

Indoor Air Quality

Very limited studies had been conducted on this subject in Egypt. These studies showed that the use of fuel - equiped cookers and heaters (gas and kerosine) results in high concentrations of more than 100 ug/m3 NO2 and 15 mg/m3 carb monoxide, 24 h average indoor homes. It is concluded that residents of inner city poor houses using kerosine are at high risk for the deleterious effects of combustion generated air pollutants.

Impact of Air Pollution on Health

Very few studies have been carried in G. Cairo to relate air pollution to human health. These studies showed high levels of lead in urban population and traffic policemen (see the section on lead).

Other investigations carried out in Shoubra El Kheima and Helwan concluded high incidence of chest diseases among school children. For example, these incidences of chest problems reached about 20% and 23% in school children of Shoubra El-Kheima and Helwan school children respectively as compared to only 3% in school children living in relatively clean air of other rural governerates.

Conclusions

It may be concluded that Cairo is characterised by high levels of several air pollutants such as Pb, NO2, SO2, CO and particulate. An intensive study should be conducted to evaluate and produce reliable data on toxic and carcinogenic compounds in Cairo air (e.g. Pb, Cr, benzopyrenes .... etc.) and their sources. This study has been started in the National Research Centre under the supervision of professor M.M. Nasralla. This project needs to be strengthened and supported to produce complete evaluation of these substances based on reliable data. A study should be also conducted to relate air pollutant concentrations to the prevailing health problems such as chest diseases, cancer ... etc. Emission inventories should be carried out for all major air pollutants. Lead additives to petrol should be reduced and lead smelting technology should be improved, controled and relocated away of residential and cultivated areas. Fuel burning adjacent to residential areas should be restricted to natural gas and oil of less than 1% sulphur content. Control measures should be introduced to reduce dust emissions from cement industries, iron and steel ... etc. Strict industrial zoning should be applied for new industries. Use of natural gas by industry and by electric power stations should be encourged.

References

Ali, E. A., Nasralla, M.M. and Shakour, A.A.1986 Spatial and Seasonal Variation of Lead in Cairo Atmosphere, Environmental Pollution 11B, 205-210.

Commins, B. 1987 Air Pollution in Egypt, (EGY/CEH/001) WHO Regional Office for the Eastern Mediteranean, Alexandria.

Faiz, A., Sinha, K., Walsh, M. and Varma, A. 1990 Automotive Air Pollution: Issues and Options for Developing Countries, World Bank Policy and Research Writing Paper WPS 492, The World Bank, Washington DC.

Ministry of Health EMC, Data on air Pollution (1989/1992).

Nasralla, M.M. and Shakour, A.A. 1981 Nitrogen Oxides and Photochemical Oxidants in Cairo City Atmosphere, Environment International 5, 55-60.

Nasralla, M.M., Shakour, A.A. and Ali, E. A. 1984a Using the British standard method to monitor SO2 in Egypt air, Second Egyptian Congress of Chemical Engineers.

Nasralla, M.M., Shakour, A.A. and Said, E.A. 1984b Effect of lead exposure on traffic policemen, Egyptian Journal of Industrial Medicine 8, 87-104.

Nasralla, M.M. 1990 Air Quality in Cairo Metropolitan Area, Report for WHO, Air Pollution Department, National Research Centre, Cairo.

Nasralla, M.M. Data on sources and air pollution in Cairo, unpublished.

Nasralla, E.A.Ali, Y.Ibrahim, Particulates in The Industrial Area, South of Cairo, J. Ind Medicine, In press (1992).

Nasralla, M.M. and Ali, E.A. project 5/2/1 on air pollution in Cairo NRC, 1989/1992.

Nasralla, M.M. A project on Toxic and carcinogenic in Cairo atmosphere, AST/NRC (in Progress)(1991/1995).

Nasralla, M.M., Ali, E.A. and N.M.Moustafa, Particulate and sulphur compounds in Cairo atmosphere, J. Industrial Medicine, 1993 (In press).

Nasralla, M.M. A Report on Air Pollution and Noise in Egypt Atmosphere, EEAA, 1991.

UN 1989 Prospects of World Urbanization 1988, Population Studies No. 112, United Nations, New York.

WMO 1971 Climatological Normals (CLINO) for Climate and Climate Ship Stations for the Period 1931-1960), World Meteorological Organization, No. 117, Geneva.

ANNEX H

COMPARATIVE ENVIRONMENTAL RISKS IN CAIRO: WATER POLLUTION PROBLEMS

COMPARATIVE ENVIRONMENTAL RISKS IN CAIRO

WATER POLLUTION PROBLEMS

BY

FATMA EL-GOHARY

DECEMBER, 1993

CONTENTS

EXECUTIVE SUMMARY

Greater Cairo and Helwan has a population of some 15 million and like all major urban areas has locations which may be wholly industrial, commercial, residential or mixed. Heavy industry is generally located around Helwan and Shoubra El-Khemia but various large individual factories are located throughout the City particularly in Embaba.

There are also many small industries spread throughout the City and generally wastewater discharges from these industries are low in volume and become rapidly diluted. However, short-term discharges of highly toxic material may cause problems and specific industries particularly those discharging prohibited substances, or heavy metals should be controlled. Some districts are also centres for specific types of industry such as tanning (Ein Sierra), and the combined discharges from such areas can present a problem and require monitoring. Recent trends in accordance with Government planning have been to locate new industry to the new satellite cities.

Work undertaken by CWO and General Organisation for Sanitary Drainage (GOSD) over the last decade has involved the design of an extensive sewerage network and six major treatment plants to serve Greater Cairo and Helwan. Three will be located on the East Bank of the River Nile, two on the West Bank and one at Helwan. These plants will significantly reduce pollution within Cairo and provide the potential for effluent and sludge reuse in agriculture.

Studies carried out indicated that industry is often not complying with Law 93, which controls the discharge of industrial wastewaters to sewers. This lack of compliance is due to a combination of Regulations which may be too severe, and lack of enforcement.

There are five Government organisations who have direct responsibility for sampling industrial effluents and these should be co-ordinated.

The review of the institutional situation suggests strengthening GOSD to enable it to more effectively carry out its duties. It is recommended that an effluent control programme be introduced with the formation of an Effluent Management General Department (EMGD) within GOSD. This will be an all embracing division of GOSD which will include an inspectorate, administration,statistical and laboratory section. To be effective the EMGD will require the right of entry, the power to take samples and the ability to make charges for discharges to the sewerage system.

RECOMMENDATIONS

1- Industry should be encouraged to practice good housekeeping. Water supplies should be metered and appropriately charged to encourage a reduction in the volume of wastewater discharged. These include:

- Improved operation and maintenance.
- Separation of cooling water from treatment water before discharge.
- Recycling of material.
- Rehabilitation of old equipment.
- Maintenance of oil and grease traps, and sedimentation tank
- The installation of pre-treatment equipment before discharg
- Education of the management and workforce.

2- The preparation of a database is recommended. It should be kept updated and extended.

3- Because new wastewater facilities are now being commissioned, an industrial effluent control programme should be introduced as a matter of urgency.

4- Five Government Organisations have direct responsibility for monitoring and control of industrial pollution. These are GOSD, Ministry of Health, GOFI, GOGCWS and the Ministry of Public Works and Water Resources. Their activities should be co-ordinated. Furthermore, immediate action should be take to strengthen these organisations.

5- Existing licences to discharge to the sewerage system should be reviewed and revised to incorporate quality and volumetric conditions, and to include provision for further periodic review.

6- It is recommended that the role of the relevant Departments and Ministries with respect to licensing under Law 93 be more clearly defined in the regulations and that the content of licence application forms and the licences themselves be set out more clearly.

7- Amendments are to be made to the schedule of standards for discharge and it will be necessary to amend (by Decree) this schedule and to introduce a separate schedule of more restricted and prohibited substances. As regards protocol for sampling of effluents the regulation may need to be amended to permit analysis in laboratories other than those of the Ministry of Health.

8- Consideration should be given to man-power development.

9- Solid wastes alongside wastewater management should be part and parcel of an integrated approach to environmental management in Greater Cairo. Waste management plans need to be developed. These plans should be quided by the use of simple collection, transfer, and resource recovery technologies. They should focus on maximizing the involvement of the private sector in service delivery, capitalizing on its resources and traditional interest in the business.

10-Assessment of waste processing and disposal alternatives conducted over the past years for several governorate suggest that composting supplemented by sanitary landfilling for ultimate disposal of noncompostable waste, offers a cost-effective and environmentally sound option.

11- Environmental concern should be integrated into our basic educational system. Communication networks should work on raising consciousness and converting the general public into environmental advocates. The Government and businesses should begin training their staff to account for the environment in their respective professional disciplines. This is necessary to introduce and sustain the concept of sound management of our water resources at all levels.

12- To effect control of point sources of pollution, it is necessary to monitor the volume and quality of the discharge from these sources. Since sampling and analysis is by far the most costly part of any monitoring programme, it is important to make use of existing, monitoring activities carried out by the different institutions.

13- The development of comperhensive plansfor wastewater and sludge reuse with special emphasis on environment,health and safety aspects, should be given priority.

1. TOPOGRAPHY AND CLIMATE

The City of Cairo (latitude 30°03',longitude 31°15, approximately) is situated on the River Nile 220 kilometers to the south-east of Alexandria and 170 kilometers to the south-west of Port Said, as shown in Figure (1).

Greater Cairo extends from Helwan in the South to a new development area, El Aboure in the north. (Figure "2").

The typical desert climate of Cairo contrasts daytime heat with cool summer nights. Winds are mild, rarely exceeding 30 km per hour. From April to November, the prevailing wind blows from the northern hemisphere, and mainly from the most northerly quadrant. In the period from January to March the wind direction is generally from the south to the south-west.

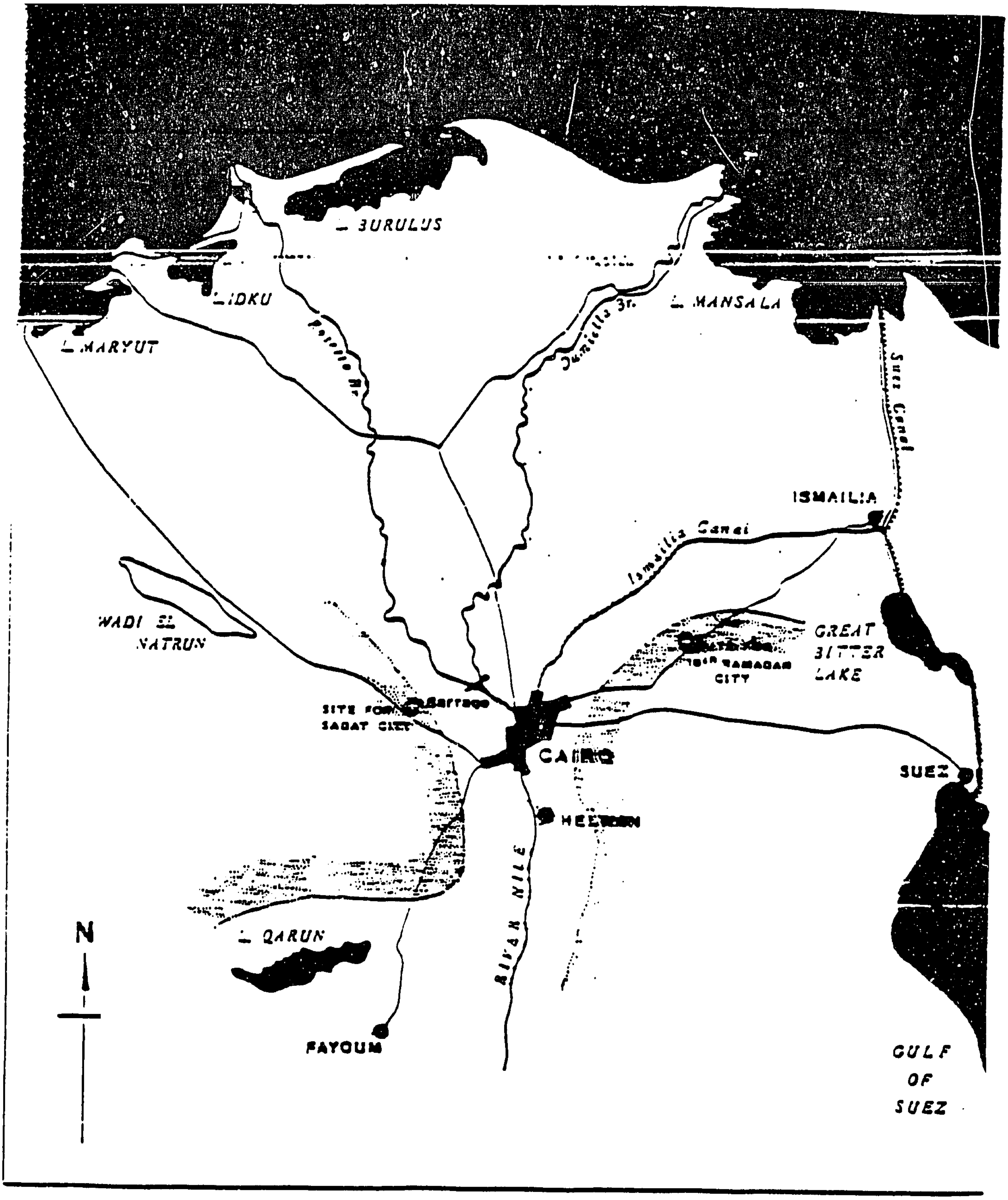
Rainfall is normally light and occurs between November and April. On average, it does not exceed approximately 27 mm per annum, but severe storms, with heavy precipitation,occasionally occur.

2. POPULATION

Ever since civilized man became established in the Nile Valley there have been important settlements within and clos to the present boundaries of the City of Cairo. Memphis, which lies 25 km to the south of Cairo on the west bank of the Nile, was the capital of Egypt during the 3rd to 6th Dyn sties (2720 BC to 2420 BC) and the district of Heliopolis wa probably the site of the religious centre of Egypt in the ea liest period.

In the year 1800 the population of the city was about 0.3 million and this had risen to 1.2 million people by 1930. Following the end of the Second World War the City began to expand very rapidly with new development occuring to the nor and north-east, on the islands of Zamalek and Roda, and also in previously undeveloped areas on the west bank of the Nile This rapid expansion has continued unabated until the presen day and the 1986 Census results show that there were 9.75 million people living in the urban area, of Greater Cairo.

As a result of this rapid expansion coupled with shortage of available funds during the war years, the problems which fac present-day Cairo are enormous. Housing production has falle far short of the City's needs and, in some quarters, the popu lation density per hectare now exceeds 1000.
Districts such as El Sharabeya and Rod El Farag are more densely populated than New York City, despite the fact that,in Cairo, the most crowded districts are those with buildings seldom exceeding three or four stores.



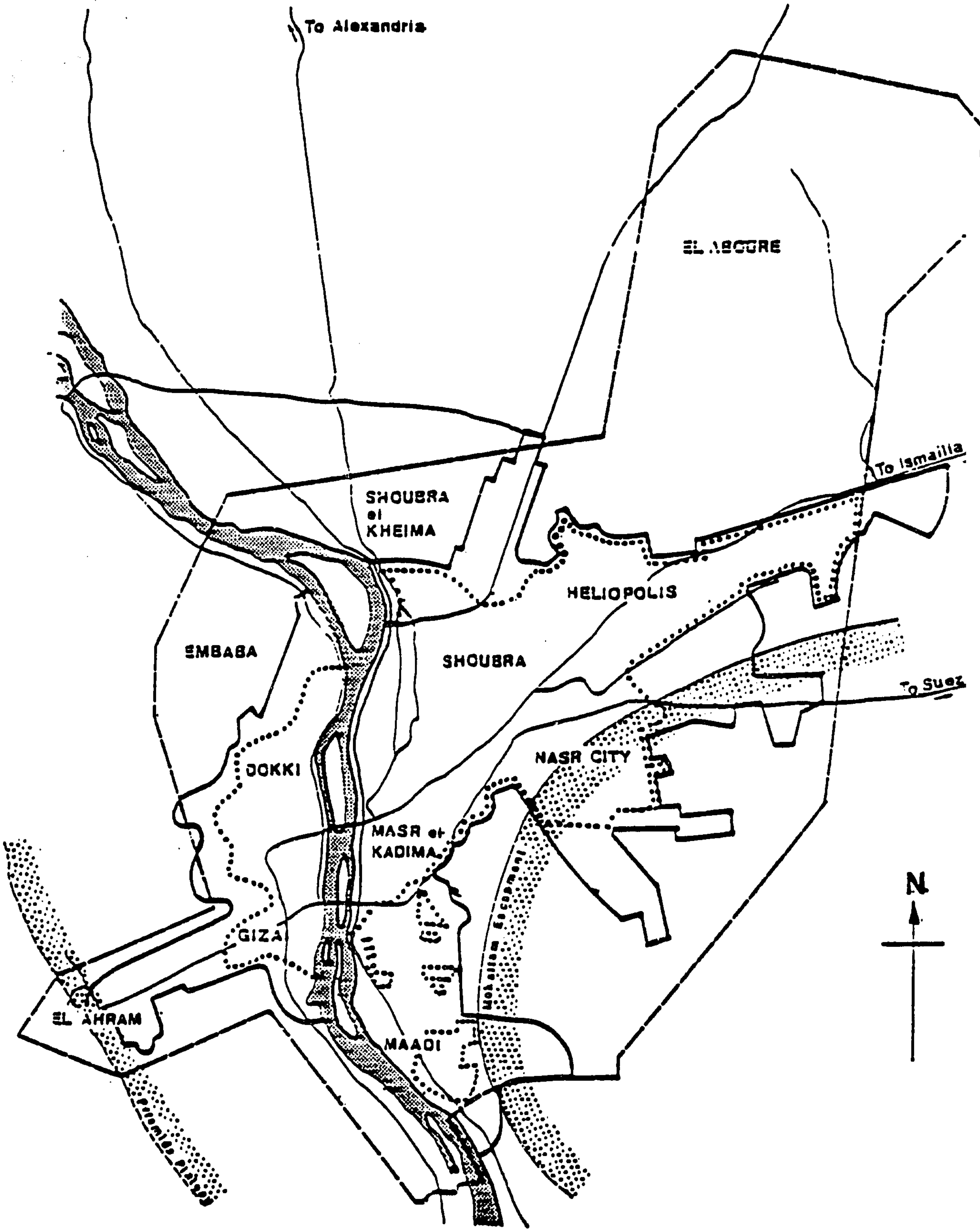
Scale 1 : 1,500,000

Km 0 50 100 Km

LO... ...P

245

Figure 1



SCALE 1 : 200,000

kms 0. 10

LEGEND:

- Project Area Boundary.
- Present Urban Area Boundary.
- Present Sewered Area Boundary.

PROJECT AREA

Figure-2

As in housing, the lack of adequate investment in the past has resulted in a deterioration of infrastructure in most sectors. There are major problems in road transport, and public utilities, including wastewater facilities, and it became evident that in order to remedy past neglect and to make adequate provision for future growth in all these areas, substantial national resources will have to be allocated to appropriate investment in the City.

3. DEVELOPMENT OF CAIRO'S WASTEWATER SYSTEM

In order to gain an understanding of the complexities of the existing wastewater system in Cairo, it is instructive to trace the development of the system from its inception at the beginning of the century until the present day. For a city of such historic size and importance it is perhaps surprising that it had no sewerage system until 1914. Up to that time the only drainage facilities comprised less than 8,000 meters of ancient masonry open storm water drain which discharged into the Nile through three separate outfalls, (Carkeet, 1916).

Over the years, several sewerage schemes have been designed and implemented.

Recently, more than one thousand million pounds sterling has been expended on the sewerage network, on both East and West Banks and in Helwan.
Work undertaken by Cairo Wastewater Organization (CWO) and General organization for Sanitary Drainage (GOSD) over the last decade has involved the design of an extensive sewerage network and six major treatment plants to serve Greater Cairo and Helwan. Three are located on the East Bank of the River Nile,two on the West Bank and one at Helwan (Figure 3). These plants will significantly reduce pollution within cairo and provide the potential for effluent and sludge reuse in agriculture. Four of the treatment plants (Zenein, Helwan,Berka and Abu Rawash) are already in operation and the others at Gabal El-Asfar and Shoubra El-Kheima are under construction. It is expected that all six plants will be effective in treating normal domestic, commerical and most industrial wastewater. Table (1) shows the population served, flows and loads to the year 2010 for both the East and West Bank. Available information indicates that most of the population will be served by the sewerage network early next century.

The wastewater treatment plants referred to above will eventually provide secondary treatment to the domestic and industrial wastewaters generated by a population of almost 16 million persons expected to be reached early in the 21st Century.

مشروع الصرف الصحي للقاهرة الكبرى

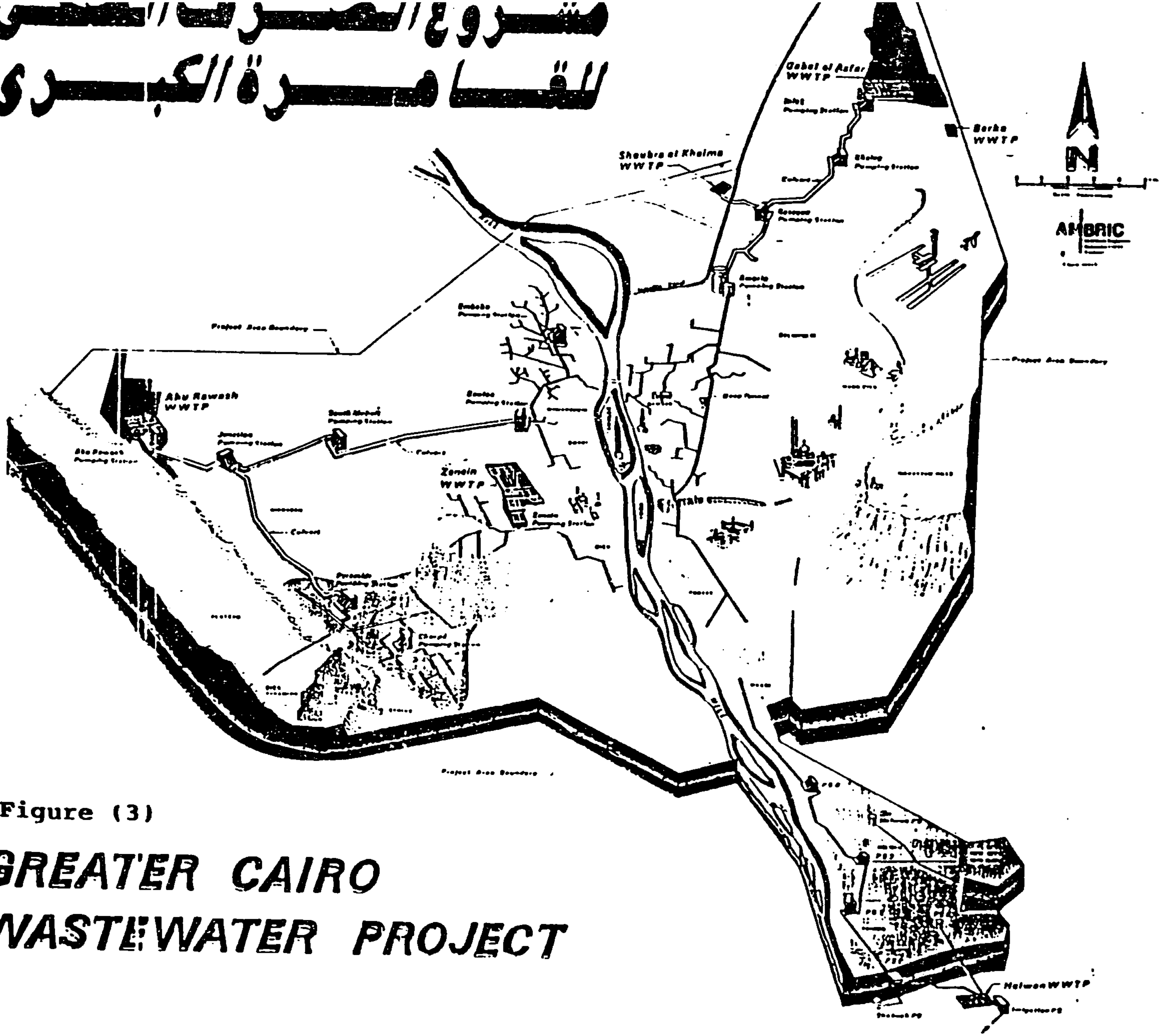


Figure (3)

GREATER CAIRO WASTEWATER PROJECT

Table (1) Summary Flow and Load Projections, East and West Bank

Item	1990	2000	2010
East Bank			
Sewered pop'n(million)	6.33	8.49	10.64
Average flow(1000 m^3/d)	1816	2551	3332
BOD (t/day)	589	794	1012
West Bank			
Sewered pop'n(million)	1.93	4.29	7.18
Average flow(1000m^3/d)	472	1173	2139
BOD (t/day)	168	375	626

Source: Ambric 1991

A huge amount of treated wastewater and sludge will be produced. Table(2) shows treatment plants capacities, projected flow and sludge production.
According to the Sludge Management Study (AMBRIC,1990), by about the year 2020, the sludge production could reach 3600 t dry solids/d. By about 1995, when the Gabel el Asfar, Berka, Shoubra el Kheima, Abu Rawash and Helwan first phase plants are in service, the sludge production level could reach 50% of the ultimate figure.

If this ultimate sludge volume were dried to about 85% solids content (approximate bulk density of 600 kg/m^3), as currently practised, approximately 2.5 million m^3 of sludge would be produced annually. The estimated annual demand for sludge for application to fruit trees on existing agricultural land, in accordance with existing reuse guidelines established by GOSD, is only about 250,000 m^3, or about one-tenth of the annual amount of sludge that will eventually be produced.

Based on these conclusions, a list of general viable options for sludge management in Cairo was developed. These options ranged from evaporation lagoons to anaerobic treatment and mechanical dewatering.

4. INDUSTRIAL WASTEWATER MANAGEMENT

4.1. Background

Although industry in its modern sense has existed in Egypt since the early 19th century, industrial exploitation of natural resources increased after World war one. Special emphasis was placed on food processing, textile manufacturing, and cement and fertilizer production. In the early fifties, industrial development took a new course, shifting away from the traditional agrarian base to focus on the introduction of heavy industries such as Iron & Steel, machinery, and chemicals. An important feature of the industrialization of Egypt during that period was the concentratio of new industries in the metropolitan areas along the Nile Delta: north and south of Cairo, particularly in Helwan and Shoubra El-Keima, Kafr El-Zayat, and Talkha, and in Alexandria Metropolitan area.

The factories in Egypt encompass a wide range of ages and designs reflecting the history of development in the country. Many of the factories built in the early 20th Century are of French or English design. Factories constructed in the late 1960's are of Russian or Czechoslovakian design while the most recent factories are mainly western, European in origin.

TABLE 2: PROJECTED FLOW AND SLUDGE PRODUCTION

	Phase I	Phase II	Phase III
Treatment Plants Capacity, cmd			
Gabal El Asfar	1,000,000*	2,000,000*	3,000,000*
Shoubra El Kheima	600,000*	600,000*	600,000*
Berka	600,000*	600,000*	600,000*
Subtotal, East Bank	2,200,000	3,200,000	4,200,000
Zenein			
Abu Rawash	330,000*	330,000*	330,000*
Subtotal, West Bank	400,000**	600,000*	1,000,000*
(*=secondary)			
(**=primary)			
Solids Loadings, t/d			
Gabal El Asfar	410	820	1230
Shoubra El Kheima	245	245	245
Berka	245	245	245
Subtotal, East Bank	900	1310	1720
Zenein	120	120	120
Abu Rawash	100	245	410
Subtotal, West Bank	220	365	530
Year of Commissioning			
East Bank Facility	1995	2005	2015
West Bank Facility	1993	2001	2013

Most industries are under the jurisdiction of the Ministry of industry. It owns 72% of the 367 public industries, followed by the Ministry of Economics with 9%, and the Ministry of supplies with 8%. Ownership of the remaining 11% is split between the Ministries of Defense, Electricity, Agriculture, Housing and Health (RNPD, 1989).

In 1956, all major idustries were nationalized. Because the trend during that period was to support industrial development and attain rapid returns on investment, inadequate attention was paid to the long-term issue of environmental deterioration. Although Law "93" on wastewater disposal was promulgated in 1962, regulations and standards set were not applied to public sector industries, inspection was discouraged, and rules not enforced. As a result, untreated wastewaters have been discharged ever since into the Nile, lakes, drains, and the Mediterranean.

The Egyptian Government however, has recently become increasingly aware of the importance of environmental risk management on economic development, health and quality of life.

4.2. Water Consumption for Industry

At the present time, industrial use of water in Egypt is estimated to amount to 3.7 bilion m^3/year. Out of this total, 2.1 bilion m^3/year is used as cooling water (e.g. power plants) and 0.6 bilion m^3/year is used as process water. By the year 2000, the industrial use of water was estimated to increase from 2.1 to 6.7 bilion m^3/year for cooling water and from 0.6 to 3 bilion m^3/year for process water (GOFI, 1985). Under such projections, nearly five times the current quantity of industrial effluent(process water) will have to be treated and discharged into the various aquatic components of the Nile system within the next ten years.

Irrespective of the probability of reaching these projections, it is clear, however, that a growing industrialization is taking place in the short-term with the result of an increase in the volume of effluents, of toxic waste and in the variety of toxic contaminats discharged to the river system. While the immediate situation calls for the implementation of pollution control measures for the existing industries, there is already a need to implement sound information and monitoring systems, which allows management of liquid wastes associated with this growing industrialization.

4.3. Assessment of the Existing Situation in Greater Cairo

Studies carried out so-far indicated that industry is often not complying with Law 93, which controls the discharge of industrial wastewaters to sewers. This lack of compliance is due to a combination of Regulations which may be too severe. and lack of enforcement.

Heavy industry is generally located around Helwan and Shoubra El-Kheima, but various large individual factories are located throughout the city particularly in Embaba (Figure "4").

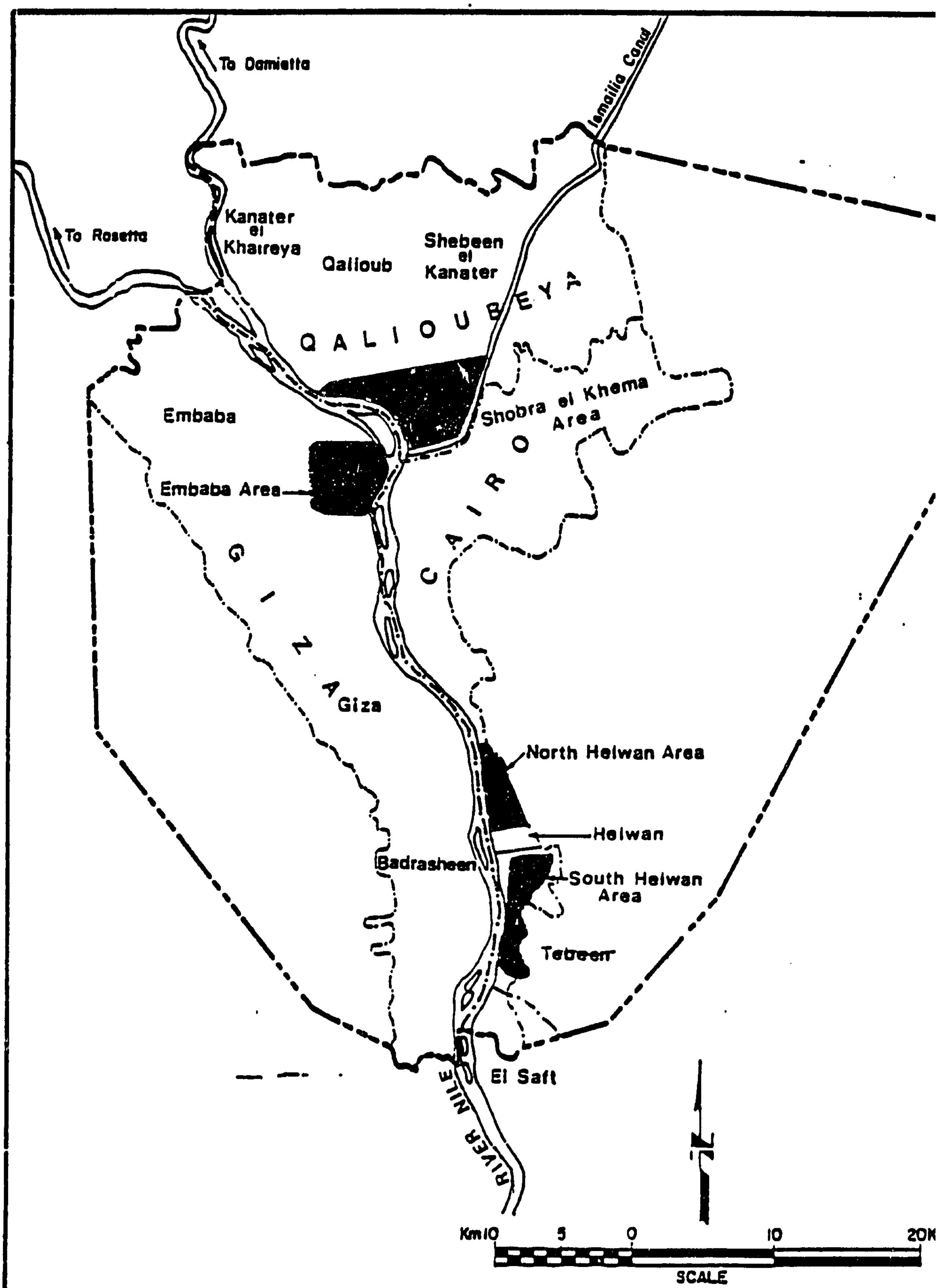
There are also many small industries spread throughout the city and generally wastewater discharges from these industries are low in volume and become rapidly diluted. However, short-term discharges of highly toxic material may cause problems, such as those discharging heavy metals.

Industry in Greater Cairo comprises 75 percent public and 25 percent private sector. Of the public sector 80 percent are under the jurisdiction of the Ministry of industry, the other 20 percent are under other Ministries such as health and supplies. The public sector industries in Cairo comprise 63 companies with 127 factories consisting of:

-23 chemical
-27 textile
-7 metal
-32 food
-29 engineering
-9 mining

These industries use some 162 million cubic metres of water a year and discharge some 129 million cubic metres of effluent (Table 3).

GOFI stated that industrial drainage of the public sector factories in Greater Cairo represents 23% of the total industrial discharges in Egypt. They estimated some 0.75 tonnes/day of heavy metals are discharged representing 46% of the total heavy metal discharge of the industrial sector. Oils and lubricants exceed 93 tonnes/day and suspended matter 97 tonnes/day. This shows that Greater Cairo area is by far the most polluted followed by Alexandria and that the most polluting industry is probably the chemical industry. (Table 4).



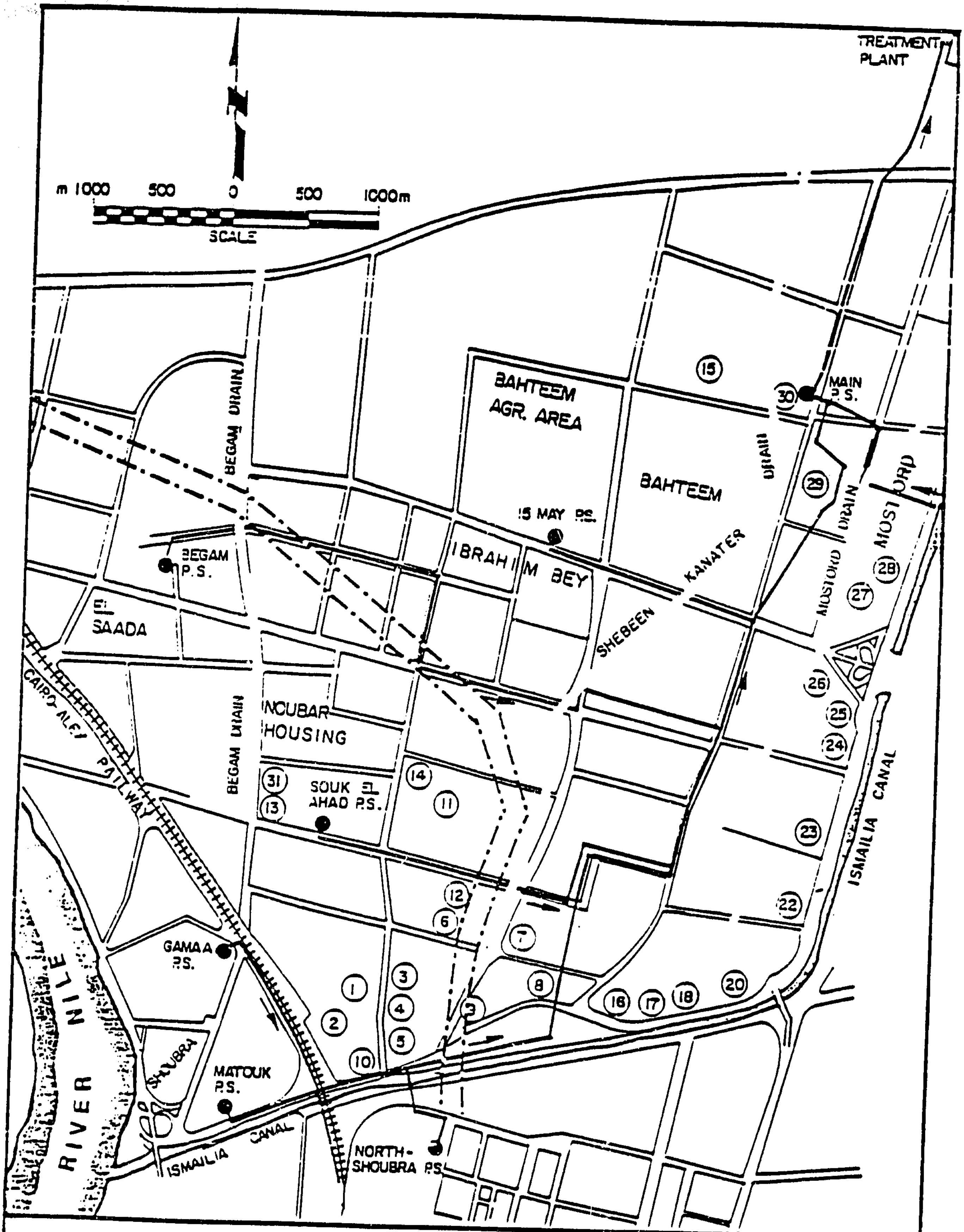
LEGEND:

GREATER CAIRO BOUNDARY

GOVERNORATE BOUNDARY

HEAVY INDUSTRIAL ZONES

Figure(4) GREATER CAIRO HEAVY INDUSTRIAL ZONES



LEGEND:

(16)	FACTORY NUMBER
———	SHOUBRA EL-KHEMA NEW PROJECT
- - -	DRAIN
-·-·-	H.V. ELECTRIC

255

GREATER CAIRO FACTORIES AT SHOUBRA EL-KHEMA ZONE

Figure 5

TABLE 3 : "Yearly Water Consumption, Effluent Volumes, and Polluting Loads - Regions

DATA	NO.	WATER (MILL. M³/YR) POLLUTION LOADS (t/DAY)						
Region		Use	Eff	BOD	COD	Oil	SS	Metals
Greater Cairo	127	162	128	71	120	93	97	0.75
Alexandria	85	110	88	91	186	43	40	0.17
Lower Egypt	60	146	125	34	42	24	86	0.5
Upper Egypt	35	211	204	72	37	5	68	0.2
The Canal & Remote Government	24	7	5	2	3	3	5	0.3
TOTAL	331	636	550	270	388	168	296	1.92

Source: GOFI

TABLE 4 : Average Water Consumption, Effluent Volumes and Polluting Loads for Industry Throughout Egypt

DATA	NOs	WATER	EFF	POLLUTION LOADS (t/DAY)				
Industry		Use mill. m^3/yr	mill. m^3/yr	BOD	COD	Oil	SS	Metals
Chemical	53	127	98	26	178	23	33	0.94
Food	119	296	227	182	142	110	168	0.17
Spinning & Weaving	75	114	88	39	47	24	64	0.3
Engineering	39	13	12	5	7	2	3	0.03
Metal/Metallurgy	11	69	60	15	14	8	24	0.2
Mining	33	19	14	3	1	1	4	0.01
TOTAL	330	638	499	270	389	168	296	1.65

Source: GOFI

The major centres of pollution within Greater Cairo have been identified as being Shoubra El-Kheima and Helwan.

SHOUBRA EL-KHEIMA

Various factories are located in this area and include:

- Spinning, weaving and dyeing
- Glass manufacture
- Cable manufacture
- Electric appliance
- Cement pipes
- Metal foundries

In a recent study, carried out by the National Research Centr's Water Pollution Control Department,(El-Gohary et al,1990) industries were identified as being the major sources of water pollution in the area. The textile industries-representing 48.3% of the total number are the main contributors to organic load, at almost 52% (26372 kg/day). The metal industry, on the other hand, which only represents 15% of the total number, discharges almost 50% (49.8%) of total wastewaters discharged and contributes 7.6% of the total BOD load, (Table 5 , and Figures from 5 - 8).

HELWAN

The locations of the factories in the Helwan are shown in Figure (9). A number of these factories are not at the moment connected to the sewerage network and discharge their effluents directly to the river, or indirectly through agricultural drains. Studies carried out by the WPCD indicated that the Iron and Steel Factory and El Nasr Automobil company discharge large quantities of toxic wastes.(El-Gohary et al, 1984&1988).

According to the Helwan wastewater Master Plan(1978), the industrial wastewater discharged from the Helwan area amounts to 42, 314,000 cubic meters per annum, (Table "6").

IMBABA INDUSTRIAL ZONE

This zone contains many large factories that drain their effluent to the Giza sewerage system. These include textiles, metal products, print-shops and shipyard workshops.,(Figure"10"

DIFFUSE FACTORIES

The second category is diffuse industrial units often employing small numbers and located within the residual areas.

Table (5) Organic load Contributed by the Different Industrial Sectors in Shoubra El-Khema.

Type of Industry	Miscell-aneous	Oil & Soap	Starch Yiest glucose	Pulp & paper	Metal Ind.	Plastic & Rubber	Textile & Dyeing	Total Load
COD Load (Kg/day)	1366.9	7006	3239.4	2322.3	11676.3	236.7	26372.3	52219.9
BOD_5 Load (Kg/day)	244.9	4568	1148	661.7	1257.7	77.9	8533.9	16492.1

Figure 6
PERCENTAGE DISTRIBUTION OF INDUSTRIES

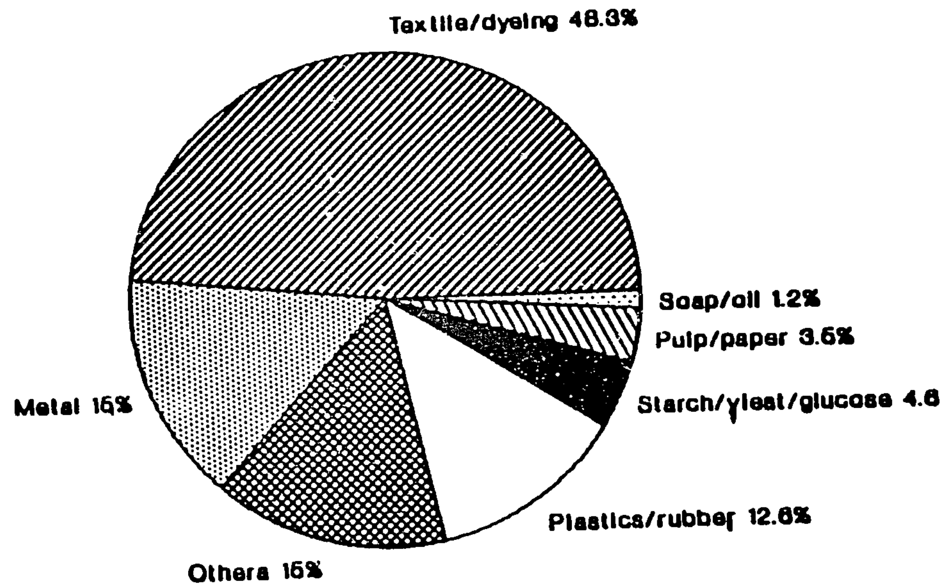
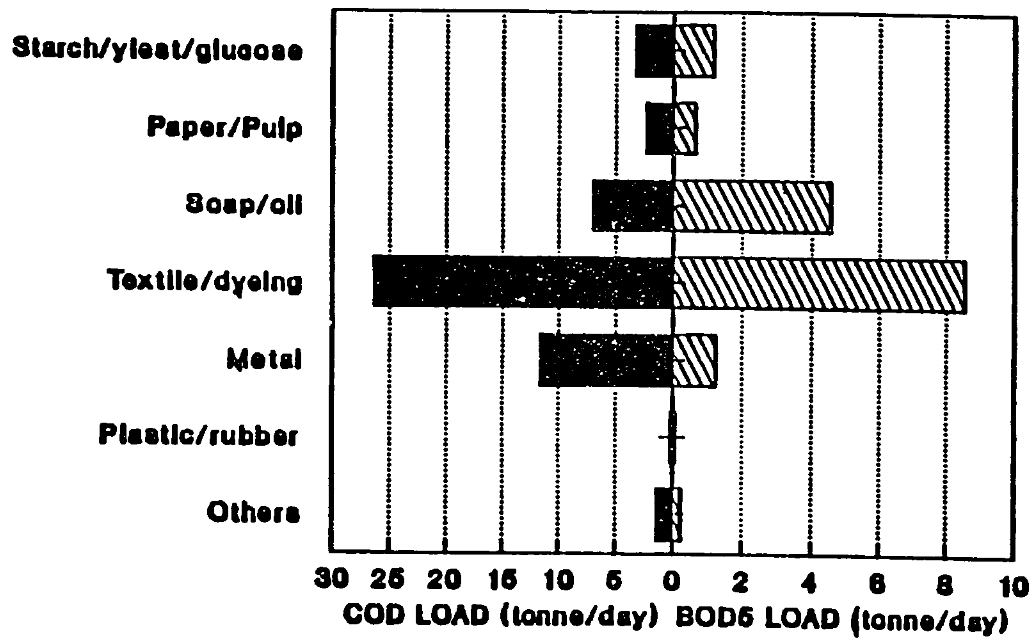
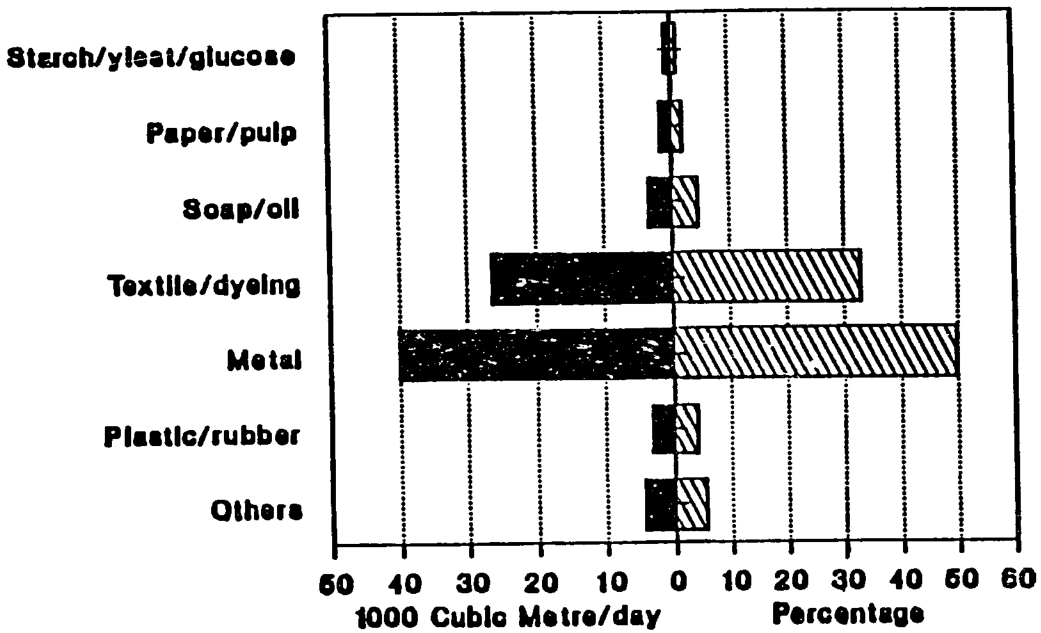


Figure 7
LOADS OF POLLUTION CONTRIBUTED FROM DIFFERENT INDUSTRIAL SECTORS

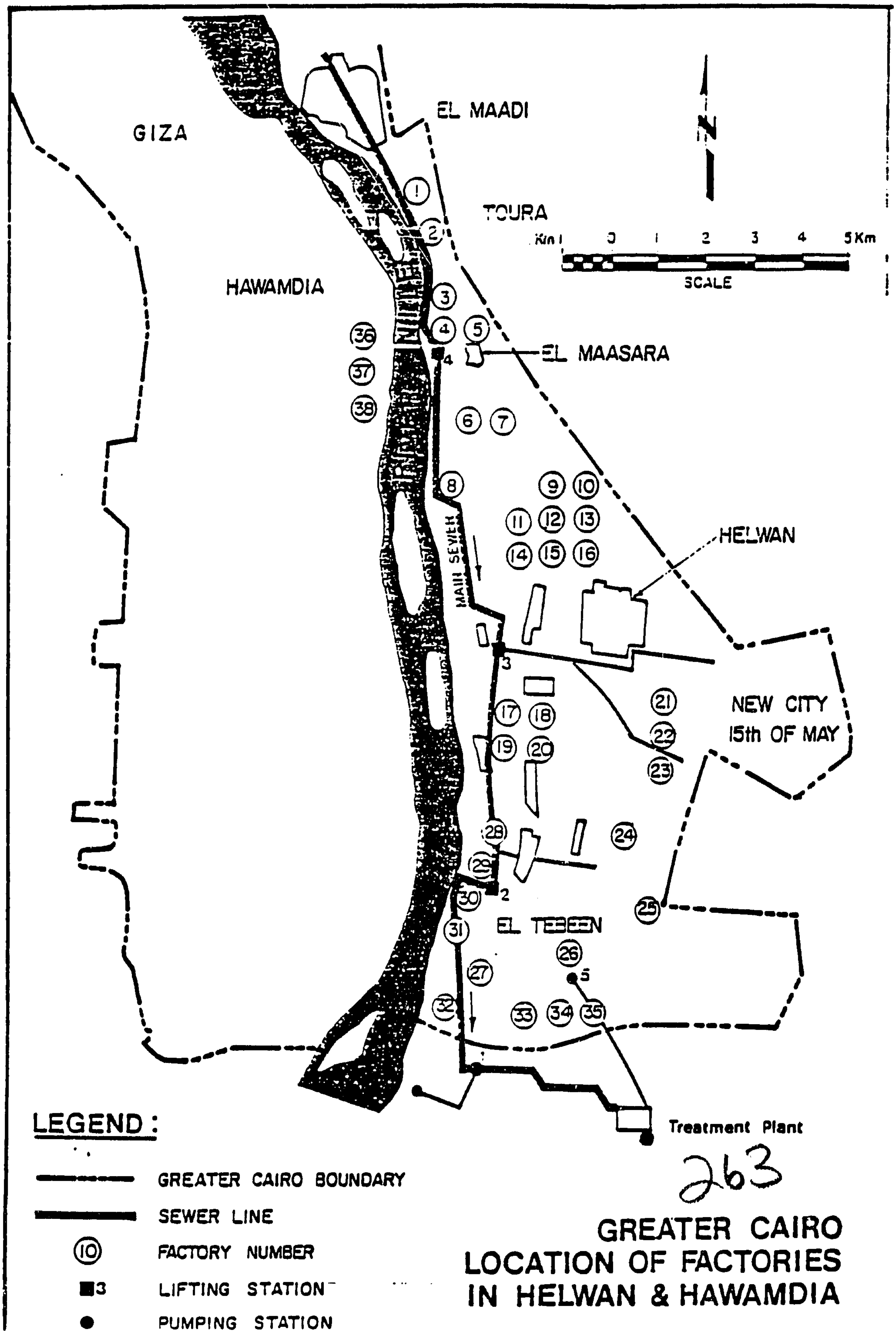


261

Figure 8
WASTEWATER DISCHARGED FROM DIFFERENT INDUSTRIAL SECTORS



262



263

GREATER CAIRO
LOCATION OF FACTORIES
IN HELWAN & HAWAMDIA

Table (6)

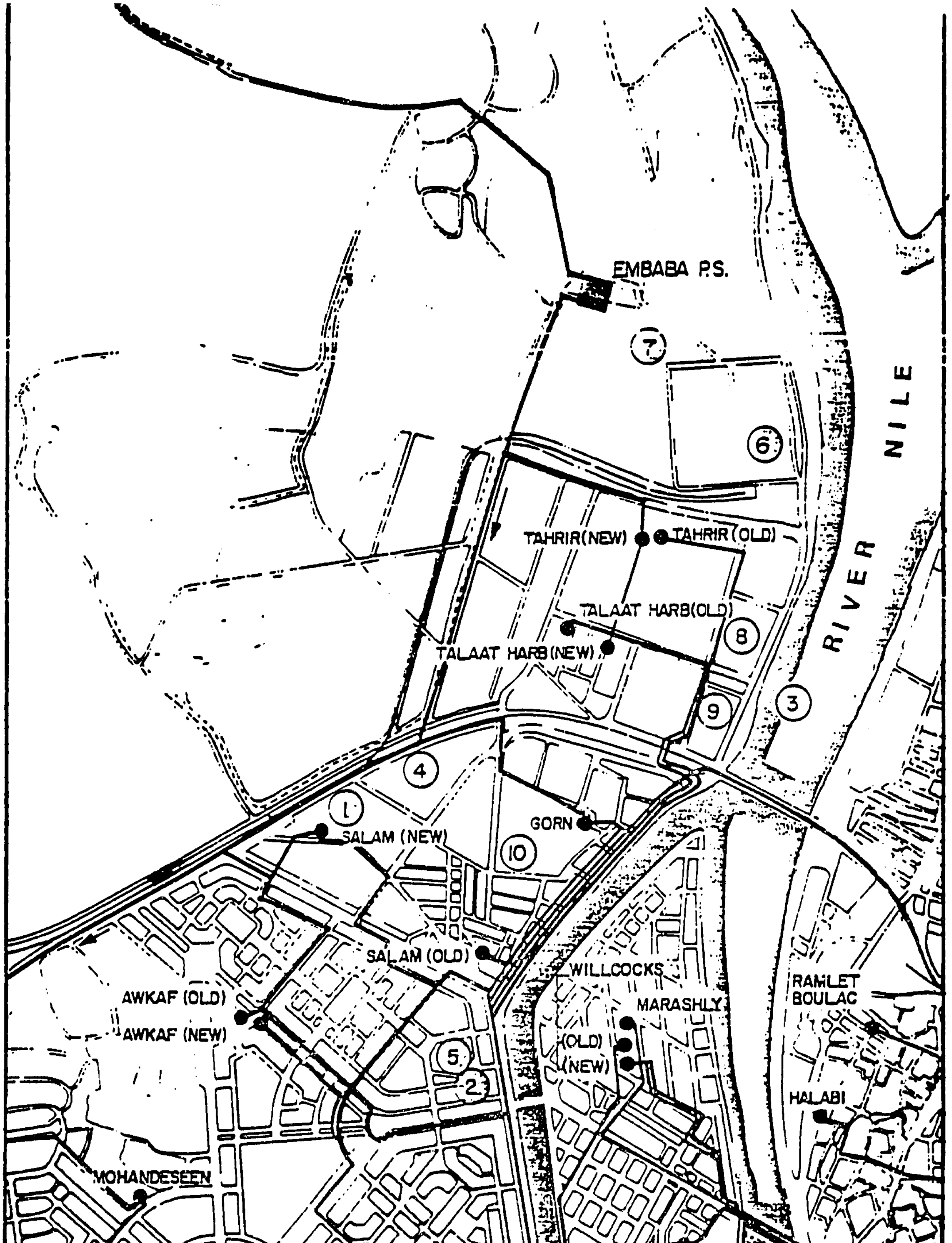
INDUSTRIAL WASTE WATER PRODUCTION
(evaluated from the questionnaire)

No.	Name of Factory	Quantity m^3/a	No.	Name of Factory	Quantity m^3/a	No.	Name of Factory	Quantity m^3/a
1	Siegwart	3 066 000	12	Military F.No.360	1 095 000	23	Forging Industry	460 000
2	Helwan Portland Cement	797 000	13	Military F.No. 36	312 000	24	Galvan Factory	2 000
3	Cement Factory of Tebeen	35 000	14	Military F.No.135	600 000	25	Chemical Fertilizer	3 504 000
4	Tourah Cement Portland[x]	-	15	Military F.No. 99	648 000	26	Coke Plant	1 401 000
5	Egyptian Telephone Co.	86 000	16	Military F.No.909	57 000	27	Spinning & Weaving	1 095 000
6	Cairo South Power Station	332 000	17	Military F.No. 9	1 248 000	28	Equipment of Spinning & Weaving	26 000
7	El Tebeen Power Station	438 000	18	Military F.No. 65	1 440 000	29	Sugar Refinery	17 520 000
8	El Nasr Automobil	652 000	19	Military F.No. 45	385 000	30	Sugar & Distillation	3 285 000
9	Egyptian Light Transport	216 000	20	Machine Tools	240 000	31	Organic Chemical Ind.	3 101 000
10	Semaf	120 000	21	Iron & Steel	19 000 000	32	Starch & Glucose	87 000
11	El Nasr Steel Pipes	4 800 000	22	Stelco	57 000	33	General Metal Co.	115 000
		10 542 000			25 082 000			30 596 000

x no discharge
own irrigation area (Forest)

Total = 42 314 000 m^3/a Without El-Badrasheen
23 906 000 m^3/a El Badrasheen

264



LEGEND:

(7) FACTORY NUMBER

——— EXISTING SEWER

265

GREATER CAIRO FACTORIES AT EMBABA ZONE

Figure 10

It was suggested that the 800 identified as diffuse industries were directly responsible for 30% of the flooding in the city's streets. These factories and production units are spread between the residential houses and they drain their wastewater to the sewerage network. The summary conclusions of a study carried out by the consulting Engineers Taylor Binnie and Partners, in cooperation with the WPCD of the NRC (1992), indicated the following problems:

TANNERIES

Cairo has around 52 tanneries all of which are situated in one area south of the City. They discharge acids, chrome salts, animal residues (which include blood, hair, intestinal contents and fat).

PETROL AND CAR SERVICE STATIONS

Car washing and lubrication operations in petrol stations result in large amounts of sand and lubricating oils. Despite the presence of oil-separation and settling tanks in these stations there is still considerable infiltration of these residues into the sewer, as many tanks are not being regularly cleaned.

BAKERIES

The number of bakeries in Cairo exceeds 350. Their wastewater generally drains to small diameter branches of the sewerage network. Some of their fuel oil containers leak and together with the wastewater residues form solid material that block pipes causing sewage flooding.

MARBLE AND TILE FACTORIES

These amount to more than 120 factories scattered between the houses and draining their effluents and wastes to the city's sewerage network. These factories cut and grind marble and produce tiles. Residues resulting from grinding and polishing cause precipitation of certain materials that are hard to remove from inside the sewer pipes.

A pilot sampling programme has identified gross pollution at some sites. The most polluting effluents enter the sewers from the following sources:

- Oil at 57,300 mg/litre from the bus depot in Zeitoon.
- Suspended matter at 17,700 mg/litre and ammonia at 600 mg/l from a glue factory in Shoubra El Kheima.

- BOD at 16,200 mg/litre from a brewery in Giza.
- Chromium at 85 mg/litre, grease at 327 mg/litre and suspended matter at 3,700 mg/litre from the tanneries in South Cairo.
- Detergent at 2,160 mg/litre from a chemical factory in South Cairo.

Other highly polluting effluents which are not discharged to the sewers included:

- Acidic discharges from the iron and steel and galvanising companies, pH values 0.67 and 1.3.
- Alkaline discharges from a concerte products company at pH 12.6.
- Iron at 4.000 mg/litre from the steel pipe and fitting factory.

Effluent characteristics from some industries sampled by the NRC is given in Table (7).

It is recommended that these industries be immediately addressed.

It would however, be emphasized that projects undertaken by CWO and GOSD, will significantly reduce pollution within the city and provide the potential for effluent and sludge reuse in agriculture.

5. WASTEWATER AND SLUDGE REUSE IN GREATER CAIRO

Reusing of municipal wastewater for agricultural purposes is one of the oldest forms of water reclamation in many countries. Egypt has already gained experience with wastewater reuse in agriculture for a number of years. The use of sewage (almost raw) for irrigation of Gabal El Asfar governmental farm, was initiated in 1915. The farm is located approximately 25 km north-east of Cairo.

The quantities of wastewater which will be available at the sewage treatment works at Greater Cairo, have been estimated to be 1.9 milliard m^3 per annum, by the year 2020. Comparison of this quantity with current water usage for all purposes throughout Egypt at 55.5 milliards m^3/year, yield a percentage of 3.4, makes re-use worthwhile consideration. Pre-requisite of any re-use program, however, is that it must be technically feasible, and environmentally acceptable. Reuse of treated wastewater and sludge if not well planned, implemented, managed and monitored, carries with it serious health risks (around 30 diseases are known to be associated with it);and poses environmental threats of soil damage,ground water contamination and air pollution.

TABLE 7 **Effluent Characteristics from Industries Sampled by NRC (Greater Cairo)**
(All results in mg/1 except pH and flow)

Manufacturer	No of Samples	Flow m^3/d	pH	BOD	COD	S.Solids	Oil/ Grease	Heavy Metals
Cement	1	320	9.6	5	15	100		
Plastics	4	220-1850	7.1-8.4	5-28	9-95	0-84	44	
Pulp/Paper	4	70-950	6.4-8.6	260-450	180-2550	7-2000	15-230	
Iron and Steel	9	300-24000	7.3-7.4	7-140	40-440	100-190	50-175	67
Non-Ferrous	7	300-2250	7.2-8.7	15-350	260-1677	55-3044	0-190	3-47
Chemical	4	175-136000	7.4-10.0	30-7500	60-1400	110-1210	43	
Pharmaceutical	4	185-630	7.3	120	760	760	100	
Oil and Soap	3	400-2000	7.2-11.0	850-33000	1900-42000	290-1930	140	
Textiles	19	25-12000	2.2-12.2	3-1080	13-4040	2-3396	29-321	
Food	15	120-792000	3.9-7.0	100-1530	410-10220	60-500	2-80	

Source: NRC

Therefore, the development of a comprehensive plan for wastewater and sludge reuse with special emphasis on environment, health and safety aspects, should be given priority.

Wastewater recycling, in Egypt, seems not only to be a rational alternative for wastewater disposal, as an environmentally sound practice: but also, and more importantly, probably, the only viable option to compensate for fresh water scarcity in the face of a growing demand dictated by development needs.

6. AMBIENT WATER QUALITY

6.1. Surface Water

6.1.1. Impact of River Use Between Aswan and Cairo

During its course from Aswan to Cairo, the river Nile receives considerable amounts of domestic, industrial and agricultural waste effluent. All agricultural drainage canals discharge in the main river south of Cairo. Furthermore, in view of the year around river flow control afforded by the Aswan High Dam, riverine navigation for the transport of people and goods has increased significantly. This has produced an oil pollution problem.

Preliminary calculations of the river's self-purification capacity indicated that it exceeds the present organic and nutrient loads discharged from domestic and agricultural waste. This applies only to biodegradable organic matter. Inorganic salts and nutrients, e.g., nitrates and phosphate, have been steadily increasing in the Nile water since the construction of the Aswan High Dam. Pesticide residues and oil and its degradation products also have been detected at increasing levels in the Nile water, and fish (Table 8).

6.1.2. Water Quality characteristics at Cairo

In addition to the above mentioned upstream conditions the river water quality at Cairo is influenced by the intensive industrial and urban activities of the area. At the present time, the impacts of these activities are not significant, and the river conditions are quite favorable for use as the source for the Cairo water supply. Nevertheless, water quality monitoring programs reveal a continuing deterioration in river conditions at Cairo.

The flow of the River Nile at Cairo varies between 80 and 150 million cubic metres per day. This large volume of water dilutes waste effluents from a number of industries. Deterioration in water quality is visually obvious only at localized areas near the river banks and at the sites of waste discharge. Midstream conditions are usually not affected, except near the Helwan industrial complex which discharges effluents from the iron and steel, and cement factories. Other areas of concern include sites of waste discharge from a number of small industries, chicken farms, and the Cairo southern power station, as well as oil pollution from boat traffic, river harbors and repair docks.

The ability of the river to dilute waste discharged from Cairo industrial and urban activities is only temporary. It is expected that the river water quality will progressively deteriorate if stringent waste effluent controls are not implemented.

Typical river water quality data are given in Table (9). These results show the observed ranges for each parameter based on surveys conducted in 1976 and 1977. These data represent midstream conditions, and they do not vary significantly from one season to another.

Analysis of trace contaminants in Nile water further substantiates the impact of industrial waste discharges in the river.

Oil and grease were detected in all water and sediment samples collected from Helwan to El Kanater. Subsurface water samples showed between 2.5 to 13.0 mg/l of oil and grease. High values were obtained near Helwan Iron & Steel Factory and El Tarrassana in Rod El Farag. This is due to the high boat traffic in these areas.

Pesticide residues, e.g., Lindane, Aldrin and DDT and its degradation products, were detected in Nile water and fish catsh at Cairo. This is an indication of the rather extensive use of chlorinated hydrocarbon pesticides in Egypt (Figures 11 & 12).

6.2. Ground water

6.2.1. Sources

Groundwater in the Greater Cairo area comes entirely from the equifer of the Nile Valley. This highly permeable, waterbearing aquifer has a great potential as a major water resource for the Greater Cairo water supply for urban development, agriculture, and industrial uses. The ammounts and distributions of groundwater for different uses is given in Table (10).

6.2.2. Quality

Studies carried out indicated the absence of general trends.

Table(8) Residues of Organo-Chlorine Insecticides in Fish Collected from River Nile, ug/kg

Sampling Sites	BBC		Lindan		Endrin		o,p-DDT		*p,p-DDT		Mean**
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	ug.kg
Aswan	1.6- 4.2	3.0	1.9-12.2	5.5	1.2-15.9	29.7	11.1- 50.2	29.7	25.4- 42.5	35.6	103.5
Asyut	1.6- 9.7	4.7	1.2-15.9	7.2	17.6-43.3	24.9	4.8- 36.5	24.6	51.0-177.6	114.6	176.0
Cairo	2.0-14.6	8.5	5.0-12.5	8.9	5.0-28.3	19.6	10.6- 18.6	15.6	26.9-146.3	71.0	123.6
El-Mansura	0.8- 2.5	1.4	8.0-12.7	10.7	10.3-45.3	25.3	29.8- 63.8	49.2	92.1-206.2	113.0	199.9
Fariskur	0.7- 3.1	1.6	3.7-15.9	8.1	11.0-35.2	21.2	22.6- 62.9	44.0	27.6- 98.3	69.3	144.2
Idfina	0.5- 2.7	1.3	4.2-14.9	10.1	6.3-28.0	18.2	0.2- 27.4	23.0	9.8-101.1	75.4	128.0
El-Mahmudiya Canal	0.8- 3.0	6.5	0.6-16.1	6.4	N.D.-86.2	21.6	13.5-141.42	93.6	105.1-189.6	105.1	233.2
Abo El-Gheit Canal	2.3- 4.9	3.1	12.5-18.6	14.5	12.5-52.6	31.0	6.2- 82.1	38.8	71.9-223.8	141.1	228.4

* p,p-DDT = Sum of po, p-DDT+p, p-DDE+p, p-DDD
**Mean values = Sum of mean values of organo-chlorine residues

TABLE (9)

NILE RIVER WATER QUALITY AT CAIRO
(1976-1977)

Constituent	Concentration Range
Temperature, °C	13 to 29
Turbidity (Silica Scale), mg/l	10 to 100
Total Suspended Solids (105°C), mg/l	5 to 60
Total Dissolved Solids (105°C), mg/l	170 to 300
pH	7.9 to 8.4
Total Alkalinity (as $CaCO_3$), mg/l	110 to 140
Total Hardness (as $CaCO_3$), mg/l	100 to 120
Calcium, mg/l	18 to 28
Magnesium, mg/l	9 to 15
Chlorides (Cl), mg/l	16 to 28
Sulfates (SO_4), mg/l	15 to 27
Fluorides (F), mg/l	0.1 to 0.2
Ammonia (N), mg/l	Not detected
Nitrite (N), mg/l	Not detected
Nitrate (N), µg/l	5 to 800
Silicate (SiO_2), mg/l	4 to 8
Total Organic Nitrogen (N), mg/l	0.4 to 1.5
Dissolved Oxygen, mg/l	7.2 to 9.2
BOD (5-day, 20°C), mg/l (Filtered samples)	1.5 to 3.0
COD, mg/l	8 to 30
Phenols, µg/l	2 to 300
Chlorophyll a, µg/l	6.3 to 25.3
Total Algal Count, cells/l	10^5 to 10^6

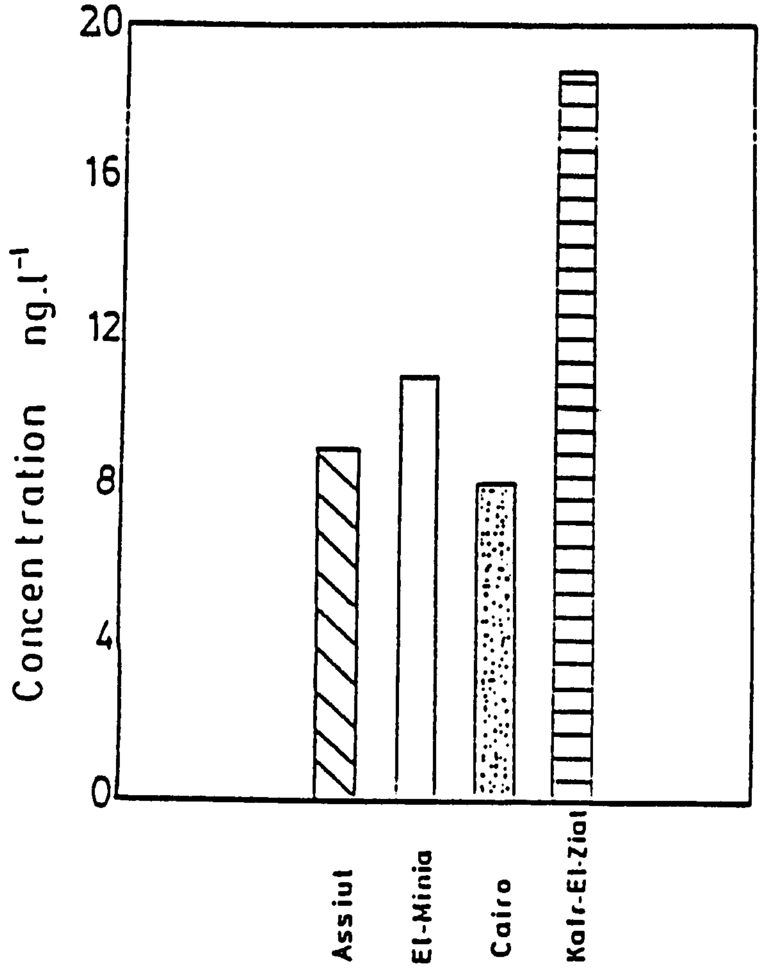


Fig (11) Concentration Of Total Organochlorine Insecticides in River Nile Waters (1979)

Source: Badawy, M. Internal Report, River Nile & Lake Nasser Research Project. The Egyptian Academy of Scientific Research and Technology, Cairo, 1982.

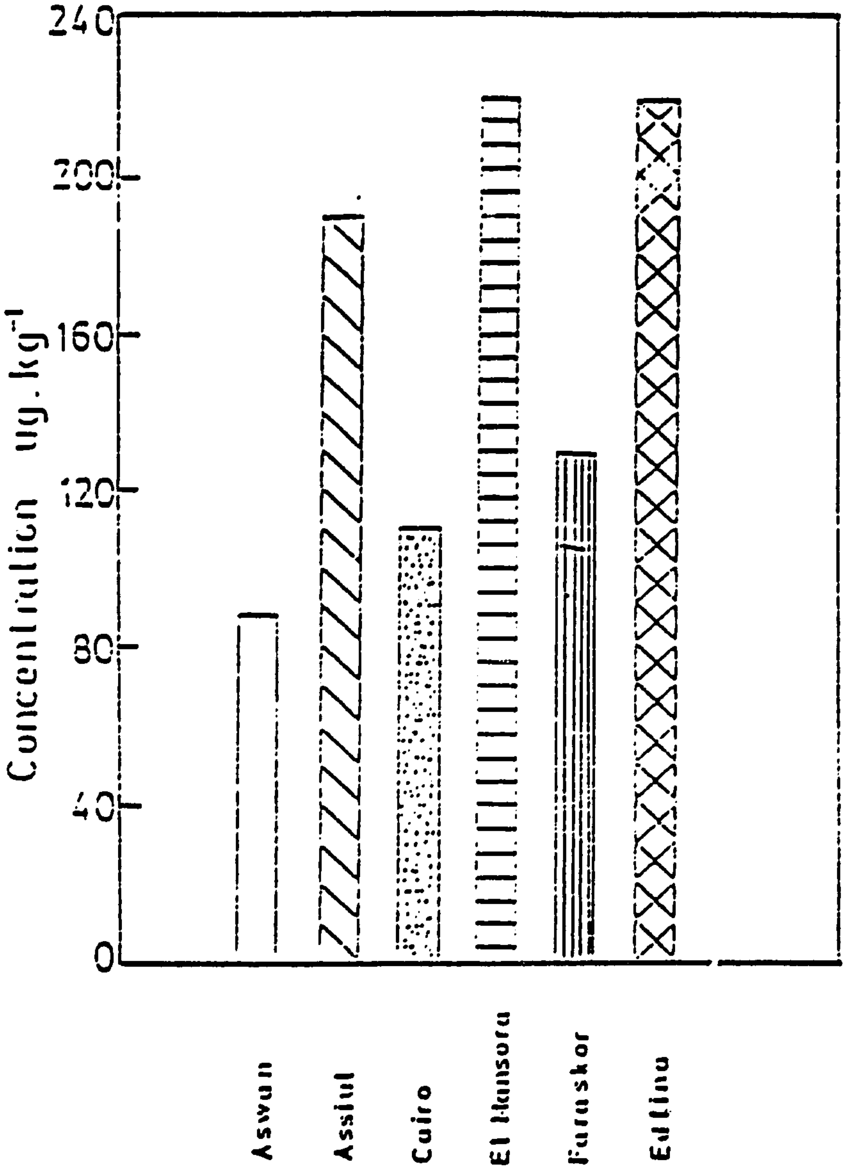


Fig (12) Concentration Of Organochlorine Insecticides in Fish Samples Collected From River Nile

Source: Badawy, M. Internal Report, River Nile & Lake Nasser Research Project. The Egyptian Academy of Scienti- earch and Technology. Cairo, 1982.

Table (10):Total Groundwater Abstractions (million m^3/year)

	Drink. Deep Wells	Drink Hand Pumps	Total Drinking	Irrigation	Total Abstra.
Nile Delta	415	275	690	600	1290
Cairo	330	-	330	0	330
Nile Valley	190	100	290	750	1040
Total	935	375	1310	1350	2660

Quality varies widely within a single well field and between each field. Five quality parameters are of greatest concern within the Cairo area: total dissolved solids, total hardness, chlorides, iron, and manganese.

Iron and manganese are the most unacceptable components. Some wells have produced waters with concentrations of manganese up to 3.0 mg/l. Iron and manganese deposits have been found on the surfaces of well screens and within well pipe. Bacteriological contamination in some shallow wells,in unsewered areas is also a problem.

7. LAWS RELEVANT TO CONTROL OF INDUSTRIAL DISCHARGES

Law "93" was enacted in 1962 and is concerned with the construction of sewers and the attachment of buildings to sewers, including industrial facilities. Although originally intended to control discharges to surface waters, this function was removed from this Decree by Law 48/1982.

Articles of this law state that upon the request of a certain factory to drain its effluents to the city's sewerage network the Ministry of Health shall test samples of this effluent to decide that it has no adverse effects on public health.The results are then submitted to GOSD who are responsible for the sewerage network. GOSD's General Department of Treatment and Research, also analyses samples of factory effluents to decide upon their suitability for drainage to the city's sewerage network. This should be prior to connecting the factory's final inspection chamber to one of the network manholes.

Table (9) is an abstract of the standards promulgated under Law No "93" modified under Ministerial Decree 9/89. This Law is currently being reappraised by the EEAA in the light of the different needs of the new sewage treatment facilities currently under construction.

A review of the existing discharge requirements indicate that some of the limits may be too severe. An example is the BOD value of 400 mg/l which may be actually less than some strong wholly domestic wastes. Modifications may reduce expenditure at the factory and make control more easily enforceable. The existing discharge limits within law "93" should be modified as appropriate.

Law 48/1982 regulates discharge of wastewater into the Nile and its water ways. Water quality standards are specified in decree 8/1983. Although this law has been issued in 1982, its enforcement is still facing difficulties. Ten years of application have shown many areas where amendments and modifications whould be required.

TABLE 9 : Egyptian Guidelines for Discharge to Sewers (Abridged)

Parameters	Limit
pH	6-10
Temperature	40°c
Suspended Solids	500 mg/l
BOD	400 mg/l
COD	700 mg/L
Sulphide	10 mg/l
Cyanide	0.1 mg/l
Grease/oils	100 mg/l
As, Hg, Cu, Ni,) < $50 m^3/d$	10 mg/l
Zn, Cr, Cd, Sn,) > $50 m^3/d$	5 mg/l

8. INSTITUTION RESPONSIBLE FOR WASTEWATER CONTROL

Five Ministries/Organisations have direct responsibility for controlling discharges of liquid industrial and non-domestic wastes to the sewerage system.
These include:

- GOSD who need to protect the sewer network.
- Ministry of Health who is required to sample under law "93".
- GOFI who advise the public sector industries.
- GOGCWS who supply water and meter supplies.
- Ministry of Public Works and Water Resources who control irrigation. Details of the responsibilities of these Institution are given in Annex "1".

9. REFERENCES

- Aly,O.A and Badawy,M.I. "Organochlorine Insecticides in Selected Agricultural Areas of Egypt". Presented at the International Symposium in Alexandria, March 1981. Management of Industrial Wastewater in Developing Nations, pp. 114-126. 1982.
- Badawy,M. River Nile and Lake Nasser Project. Internal Report. The Egyptian Academy of Scientific Research and Technology. Cairo 1982.
- El-Gohary,F.A. Nawar, S. and Abu-ElEla, S. "Changes in River Nile Water Quality and Impacts of Wastewater Discharge. International Symposium on Environmental Technology for Developing Countries. Istanbol,Turkey (1982).
- El-Gohary,F.A., and El-Khouly,M.S. "Management of Solid wastes in the Iron&Steel Industry". International Symposium on Industrial and Hazardous Solid Wastes". Philadelphia, Pennsyluania, 7-10 March (1983).
- El-Gohary F.A., Sohair I. Abu ElEla and Hamdy I. Ali "Management of Wastewater from Soap and Food Industries. Case Study.
Cairo International Seminar on Industrial Hazardous Wastes, 23-25 November, 1986.
- El-Gohary,F.A. Abu ElEla,S.I. and Ali, H.I."Reinforcing Steel Plant Wastewater Treatment and Reuse" Journal of the Egyptian Society of Engineers No."4". Vol.(25),1986.
- El-Gohary,F.A. Abu ElEla S.I. and Ali H.I."Management of Wastewater From Soap and Food Industries: A Case Study. The Science of the Total Environment,66 (1987) 203-212.

-El-Gohary,F.A., Abu ElEla S.I. and Ali H.I."Wastewater Management in the Automobil Industry". Wat. Sci. Techn. Vol. 21,pp 255-263 (1988).

-RNPD Water Quality Conditions in the River Nile System A general review, Reported 515 (1989).

-El-Gohary F.A., Abou ElEla,S.I. and Ali H.I. "Feasibility study of Wastewater Disposal from Oil & Soap Environmental Contamination, 4th International Conference-Barcelona, October (1990).

ANNEX I

COMPARATIVE ENVIRONMENTAL RISK ANALYSIS IN THE GREATER CAIRO AREA

Comparative Environmental Risk Analysis in the Greater Cairo Area

Dr. Amin El Gamal

January 1994

281

Contents

Comparative Environmental Risk Analysis in the Greater Cairo Area

Introduction :

The Greater Cairo area (GCA) or the Metropolitan Cairo Area (MCA) is composed of the governorate of Cairo (totally urban) and parts of the Qaliubia and Giza governorates (both urban and rural areas). It occupies an area of about 85000 acres east and west of the River Nile at its bifurcation into Damietta and Rosetta branchs, being virtually the crossroads of most of the inhabited area in Egypt.

It is not only the political capital but it is the most populous area (27% of the whole population of Egypt), with the highest population density .

It also hosts about 49% of all the industries in the country and over 90% of the heavy industries (Fig 1&2). The MCA has 45% of the motor vehicles of different types in Egypt(Fig. 3). It also consumes 41% of all the electric energy consumption in the country.(Fig. 4)

Area per person of public parks is less than one m^2 (Fig.5). For these reasons the Greater Cairo Area is the main area of population attraction and migration which results in the highest population growth rate (4%) as against 2.2% for the whole country (1992) and the proliferation of unofficial housing which has taken alarming proportions in the last three decades (1960-1990) .

The buildings in these unofficial areas are of very low quality, utilities and servies are often absent with very little or no roads. Besides these, the old quarters of the city of Cairo have many slum areas with high population density where the services cannot cope with the increasi load and needs for water supply, sanitation services, sol waste collection. There is also deficiency of roads and op spaces .

The Greater Cairo Area draws its water supply from t River Nile and Ismailia Canal. Sewage disposal is relyin before finalization of the new major projects, on collecti to the north east in Gabal Asfar treatment plant (built 1914) with a limited capacity and a limited treatme potential (primany treatment), and collection to the sou west in Abu Rawash & Zenein treatment plants .

This system will witness a great improvement aft finalization of the main tunnel & new treatment plan (shceduled for 1995) .

From this brief overview we can understand the reasons the difference in the health status of the inhabitants of Greater Cairo Area from that of the rest of the population Egypt.

These can be summarized in overcrowding, unhealtly housi high degree of air pollution, water pollution both at water sources, and in the distribution network and chemi food pollution .

II <u>Causes of Environmental Pollution in the Greater Cairo Area</u>

1. <u>Unoffical Housing</u>

In a recent study (January 1993), Prepared by the Mini of Housing and new communities (Table 1) the squatter a and shanty urban areas constituted 24.3% of the total are greater Cairo (20625 from 85000 acres), the residents in t areas 5880500 persons constituted 45.6% of the 12.9 mill residing in Greater Cairo .

These areas are 11 in Cairo, 2 in Qaliubya, 10 in Giza with a total of 23 areas. Only 3 of these have water supply, sanitation and roads, 20 were partially served, 13 had no roads. Three have no education facilities, 4 had almost no facilities while only 6 were served. The provisional cost for upgrading these areas amounted in the study to 450 million LE. It is to be noted that 11 of these started in 1960,4 in 1965, 1 in 1968, 5 in 1970 & 2 in 1975.

It should also be noted that all these areas are of the informal housing type, slum areas and decaying houses and facilities in the old parts of the city are not included.

2. Air Pollution :

As a result of the heavy traffic of over 700000 motor vehicles registered in Greater Cairo besides those from other governorates coming to or passing through Cairo, together with slow movement in the jammed Cairo traffic resulting in frequent car idling there is an increased pollution by CO, hydrocarbons & smoke. The concentration of industries specially to the north and south of Cairo and the large number of electric power plants results in high concentrations of air pollutants:

SO_2 ranging from 251 - 83 $\mu g/m^3$ (Table 2) (1990) (the maximum permissible level is 200)

Smoke ranging from 179 - 105 $\mu g/m^3$ (Fig 6) (1990) (the maximum permissbie level is 150)

Total Suspended Particles range from 679 - 923 μ g/m³ (1990) (the maximum permissible level is 150) (Table 3)

Dust Emmissions from cement factories alone (Tora, Helwan National)

600000 tons/year or 1650 ton/day (Fig 7)

Heavy Metals : long range precpitation : (Table 4)

Chromium ranges from	135 - 30	mgm/m³
Manganese ranges from	240 - 56	mgm/m³
Nickle, ranges from	120 - 30	mgm/m³
Cadmium ranges from	70 - 22	mgm/m³
Lead ranges from	1090 - 200	mgm/m³

3. <u>Water Pollution</u>

Occurs in the GCA as a result of discharge of domestic waste waters carrying microbiological pollution or industrial wastewater from the industrial complexes north and south of Cairo. Another source is agricultural wastewaters carrying residues of pesticides, fertilizers and animal wastes to surface waters .

The Ministry of Irrigation (Water Research Center) has identified seven black spots as the most polluted areas in surface waters in Egypt as follows :

- Northeastern Region of Cairo, Shoubra El-Kheima
- East Cairo sewerage and treatment system and Bah El-Baqar drain
- West Cairo sewerage and treatment system and El-Moheet drain

- Downstream section of Damietta Branch
- Downstream section of Rosetta Branch,
- Lake Maryut
- Lake Manzala

The first three of these are in the Greater Cairo Area

The following issues are connected with the "black spot" areas :

- Bacterial pollution
- Pesticides
- Heavy metals
- Public health hazards .
- Lack of information on water quality status, causes and effects
- Further degradation as a result of inappropriate development .

It is worth mentioning that water treatment does not include removal of chemical pollutants.

4. Food Pollution

Occurs as a result of use of polluted water or pesticide application or bad handling, preparation or storage.

Food pollution can be microbial, parasitic or chemical.

5. Solid waste management :

As a result of increasing population, bad housing, deficient roads and inefficient services, more than half of the six thousand tons of solid waste produced in Greater Cairo per day do not receive any service of collection. Most of what is collected is simply dumped in the open, very little composting or sanitary landfill services are available. This results in breeding of some dieases vector insects (house

III Constraints to Assessment of Health Risks due to Environmental Pollution in the Greater Cairo Area :

1. In Egypt, notification of dieases is very defective, even in legally notifiable dieases. The private sector, which constitutes a large portion of the health system does not notify diseases encountered in every day practice. This might have justifiable causes such as confidentiality of information but is mainly due to a particular attitude among the health profession. Private hospitals pose a similar problem .

In the government and public sector of the health services the problem is in defective collection of data; inaccurat registration of diceases and causes of death. This is eviden from published figures on incidence of tuberculosis cases This incidence was 1209 in 1986, 1378 in 1988, 1487 in 198 and 274 in 1990, yet in 1987 was 22063 as result of T questionnaire carried out in that year showing a tenfol increase (Eastern Mediterranean Region Epidemiologia Bulletin Nos. 20&21 July 1992). Another example is th official figure of vaccination in childhood against vaccin preventable diseases, coverage is claimed to be over 90%, this does not conform with the figures of incidence o poliomyelitis or even diphtheria as shown in the East Mediterranean Region Epidemiological Bulletin, July 1992

	1986	1987	1988	1989	1990
Poliomyelitis	416	629	550	474	565
Diphtheria	630	368	184	110	59

298

Such being the situation of health statistics and registration one cannot identify with certainty the magnitude of a particular health problem caused by environmental pollution .

To evercome such a major defect in the system it is proposed to conduct scientifically and statistically representative and valid health surveys as an urgent and short term measure. For a long term measure, strengthening of the statistical units in the health system, training of personnel and increase awareness of the importance of correct information .

2. Although it can be easy to attribute a certain health problem to a certain pollutant as for example the level of carboxyhemoglobin in blood and inhalation of carbon monoxide in the air, yet this is the exception. It is usually very difficult to decide whether infection by typhoid is due to water pollution or food pollution or even bad personal hygiene. Also, bronchitis and respiratory infection can be caused by direct trans mission from one person to another and can be initiated or augmented by air pollution by sulphur dioxide or nitrous oxides.

In other words, the health situation in a country can be considered as a collective outcome of many types of environmental pollution and not separate islands of cause and effect. Improving this situation will need an equally collective approach with special emphasis on :

- the more serious threats to human health
- the areas of serious environmental deterioration and,
- the more vulnerable groups such as children, workers in dangerous occupations (mines, quarries ..)

3. Disease incidence among hospital patients which is the main source of routine information in the health sector does not necessarily reflect the situation among the general population. Disease incidence among school children is an indication of the situation in that age group and cannot be extrapolated to the other age groups.

4. In an area like Greater Cairo, being the political, industrial and commercial capital of the country, there are many health units that have a national character. In Cairo there are some centers of this nature such as :

The Poliomyelitis Institute

The National Heart Institute

The National Oncology Institute

The Tropical Disease Institute

There are also three of the four mental disease hospitals in Egypt (Abbassia, Khanka and Helwan). Two of the largest chest hospitals (Abbassia & Giza) and two of the largest fever hospitals (Abbassia and Imbaba) .

These health centers along with some of the large university and teaching hospitals attract patients from all over the country and are not restricted to the inhabitants of the greater Cairo Area. Thus there statistics have a national nature and cannot be taken as reflecting the health situation

290

IV Health Impact of Environmental Pollution in the Greater Cairo Area

1. Bearing in mind the reservations explained in III above on the validity and credibility of available information, we can state that infecteous diseases specially those of the gastrointestinal tract (G.I.T) and the respiratory system constitute 43.9% of all hospital discharges in metropolitan areas as against 46.0% for the whole country (Table 5). Hospital morbidity however for the MCA shows that GIT & Respiratory system diseases constitute 25.4% as against 28.5% for Egypt (Table 6). From this we can conclude that the incidence of infecteous diseases is more or less the same for GCA and Egypt as a whole .

Rate of notified infecteous diseases per 100 000 population (Table 7) in 1990 shows similarity between that of MCA and Egypt with the possible exception of pneumonia which is 4.4% in the former and 11.7% for the latter, a less marked difference exists for infective hepatitis being 24.65% for MCA and 27.4% for Egypt. The breakdown of the MCA figures in (Table 7) is shown in (Table 8) .

2. The figures of disease incidence for Egypt given in the Eastern Mediterranean Region Epidemiological Bulletin Nos 20&21, July 1992 is shown in (Table 9) which can be taken as indication of the situation in GCA as mentioned before, shows the very high incidence of water borne diseases such as infective hepatitis, typhoid fever as is also clear from (Table 10) showing the number of deaths caused by water borne

Another serious health problem, mainly water borne is diarrheal diseases particularly among children. The results of a survey carried out within the Demographic and Health Survey in Egypt in 1988 and again in 1992 shows a high percentage of the children under age 5 who have had a diarrheal episode within 24 hours to range from 4.4% and 6.8% and those within the previous 7 days to be from 12% to 16% (Tables 11&12). The incidence rate of diarrhea among children below 5 years 1992 shows a difference per 1000 child from 34.95 in the city of Cairo to 99.18 is Qaliubia and91.0 in Giza. For the whole country it is 94.64 (Table 13).

3. The health impact of air pollution

This is explained in detail in the National Environmental Action plan in Egypt (1992) as follwes :

a. Surveys have shown that about 20% of the population in Shoubra El-Kheima suffer from lung diseases because of high exposures to SO_2 and Smoke (1980 - 84);

b. A survey in areas close to the cement industry in Helwan has shown that 29% of school children suffer from lung disease compared to 9% in rural areas (1987);

c. The mortality rate due to chest diseases in Helwan is 19% for all age groups (Fig 8)

d. The reported ozone concentrations in and around Cairo is expected to cause significant eye irritation, and aggravation of respiratory diseases and significant effect on growth of plants (crops). Crop losses of 50-60% have been reported for clover in Shoubra El-Kheima relative to reference areas;

292

e. In Cairo, tested traffic policemen have up to 14% carboxy-hemoglobin in their blood (caused by elevated CO concentrations), which produces stress to subjects with heart disease, (1990); (Fig 9).

f. A direct relationship between exposure to air pollution and concentration of lead in blood has been found in Cairo traffic policemen (38-63 μg Pb/100 ml) and people living in urban residential areas (30 μg Pb/100 ml). The levels are more than three times the maximum safe levels (WHO guidelines) and are known to cause neural problems and mental retardation especially in children;

g. The deposition of heavy metals in the polluted areas is in the range of 0.5-2 g/m^2/year. These are high deposition values. Most heavy metals are toxic to humans and accumulate in the body. The top-soil concentration of lead in industrial areas is 13-36 times the concentration in rural areas, and the concentration of cadmium 8-72 times. The concentration of lead in edible portions of vegetables have been found to be up to 10 times the level in rural areas.

h. The relation between increased total particulate matter in the air and respiratory diseases can be substantiated by a health examination survey done in Helwan where cement industries cause a very high level of STP, in 1981, that 50.4% children gave history of respiratory disease during the previous three months (Table 14) and positive findings in the chest as bronchitis in 17.7% and asthmatic bronchitis in 1.9%

193

In another study by the Demographic and Health Survey (DHS) in 1988 among children under 5 in urban governorates had shown that 30.4% of the sample had cough only and 22.0% had cough and difficulty in breathing and in the whole country 22.0% had cough only and 20.2% has cough with difficulty in breathing. This shows a significant difference due to increased air pollution in urban areas. Similar findings were found among children under 5 in 1991, in urban governorates cases with cough in the previous 14 days were 40.9% and cough with difficult breathing 14.9% whereas in the total country the figures were 31.5% and 12.5% respectively (Table 16).

4. The health impact of over-crowding

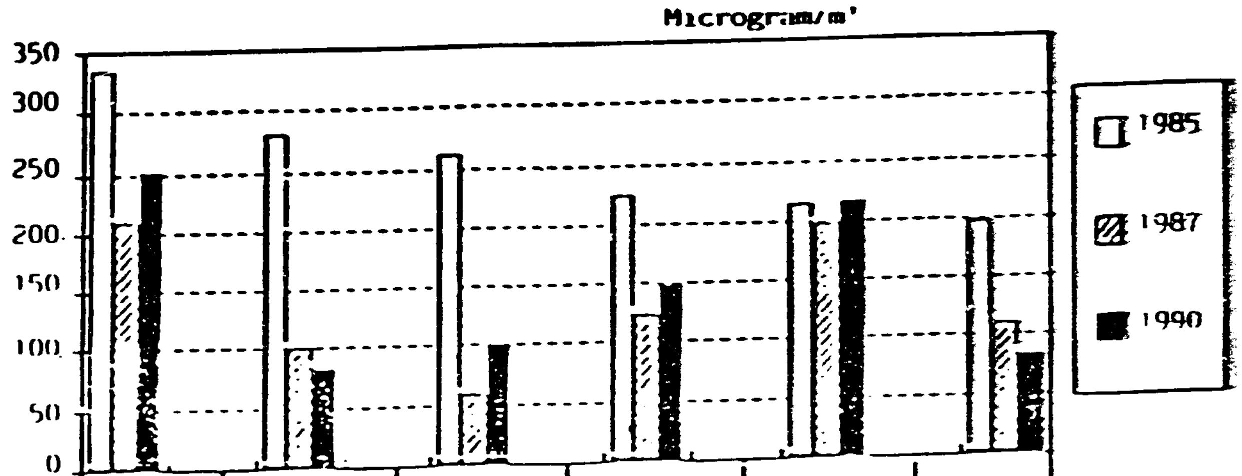
Include the high incidence of tuberculosis mentioned before and a skin disease, Scabies which was found to be 24.7% of children examination at admittance to school for Cairo city, 22.6% for GCA and 20.9% in Egypt (Table 17).

V - Tables

- Unofficial Housing areas constitute 24.3% of total area (85000 acres)
- The inhabitants of the unofficial settlement constitute 45.6% of the total population of Grea

					(000)			Water Sewage Roads	Educ., Health Sports	of open areas	needed	costs (mcLE)
Cairo	1. EinShams, Mataria	1965	Agr.	3700	1110	300	Resid, Com.	Served	Part. Served	20%	Services, Roads	55
	2. Waily & Zawya	1965	Agr.	850	255	300	Resid., Com.	Served	Part. Served	-	Services, Roads	13
	3. Manshiat Nasser	1965	Mount.	600	120	200	Resid, Occup.	Part. Served	no educ.	40%	Services, Roads	12
	4. Ezbet Haggana	1968	Desert	600	108	180	Resid, Occup.	Part. Water	not served	-	removal	11
	5. Fostat	1975	Mount.	400	100	250	Residential	Part, No roads	not served	-	services, roads	10
	6. Bassateen	1970	Agr.	400	148	270	Res., Com., Occ.	Part. No roads	Served	20%	services&utilities	15
	7. Dar ElSalam	1965	Agr.	1300	480	370	Residential	Part. No roads	not served	5%	services&utilities	50
	8. Tora & Maasara	1970	Agr.	1000	300	300	Residential	Part. No roads	part. served	25%	utilities	15
	9. Arab Ghoneim	1960	Agr.	700	126	180	Resid., Occ.	Water, Sewage	Served	-	-	-
	10. Kafr ElElw	1960	Agr.	250	52	210	Resid., Occ.	Sewage	Part. served	25%	Services&water	6
	11. Tibbeen	1960	Agr.	400	48	120	Residential	Part. No. roads	Part. served	-	services&utilities	5
	Total Cairo			1020	2847	279						192
Qaliubia	12. Shobra Khema W.	1960	Agr.	1400	350	250	Res., Occ.	Part. No roads	Partial	20%	Serv. & Util.	35
	13. Shobra Khema E.	1960	Agr.	1200	300	250	Res., Occ.	Part. No roads	Partial	20%	Serv. & Util.	30
	Total Qal.			2600	650	250						65
Giza	14. Imbaba	1960	Agr.	1600	560	350	Residential	Served, No roads	not served	-	services& roads	56
	15. Boulak Dakrour	1960	Agr.	1300	459	350	Residential	Served, No roads	no educ.	-	services & roads	56
	16. Feisal	1970	Agr.	1000	300	300	Resid, Comm.	Served, No roads	served	25%	services & roads	15
	17. Ahram	1960	Agr.	1400	420	300	Residential	Partial	no educ.	15%	services & roads	40
	18. Marioutiah	1975	Agr.	1300	325	250	Resid, Occ.	Served, No roads	not served	25%	services	20
	19. Sakiet Makki	1960	Agr.	175	58,5	300	Residential	Served, No roads	served	-	roads	1
	20. Moneeb	1970	Agr.	150	45	300	Residential	Partial	not served	-	services	1
	21. Manial Sheha	1970	Agr.	100	20	200	Residential	Partial	not served	-	services, utilit.	1
	22. Hawamdia	1960	Agr.	450	126	280	Residential	Partial, No roads	served	-	services, roads	5
	23. Badrashein	1960	Agr.	350	70	200	Residential	served	served	25%	—	—
	Total Giza			7825	2383,5	305						193

(Table 2) Average high Concentration of SO_2 by Governorate



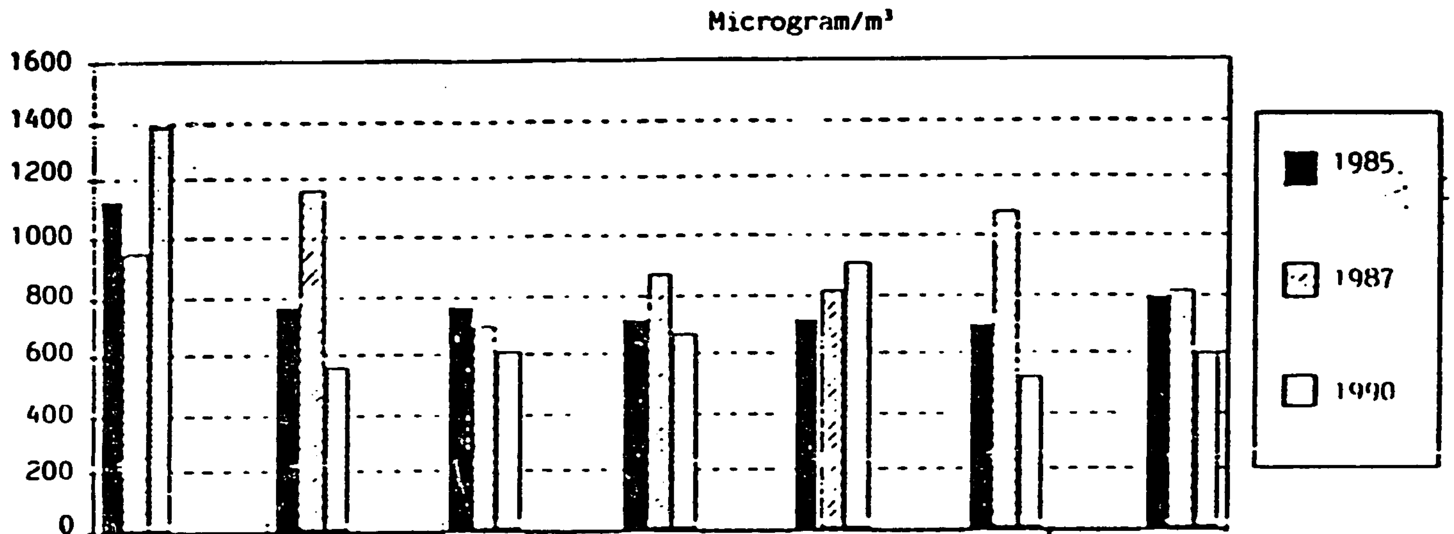
Kaliobia	Cairo	Giza	Gharbia	Behira	Egypt	
335	281	262	225	214	197	1985
209	101	58	124	196	111	1987
251	83	100	149	218	83	1990

GCA

Env. Monitoring Center 1991/92

Standard level of SO_2 = 200

(Table 3) Annual average of highest concentration of suspended matter



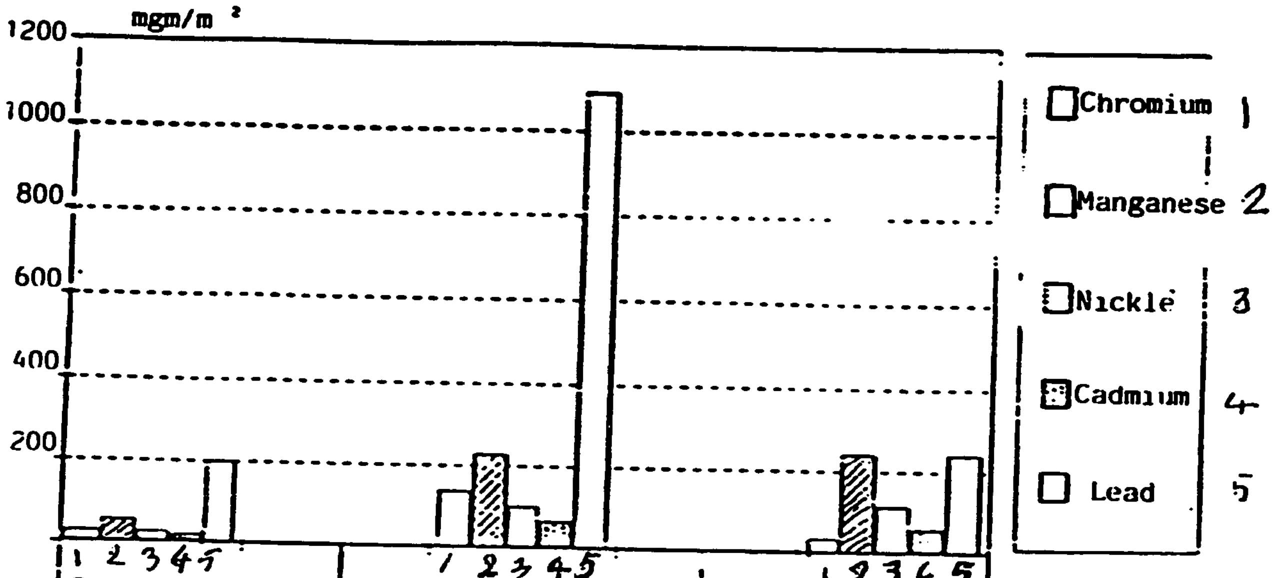
	Alex	Giza	Minia	Cairo	Gharbia	Kaliobia	Egypt	
	1136	769	769	722	717	692	805	1985
	961	1170	696	882	817	1087	819	1987
	1387	560	620	679	911	523	606	1990

GCA

Env. Monitoring Center

Standard suspended matter = 150

(Table 4) Long range precipitation of heavy metals in some districts in Greater Cairo 1987 - 1989



Shoubra, minimum	Shoubra, maximum	Helwan	
30	135	36	Chromium
56	230	240	Manganese
30	100	120	Nickle
22	70	60	Cadmium
200	1090	240	Lead

UNEP Report 1991/1992

(Table 5) Hospital discharges. Internal Circulation

	Metropolitan		Total	
	No.	%	No.	%
culatory	196	8.6	2526	9.8
piratory	207	18.4	4865	18.9
.T.	287	25.5	6981	27.1
genital	129	11.5	3144	12.2
.dent	405	36.0	8213	32.0
	1124	100.0	25729	100.0

: Information & Documentation Center

(Table 6) Hospital Morbidity 1991

	(1)	(9)	(14)	MCA	%	Egypt	%
culatory Sys.	5	33	58	196	5.0	2526	6.1
piratory Sys.	12	42	153	207	10.6	4865	11.7
.T. Sys.	41	94	152	287	14.8	6981	16.8
genital	25	19	85	129	6.6	3144	7.6
gnancy L.& Pur.	155	67	393	615	31.6	8042	19.4
idents.	35	71	299	405	20.8	8213	19.8
ers	12	48	145	205	10.6	7737	18.6
otal	285	374	1285	1944	100.0	41508	100.0

(1) CAIRO, (9) Kaliubia & (14) Giza

ce : MOH - IDC (1993) : Sample Survey of 1991

(Table 7) Notified Infectious Diseases 1990

Rate per 100,000 population

	MCA		Total Egypt	
	Cases	Rate	Cases	Rate
Typhoid	1072	11.8	5201	9.8
Infective hepatitis	2225	24.65	14579	27.4
Respiratory T.B.	582	6.4	3545	6.7
Poliomyelitis	31	0.3	214	0.4
Pneumonia	401	4.4	6243	11.7
Malaria	56	0.6	259	0.5
Rabies	6	0.1	61	0.1
Dysentry	34	0.4	144	0.3
Population (000)	9.059		53,153	

MCA = CAIRO + urban (Kaliobia + Giza)(metropolitan Cairo Area)

Source : ICD 1992 - MOH

(Table 8)

	Cairo	Kaliobia U.	Giza U.	MCA
Typhoid	730	83	259	1072
Infective hepatitis	1523	188	514	2225
Respiratory T.B	32	0	550	582
Pol.iomyelitis	6	2	23	31
Pneumomia	334	66	1	401
Malaria	4	52	0	56
Rabies	6	0	0	6
Dysentry	34	0	0	34
Population (1000)	6513(T)	2841(T)	4214(T)	

(Table 9)

Incidence of Some disease cases in Egypt

	1986	1988	1990
Malaria	63	65	75
Diphtheria	630	368	59
Whooping cough	9	14	1
Tetanus	9995	9287	4946
Tetanus neonatorum	7256	6901	3275
Poliomyelitis	339	169	565
Measles	1176	1805	887
Tuberculosis	1133	22063 (survey)	2742
Hepatitis (infective)	21670	15188	14209
Meningitis	824	957	3976
Cholera	—	—	
Typhoid fever	3735	3546	6569

Table 10)

Number of deaths caused by various water-borne diseases in Egypt
(Environmental Action Plan, 1992)

Causes of Death	Number of deaths in 1979	Number of deaths in 198
Infectious and parasitic diseases	19,395	48,458
Typhoid fever	492	102
Other intestinal infectious diseases	n.a.	40,285
Others bacterial diseases	n.a.	1,414
Malaria	n.a.	4
Other infectious and parasitic diseases	n.a.	384

(Table 11) Percent of Children Under Age 5

Having Diarrhea Episode 1988

	Percent of Children with diarrhea in		
	24 hr	7days	No. of children
Urban Governorates	5.5	14.8	1,549
Total sample	6.8	16.0	7,912

Source : Demographic and Health Survey 1988

DHS - Egypt National Population Council

Table 9,7 Page 146

(Table 12) Percent of Children with Diarrhea

	24 hr	7 days	No of children
Urban Governorate	4.4	12.0	1,484
Total	5.6	13.4	8,018

Source : Egypt Demographic and Health Survey 1992

Preliminary Report Table 17 . Page 24

March 1993. National Population Council

(Table 13)

Incidence rate of diarrhea among children below 5 years of age by governorate 1992

Governorate	Popu.	Popu.<5	Cas.<1	Cas.1-<2	Cas2-<5.	Cas.5+	Cas.<5	Rate<5yr
Cairo	6800	1040.4	19055	10970	6337	286	36362	34.95
Kaliobia	2966	453.798	18293	16756	9957	1343	45006	99.18
Giza	4287	655.911	27980	20465	11243	1399	59688	91.00
Total Egypt	56192	8597376	371396	285013	157255	15874	813664	94.64

Rate per 1000 child <5 years.

Population in thousands.

(Tabiel 14) Health Examination Survey - Helwan Zone 1981

A. History of Respiratory Diseases During Past 3 months

Age	Number Examined	Yes %
< 1yr	90	57.8%
1yr-	91	47.3%
2yr-	81	50.6%
3yr-	101	56.4%
4yr-	77	48.1%
5yr+	84	40.5%
Total	524	50.4%

B. Positive Findings in the Chest

ichitis	524	93	17.7%
imatic bron.	524	10	1.9%

Source : Health Care Delivery System

Urban Health Delivery System Project

Health Sector Assessment

(Table 15) Among Children Under 5, Percent having Cough and Percent Having Cough with difficulty breathing within the month before the interview 1988

	% Cough Only	% Cough with D. Breathing	Sample
Urban Governorate	30.4	22.0	1,459
Total Country	25.2	20.2	7,912

Source : DHS 1988 (Demographic and Health Survey)
Table 9,10 Page 151

(Table 16) Prevalence of Respiratory Infection Among Children under 5 1991

% having cough in the last 14 days

	Cough	Cough + difficult breathing
Urban Governorate	40.9	14.9
Total	31.5	12.5

Source : Children & Women in Egypt
A Situation Analysis Egypt - August 1993
(In Print). CAPMAS + UNICEF
Annex 1 Table (7)

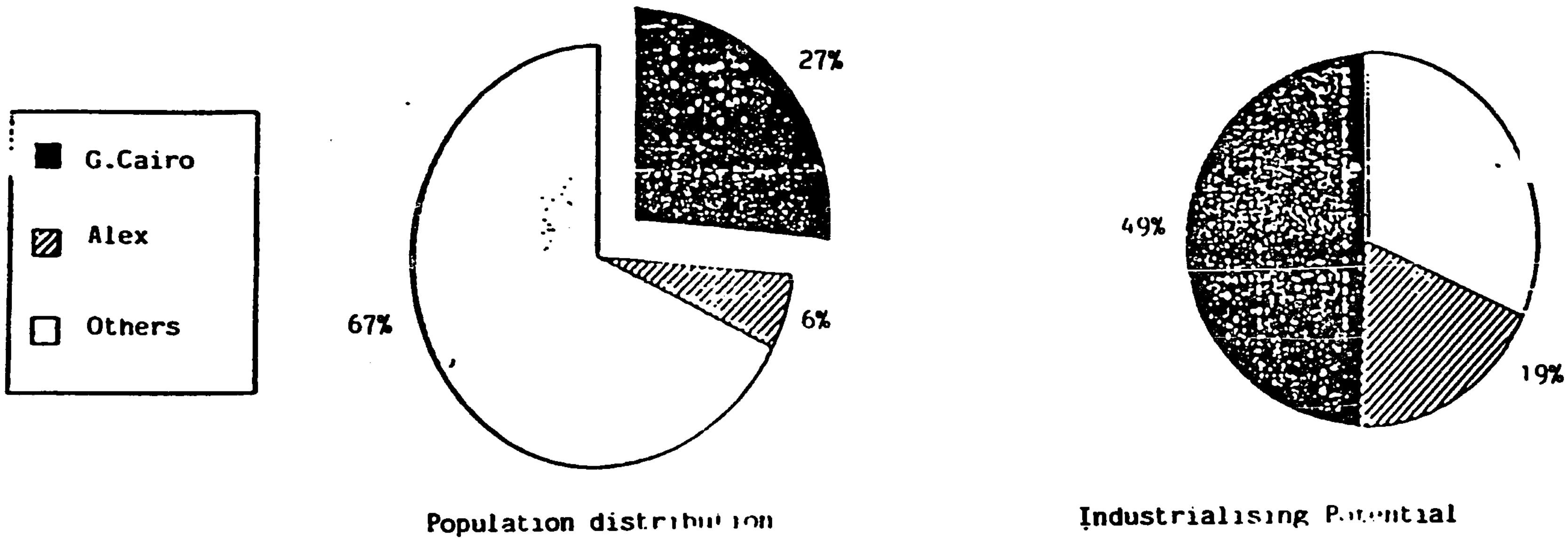
(Table 17)

Percentage of Scabies Among School Children suffering from skin diseases (91/

Cairo Alone	14907	24.7 %
Cairo + Giza + Kaliobia	19679	22.6 %
Total Egypt	45620	20.9 %

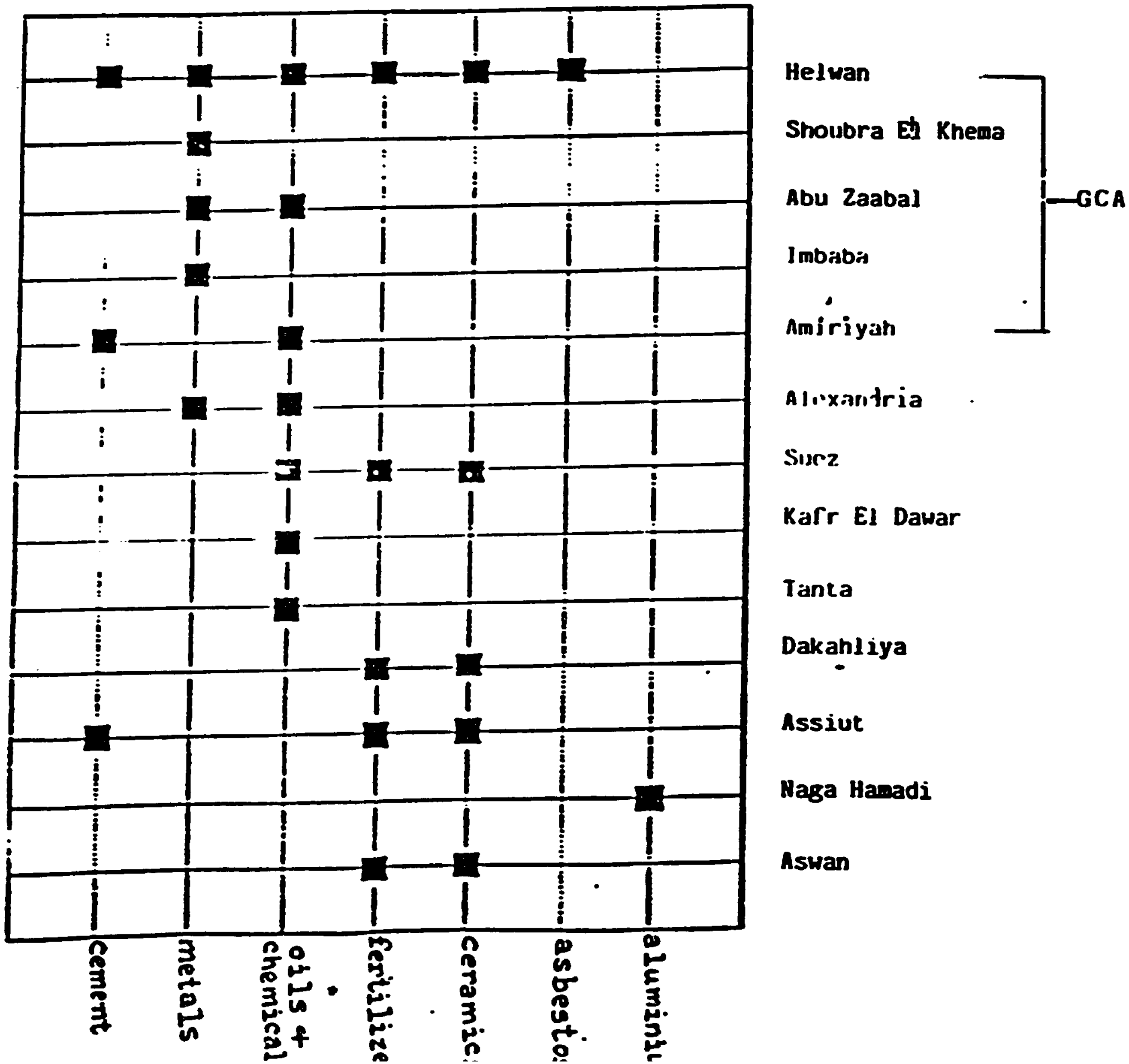
VI - Figures

(Fig 1) Main Governorates with Industrialising Potential 1990



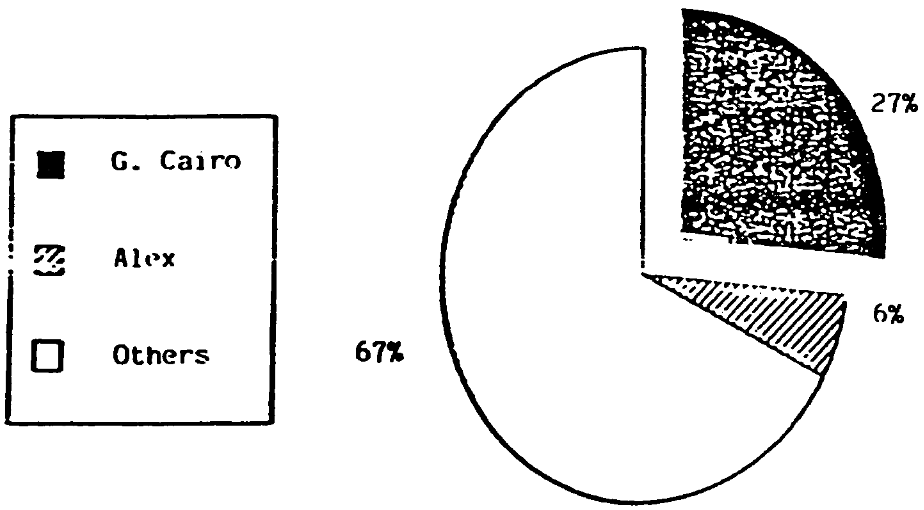
National Env. Action Plan 1992

G. Cairo has 95% of heavy industries that are the main source of air pollution

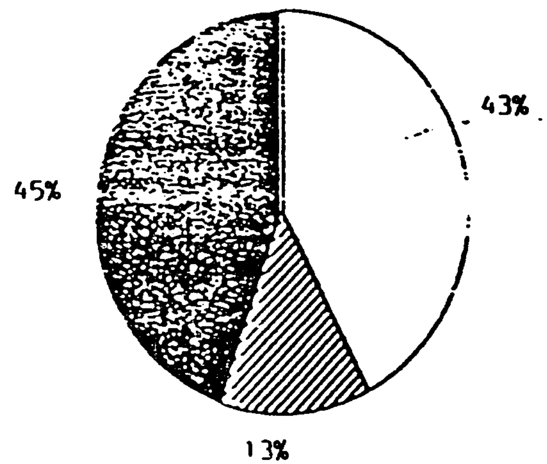


(Fig 2) Sites of Main Polluting Industries

(Fig 3) Main governorates with large number of Vehicles 1990



Population distribution

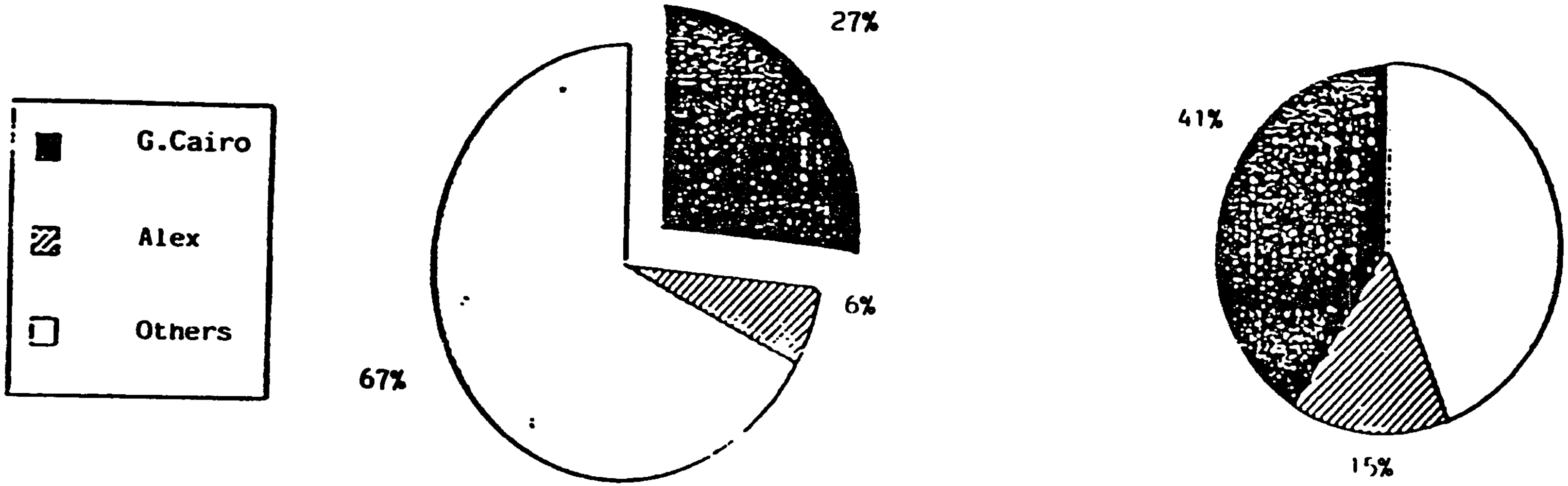


Numerical distribution of cars

National Env. Action Plan 1992

Total number of vehicles 2 millions
Increase rate in G. Cairo 10% per year
(1980-1990)

(Fig 4) Electric Energy Comsumption by Governorate - 1990



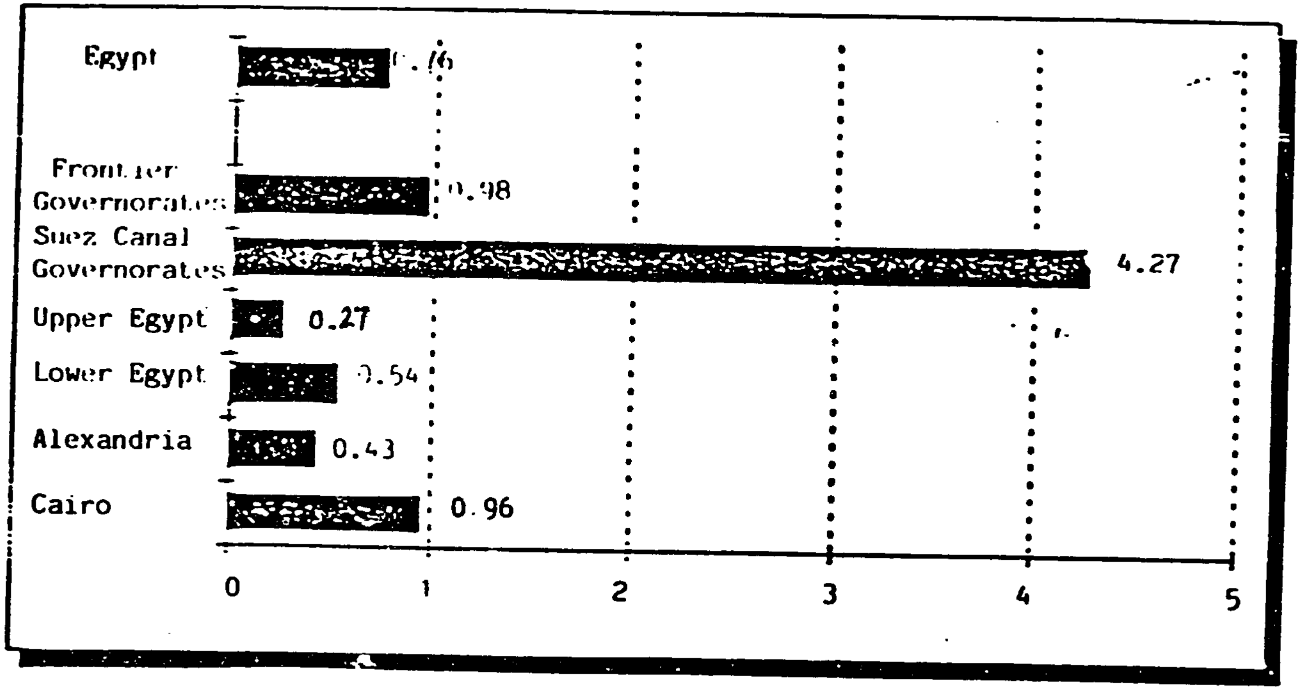
Population distribution 1990
Total = 52.4 m.

Total Electricity Consumption=
30585 G. Watt

Increase in Electricity
Consumption = 8.7%(1980-1990)

National Environmental Action Plan 1992

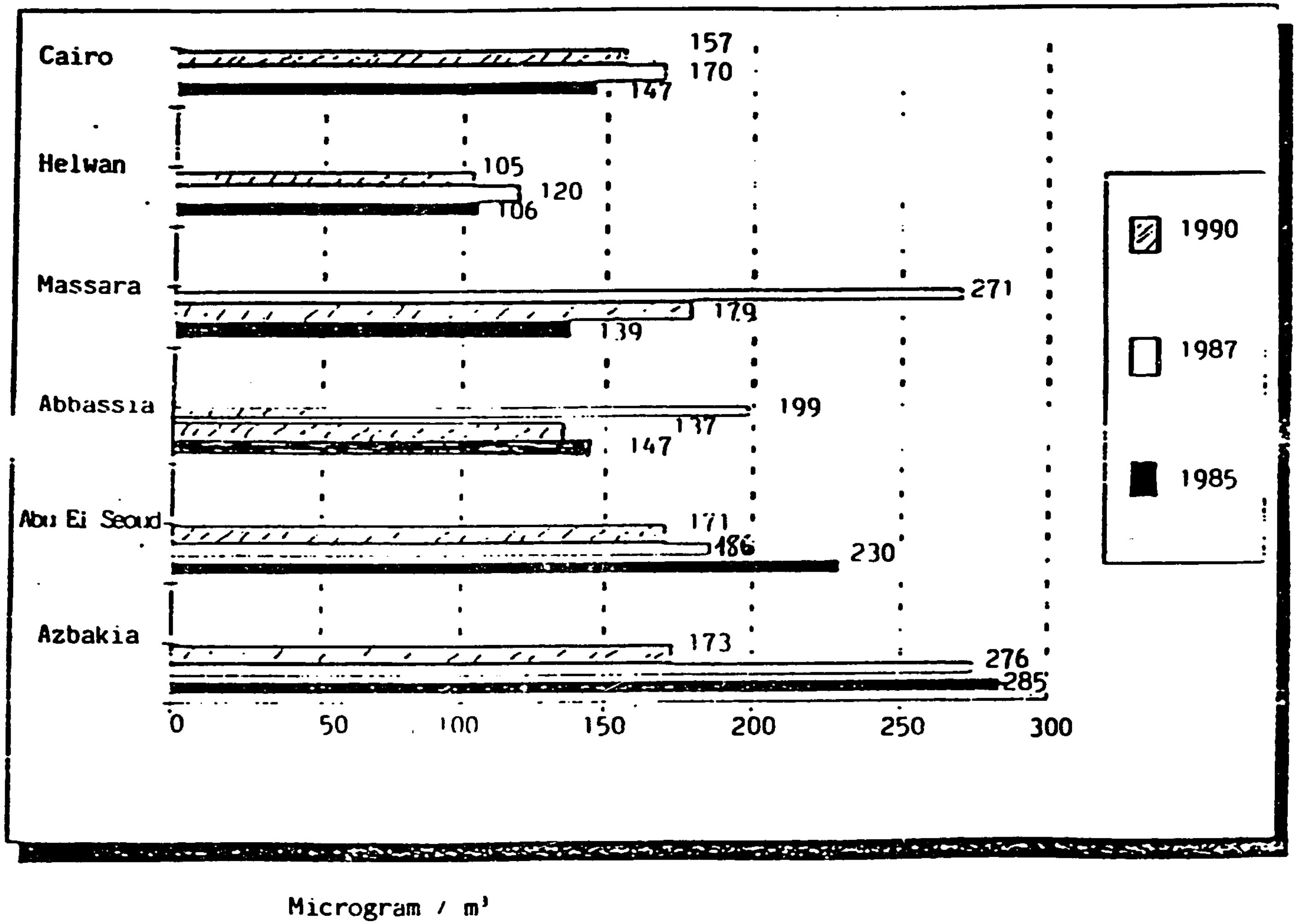
(Fig 5) Area per person of public parks in square meters



in Square meters

National Env. Action Plan 1992

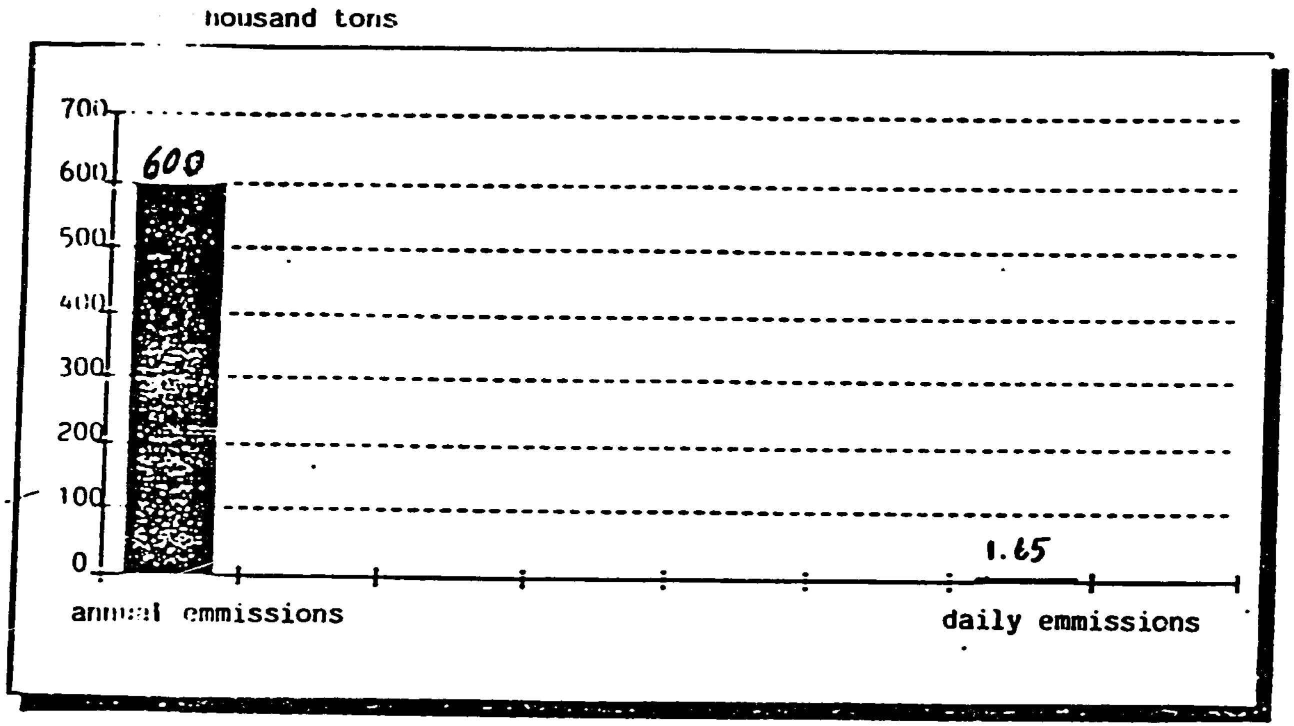
(Fig 6) Annual average smoke concentration in Cairo and some of its districts



Env. Monitoring Center

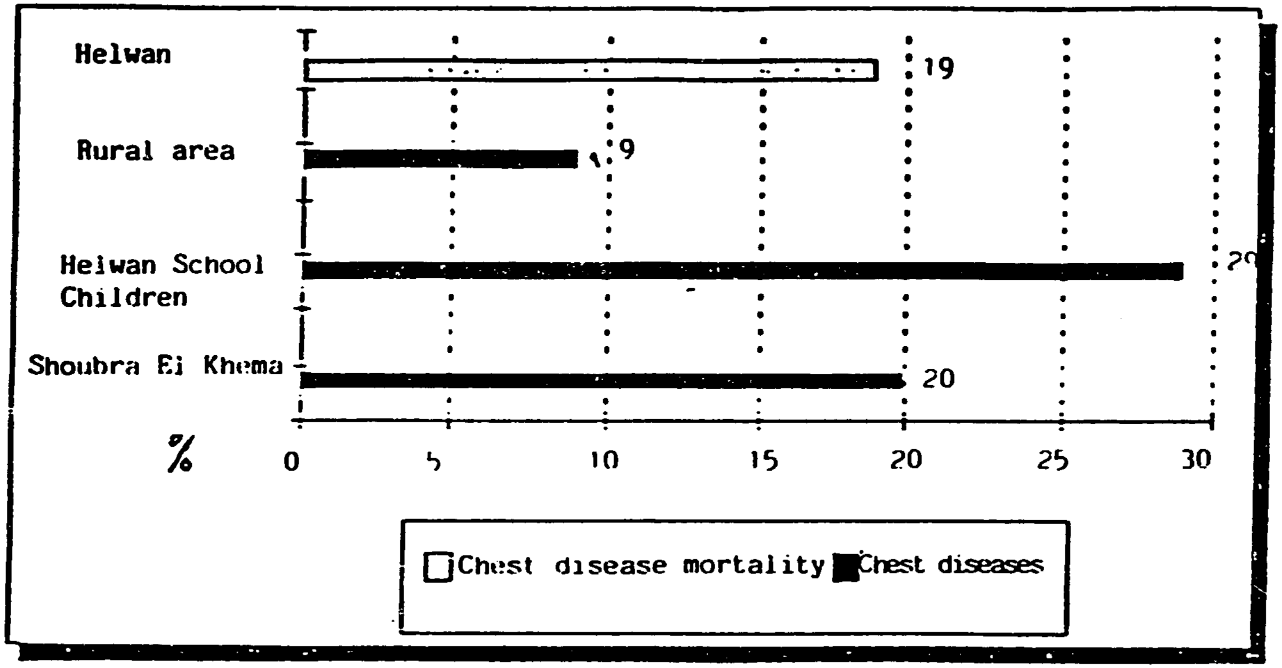
Standard average smoke conc. = 150

(Fig 7) Dust Emmissions from Cement factories in Helwan
(Tora, Helwan, National)



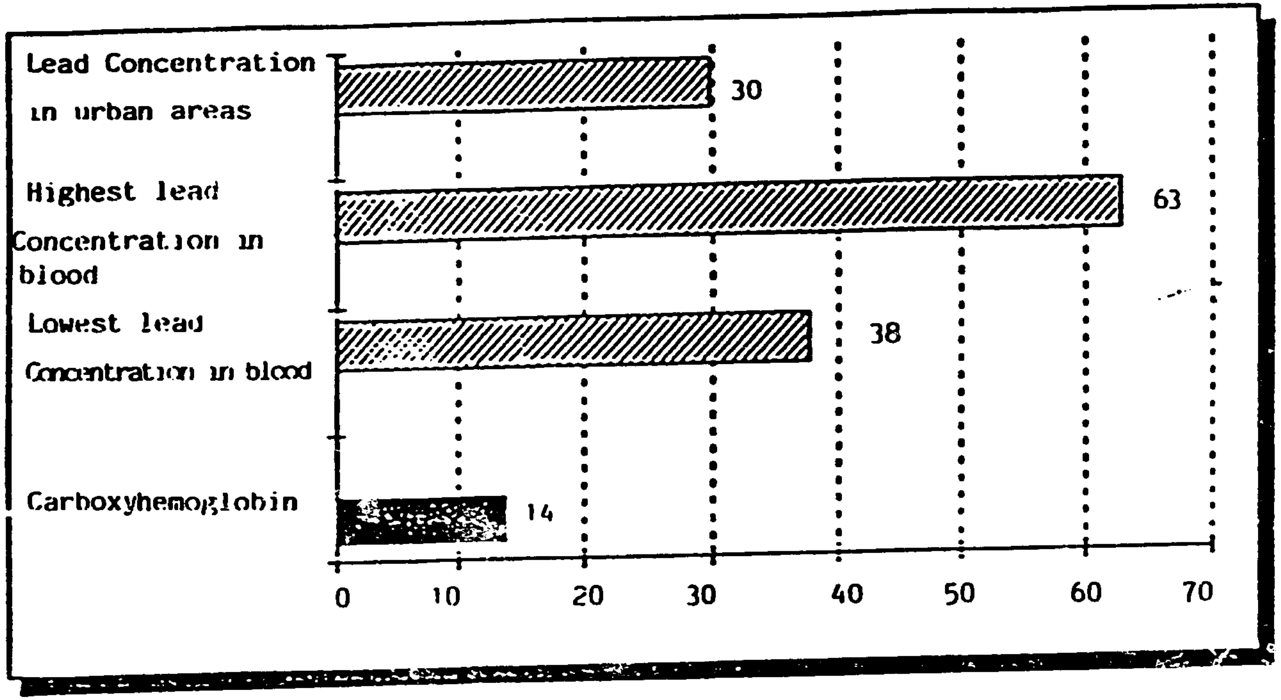
National Env. Action Plan 92

(Fig 8) Chest disease Caused by exposure to high levels of SO_2 and mortality due to those disease



National Env. Action Plan 1992

(Fig 9) Health effects of air Pollution in Cairo
Traffic Policeman (1990)



Carboxyhemoglobin % and lead concentration microgram /100ml

National Env. Action Plan 1992

3/5

ANNEX J

RANKING ENVIRONMENTAL HEALTH RISKS IN CAIRO, EGYPT

بسم الله الرحمن الرحيم

Prof. Dr. Ph. Dr. Sc.
Ahmed Abdel -Wahab Abdel -Gawaad
Professor of Environmental Pollution
Faculty of Agriculture, Moshtohor, Kaliobia,Egypt
Sustainable Development & Environment Protection.

P.O.Box 613 Maadi, Cairo, Egypt.
Phone:(2-02) 3503503
Fax :(2-02) 2695297
Telex :20422 KRMCO UN

RANKING ENVIRONMENTAL HEALTH RISKS IN CAIRO,EGYPT

January 1994

(In the interest of space, only a portion of the original 600+ pages of this report have been reproduced.)

Introduction

The best scientsts of any time may only poorly understand the fundamental processing govering the impact of environment on food production and food quality, and their side effects on public health.

Health means more than an absence of diseases,Health is a state of complete physical ,mental and social well-being and not merely the absence of disease or infirmity.

I tried in this work to throw high lights about the impact of environment on food,and food safety from three dimentions,food quantity, food quality and food management.

In food safety ,the periority problem is the elimination or reduction of contamination by foodborne pathogens,parasites and agrochemicals.The improve of regulation and management of using chemicals is very important.

Now measurable amounts of pollutants in our food present a variety of problems.If a chemical is nontoxic to human being and causes no harm to living cells,residual amounts in food could be tolerated.

Many different types of chemical exposures can increase the incidence of tumors in human beings,but usually a long period of time is required before the carcinogenic risk of an exposure is manifested.Most chemical carcinogens operate via a combination of mechanisms and even their primary mechanism of action may vary depending on the target tissues.The classification of chemicals by mechanism of action or by monogenotoxic or genotoxic activity has certain inherent difficults because no classification of chemicals is exhaustive or definitive.

Complex mixtures present special problems for toxicological studies and Health risk assessment The issues unique to complex mixtures are related to the complexity of the exposures,bioavailability and dosimetry of the active components and the predicability of the effects from one mixture to another.The complexity of mixtures presents problems in sampling and chemical analysis..

As until now no effort has been made to document and understand the interaction of Environmental pollution and food production and quality,it was neccessary to collect all available data about such problem. .Because decisions in different programs are made in isolation without a review of their overall present and future impact,other environmental and public health problems may be created.

Chemical pollutants are now measured in a variety of settings,and their risks are estimated on a local basis.For these situations exposure assessments may be a major factor in risk assesment.For exposure assessments,hypothetical scenarios are developed that may or may not resemble reality.Often the mode of transport or the bioavailability of the chemical is unknown.However,rather than pointing out that the exposure may be overestimated and giving a range,risk assessors may present the worst case estimate.The risk assessors may point out what these estimates really mean,but these qualifiers are often not considered when risk management decisions are made.

Food safety must have a national priority after water safety in Egypt Considerable effort must be devoted by the government to ensure that food will not have an adverse effect on human health.Our governments have introduced laws,regulation and guidlines designed to prevent human health risks and environmental degredation, but that needs enforcemnt..

But,the importance of the quality of data is achieving the evaluation of the effects of unsafety food on human health is self-evident.The importance of the quality of data generated in the laboratories and field toxicological studies is parallelled by the need for quality of analytical data.It is important to realize that chemical risk assessent utilizes not only data from studies carried out for regulatory purposes,such as notification ,but also data from many types research sudies both pure and applied.In the process of risk assessment,biological dose-effect and dose response data are integrated with analutical data.Thus,overall quality management of data generation and application of quality assurance and quality are crucial.

The validity and usefullness of the results from experimental studies,whether these relate to basic research or tests carried out to meat regulatory requirement,are critically dependent on the way in which they are designed,the quality and quantity of data are both important.Limited or inadequate data,even where there are no doubts on their quality,cannot result in a balanced evaluation,and the over all conclusion on risks to human health and the environmet are inevitably limited. An extensive data base that is poor assessments and probably erronrous conclusions.

The application of modern quality management approaches to the two fields of food safety risk assessment is crucial. These fields are ;1- quality management of laboratory toxicity studies and 2- studies to monitor the extent of exposure and effects and the presence of chemicals in man and the environment.

In this primary report I tried to collect some data and some study cases,but still have not less than 1000 study case.

The shortage of time and the high numbers of references made it a very diffecult Jop.,

But the collection of data must precede the analysis of them.

Content

Part III

High Lights about the difficults which will face any scientist who will work about Environment health risks Assesment in Greater Cairo.

As it is mentioned before, Cairo is no exception than other large capitals of third world countries in its fast urban growth after the second decate of the twentieth century. Greater Cairo metropolis,Giza,Cairo,Kalubia progresses from being the 26th largest world metropolis in 1950 (2.5 million) to the 17 th rank in 1985 (8,5 million) and is expected to be the 12 th largest metropolis of the world by the year 2000 at 13.2 million inhabitants.Greater Cairo can be considered as an area consists of 76 settlements ,each has special physical structure,special infrastructure ,special population,different population dencity ,different environmental problems and different health risks.In Cairo we can find a very modern settlement (16 % of the Greater Cairo), while the rest 84% is considered as uncontrolled or unplanned or chaotic or spontaneous growth,or sporadical growth.These 76 squatter settlements varied charply in their state of environment .and it is necessary to study the state of environment in each as study case.But we find it is easy to devide these settlement to 7 groups which nearly have the same state of environment It is necessaryto put also in consideration the driving force to reduce exposure of human and the environment. Man-madechemicals is the assumption that at certain concentrations such chemicals are harmful,This is not disputed ,however ,it is difficult to characterize this concept further.If such chemicals are already in the environment,should they be removed and to what extent?.What concentration of a given chemical should be permitted in water ,air and other media.The information necessary to address these questions consists of two parts: the assesment of the levels of the pollutants and the resulting degree of exposure ,and the assesment of the health and environment effects of the pollutants.Based on this informations the potential risk can be assessed. Such an approach seems straightforward,however.it is often not possible to quantitate or define a particular risk with certainty.

Using standard assumptions in risk assessment means that an estimate of risk can be stated and reviewed by others and comparisons can be made between different risk assesments.However ,there is a fundamental problem with the use of standard assumptions .Because biological mechanisms of action vary ,wrong comparisons may be made

Factors affecting risk assesment:

Sampling and analysis:Representative environmental sampling is complex and chemical analysis of very low concentrations of chemicals in environmental samples is expensive and difficult.If the sample collection is not representative,then exposure may be over-or underestimated (Study case:Official data gave a wrong state of environment in Greater Cairo, Most the sample were taken from El-Tahrir Square and Ramsis Square in the mid day. These data show that Great Cairo Is highly polluted by Exhaust pollutants but this fact is not correct ,where these area represent only 14% of Greater Cairo and the situation is completely different in 84% of the Greater Cairo.)

Limited budgets for Monitoring pollutants in Great Cairo often lead to a deemphasis of quality control and quality assurance.For that the quality of data available to the risk assessor are vary widely..It is difficult to conduct trend analysis to determine whether levels of pollutants are increasing or decreasing over time.

Furthermore ,results obtained under different programms cannot be correlated because of the inconsistencies in the methods used.

Chemical analysis: The concentration at which most chemicals are deemed to represent an acceptable risk are minuscule. It usually is not appreciated that higher levels will often not result in any harm.Furthermore,the ability to measure chemicals accurately decreases with increasingly lower concentrations.For instance they may not be any true difference between 5 and 10 ppb (ug/kg) of a given chemical in a medium such as soil or air.Also,the analytical methods used for many chemicals have not been standarized nor are the same analytical methods used even for the same medium

Dosage:For chemicals present in food or water a dose is not calculated even if chemical concentration and consumption may vary depending on other food constituents present,the age of the person exposed,and the form of the chemical.Examples are the higher absorption of lead by gastrointestinal tract of infants,the differences in absorption of lead acetate and lead sulfide,and the effect of particle size and of calcium on absorption of lead

Estimating uptake of chemicals from air and soil is even more problematic.Air models presently in use appear to determine the upper bound of risk without giving any information on what the more likely exposure would be.If the chemical is present as an aerosol or attached to particles in air.the size of the droplets or particles determines whether the chemical reachesthe lungs.It is presently not known to what extent chemicals attached to such particles.Thus uptake of chemicals in the environment may vary widely.

Different environmental laws were developed for air and water and for waste and landfills. Decision makers made it in isolation in different programs responsible for these areas,resulting in apparent inconsistencies.Only recently have attempts been made to determine whether reducing a chemical or banning it in a particular medium such as water will make a significant contribution to overall reduction of exposure of humans and the environment.For instance,in regulating levels of chemicals in water,it is usually not considered whether humans would get much greater exposure from air or from food or by using these substances in their daily live.Which measures of exposure reduction to certain chemicals is the most economic or the most effective usually is not examined either..

Beacuse decisions in different programs are made in isolation without a review of their over all present and future impact,other environmental and public health problems may be created.

The difficults faced in saftly increasing industrial activity,in order to provide for the economic well-being of existing populations will be greatly exacerbated by this population growth. With the proportion of the population living in Great Cairo increasing from the present 9 million to 13.2million by the year 2000,and the siting of industries within urban areas,there is an enhanced likelihood that effluents will affect a larger population,and that such a population will be faced with multiple environmental threats from different industries.

Various environmental and occupational factors of a physical,chemical ,biological or psychosocial nature have the potential to induce different types of pathological processes..The intensity of exposure ,usually expressed as dose(concentration times exposure duration),as well as the dose pattern (high versus low concentrations; intermittent versus continuous exposure),will determine the acute or chronic nature of the health impact.

Diseases caused by chemicals have been observed in most organ systems after high exposures,such as those encountered in occupational setting,including allergic reactions of the skin (i.e. chromium) and of the respiratory tract (.disocyanates.,phthalic anhydrides) ,and different chronic lung diseases (siliocosis ,asbestosis,byssinosis ,hard metal disease).Other diseases include those of the kidney (cadmium,mercury),the central nervous system (organic solvents,mercury manganese), the cardiovascular system (cobalt,carbon disulfide,organic nitrates,chlorinated solvents),the blood-forming organs (lead,benzene), the reproductive organs (dibromochloropropane,probably lead and some solvents) the eye(trinitrotoluene),the liver (carbon tetrachloride,trinitrotpluene) and malignant diseases of different organs (asbestos,arsenic,nickel,aromaticamines,benzene).

Because most manifestations of diseases associated with environmental factors are non-specific ,i.e, lung cancer and chronic obstructive pulmonary disease,it is usually very difficult to determine the extent to which exposure to environmental agents contributes to human disease and to health impairment.This is because the etiology of most diseases is multifactorial and the contribution of any one environmental agent to the total disease incidence is often difficult to "tease" out of epidemiological studies of exposed factors may interfere with the resistance of the body,thereby increasing susceptibility to disease,though identification of such effects is often fraught with serious difficulties.

Because industrial effluents potential affecting Great Cairo community health usually result in levels of exposure that are not as high as those to which workers are exposed within the industrial facility,the past health experience of workers has in many cases been the bases for estimating the impact of environmental agents.

Complex Mixture of pollutants in Risk Assessment:

Complex mixtures present special problems for toxicological studies and Health risk assessment The issues unique to complex mixtures are related to the complexity of the exposures,bioavailability and dosimetry of the active components and the predicability of the effects from one mixture to another.The complexity of mixtures presents problems in sampling and chemical analysis..In addition ,the composition of many complex mixtures changes as a result of process changes.,fuel variations,operational conditions,etc.Mixtures that are derived from multiple sources such as air pollution may have varying contributions for these sources over time.For example,woodstove emissions will often increase in the winter time at night while automotive emissions will be highest during the peack traffic hours While the concentrations of such gases around Industrial areas are nearly in the same levels all over the days hours and in some cases in working hours.

Assesment of total human exposure and dosimetry of chemical air pollutants is often difficult.Complex mixtures ,however ,present a challenge beyond the problems encountered with individual chemicals.

The value of incorporating immunological experimental data for the toxicological assessment of drugs,chemicals,and biologicals for human risk assessment hads been increasingly accepted.The potential for human immunosuppression remains of concern,however because of a large data base generated from animal studies that demonstrates immunosuppression as well as reports of immunosuppression in humans inadvertently (e.g. halogenated aromatic hydrocarbons) or occupationally (asbestos,benzene)exposed to xenobiotics.This concern is exacerbated by current knowledge regarding the long term consequence of immunosuppression that may be associated with pathologic conditions (i.e.cancer ,increased infections).Likewise,exposure to immunotoxic xenobiotics may present additional risk to individuals with already fragile immune systems (i.e. malnutrition,infancy ,old age).There have been considerable concern regarding :Chemical hypersensitivity syndrome: (multiple chemical sensitivities syndrome) and its relationship to hypersensitivity as well as immunosuppression ..

The most environmentally abundant toxic metals /metalloids (arsenic,cadmium,lead and mercury) are each known to produce cell injury in the kidney but the molecular mechanisms underlying these events are now being elucidated.It is clear that the nephrotoxicity of these agents is due in part to the fact that unirary elimination is a majore route of excretion from the body.The role(s) of molecular factors such as metal -binding proteins,inclusion bodies and cell-specific receptor like protein that appear to influence renal tubule cell expression have attracted increased interest as determinants that modulate cell populations as special risk for toxicity and renal cancer..In reality,it is clear that environmental exposure to metals involves all of these agents at the same time and in varying concentrations from different media.Cadmium exposure has a marked effect on total renal uptake of lead and the formation of inclusion bodies..More recent studies indicated that cadmium is the most effective competitor for displacing lead from these molecules .For that it is neccessary to put in consideration the interaction between metals in mechanism-based risk assessment situations where more than one element is present.

Now measurable amounts of pollutants in our food present a varietyof problems.If a chemical is nontoxic to human being and causes no harm to living cells,residual amounts in food could be tolerated.

Many different types of chemical exposures can increase the incidence of tumors in human beings,but usually a long period of time is required before the carcinogenic risk of an exposure is manifested.Most chemical carcinogens operate via a combination of mechanisms and even their primary mechanism of action may vary depending on the target tissues.The clasification of chemicals by mechanism of action or by monogenotoxic or genotoxic activity has certain inherent difficults because no classification of chemicals is exhaustive or definitive

Health

Health ,means more that an absence of diseases."Health is a state of complete physical,mental,and social well-being and not merely the absence of disease or infirmity (WHO).Health is only possible where resources are available to meet human needs and where the living and working environment is protected from life-threatening and health-threatening pollutants,pathogens and physical hazards.But health also includes a sense of wellbeing and security.Divicient living and working environments are associated with both physical and psychosocial health problems.Violence and alienation are associated not only with poor job prospects but also with overcrowded poor-quality housing,dificient services and inadequate provision for leisure recreation and children's play and development

Growing understanding of this link in Egypt must led to the concept of a health -promoting environment where not only are health risks minimized but personal and community fulfilment,self-esteem and security are encouraged.

The complex relationship between health and the environment extends the responsibility for promoting health to all groups in society .Health is no longer the responsibility only of doctors,nurces,midwives and other health professionals who seek to prevent or cure diseases or of those who seek to remove pathogens from the human environment and reduce accidents.It is also responsibility of planners,architectors,teachers,employers ,and all others who influence the physical or social environment.It is the responsibility of health professionals to work with all groups in society in promoting health.

This understanding of health also means ,above all ,that individuals,households and communities have substantial responsibility for their own health.Personal and community responsibilities for health are essential adjuncts to individual and community rights.The right of individuals to adequate shelter,health care,and education (including health education) must have as a counterpart their commitment to the promotion and protection of their own and their neighbours'health and welfare. Table 1.

334

Food ,Diet and Health

While food supplies are sufficient to meat the Egypt's aggregate minimum requirement s,they are so inequitably distributed among the different governorates and among the people of the same governorate because of income disparties that the lives of hundreds of thousands are affected..Underdevelopment and malnutrition in many slums settlements in Greater Cairo or in many villages all over Egypt will remain the greatest problems posed by the relationship of population,food and health. There is no single formula for dealing with malnutrition,In terms of numbers it affects mainly the low-income urban and mainly rural poor groups,especially among infants,preschool children and women.The major dietry deficiency is that of protein.Many dietry deficiencies are related to environmental factors,in the sense either of limited access to foods that enable the deficiency to remedied or of pollutants or pathogens in environment exacerbating their effects.Communcable diseases remain principal cause of sickness and death,but it is not sufficiently recognized that the resistance of children and adults to infectious diseases often depends on their nutritional state since this may have a profound effect on the development of immunity

Interaction between nutrition and infection to produce the "manutrition/infection complex" create the greatest public health problem in the world.Infection infuences nutritional status through its effects on the intake,absorption and utilization of nutrients and in some cases on the body's requirement for them..A child's rate of growth is retarted by too little food and/or too many infections or parasites..Malnutrition may result in lower immunity .Infection can lead to loss of appetite,decreased efficiency of food and nutrient utilization increased energy requirements and decreased growth.The relationship between diarrhoeal diseases and physical growth has been clearly shown.These interrelations produce the malnutrition and infection cycle so prevalent in Egypt..The vulnerability of malnourished people to environment health risks is clearly documented in Egypt.**Hence the importance of improved water supplies ,sanitation and safe food to reduce water-related and foodborne diseases and programmes to control diseases vectors supported by education and health care.** For that the author will try to throw high lights on Food through several dimentions,food production, food quality and food management.

Pure food is no doubt the most chemically complex part of the environment to which humans are coontinuously and directly exposed .Even without contaminants or additives ,the number of chemicals in food ,in addition to those substances having nutritive value is immense,the variety of chemical types present naturally in food is also great.Thousands of chemicals naturally present impart flavor or color; some serve no such functions,but are present because they play a role in the life of the plant or animal from which we drive the food.Some of these naturally occuring substances are known to be toxic; the most acute have long been eliminated from the human diet,primarily through a long (and unfortunate) process of trial and error.However ,very little is known about the possible long-term or more subtle health effects and chemical nature of most of these naturally occuring components of food.
A second group of food chemicals are those that are intentionally added to food to achieve some desirable technical effect on social goal.Some chemicals are directly added to food(such as preservatives,artificial sweeteners,stabilizers or colors).Other chemicals ,whose use is intentional ,are not directly added to food,but enter food indirectly because of the ways they are used .Among such indirectly added substances are chemical migrants from ,packaging materials,trace contaminants in direct additives,pesticide chemicals and drugs used in food-producing animals that may yield residues in meat ,milk or eggs.All of these substances ,directly or indirectly added are called additives.
Finally ,there is a third class of chemicals (and some biological products as well)known as food contaminants.Included are chemical products of bacteria and fungi that can grow on imroperly stored food,and certain industrial chemicals that have polluted the environment and have found their way into segments of food supply.
Toxicologists have long been faced with the challenge of defining safe levels of human exposure to substances intentionally added to or contaminati ng food.To this day there are no methods for defining such levels without imposing assumptions that cannot be scientifically tested.All chemicals can be made to produce toxicity of some form level of exposure.Before permiting human exposure to any chemical through its presence in food,it is important to characterize fully its toxicity.
While it is likely that the risk at the ADI is very low,it cannot be concluded that exposure at this level is absolutely safe.Conversely,the uncertainties in the system are such that it is not possible to conclude that exposure at levels above the ADI will necessarily carry some risks.The ADI is a convenient

operational definition of safty,but it is not a dividing like between Safe and Unsafe exposure.This limitation in the safety assessment scheme becomes imortant when the purpose is not to define saftey but rather to estimate risks at various levels of exposure.For the latter purpose,the safety assesssment scheme has little value.

Food safety is a national priority after water safety in EgyptConsiderable effort is being devoted by the government to ensure that food will not have an adverse effect on human health.Our governments have introduced laws,regulation and guidlines designed to prevent human health risks and environmental degredation.

But,the importance of the quality of data is achieving the evaluation of the effects of unsafety food on human health is self-evident.The importance of the quality of data generated in the laboratories and field toxicological studies is parallelled by the need for quality of analytical data.It is important to realize that chemical risk assessent utilizes not only data from studies carried out for regulatory purposes,such as notification ,but also data from many types research sudies both pure and applied.In the process of risk assessment,biological dose-effect and dose response data are integrated with analutical data.Thus,overall quality management of data generation and application of quality assurance and quality are crucial.

The validity and usefullness of the results from experimental studies,whether these relate to basic research or tests carried out to meat regulatory requirement.,are critically dependent on the way in which they are designed,the quality and quantity of data are both important.Limited or inadequate data,even where there are no doubts on their quality,cannot result in a balanced evaluation,and the over all conclusion on risks to human health and the environmet are inevitably limited. An extensive data base that is poor assessments and probably erronrous conclusions.

The application of modern quality management approaches to the two fields of food safety risk assessment is crucial. These fields are ;1- quality management of laboratory toxicity studies and 2- studies to monitor the extent of exposure and effects and the presence of chemicals in man and the environment.

1- Quality management of laboratory toxicity studies ;

To ensure that studies are valid and properly conducted,an organizational structure should be established that will serve the needs of the testing facility and will employ and adequate number of personnel that are well qualified by education ,training and or experience to perform their assigned tasks,but this organizational structure is absent in Egypt.Regardless of specific organizational structure,facility personnel include test facility management ,study directors,quality assurance programme personnel and support personnel.The resposibilities for successfully running a laboratory are shared among these groups.The suggested composition and responsibilities of each of these groups are available .

All testing facilities needed(i.e. laboratories,field operations),regardless of size ,that generate data for assessing the iimpact of cheicals(i.e. heavy metals, pesticides ,food additives,hormones,growth regulators,agrochemicals,drugs,micotoxins and aflatoxins, micoorganisms) on human health should have an efficient management system.The establishment of an independent quality assurance programme is an essential mechanism for accomplishing these goala.

A test site must have suitable facilities and equipments to ensure the proper conduct of studies.

A clearly written comprehensive study plan is an essential element of food safety studies.A study plan should state the objectives,schedules and all methods for the conduct of a study.

Quality assurance involves the development and use of standard operating procedures.Standard operation procedures are written procedures which describe how to perform certain routine laboratory tests or activity,normally not specified in detail in study plans or test guidelines.

Control and reference substances (test substances) are chemicals that are adminstered to the test system as a possitive or negative reference for the purpose of establishing a basis for comparison with the test substance.

Quality control is applied to routine laboratory biological,chemical and physical analyses in order to assure reliability and comparability of test data.It involves statistical approaches designed to demonstrate the constancy variability and precision of analytical data.(**Please see our suggestion about quality management for food safety testing Organisation).**

Despite the fact that at national level there is at present sufficient food for all,great difficulties have to be overcome to ensure the availability and equitable distrbution of safe ,nutritious and affordable food supplies to meet health needs.

Some current national policies causes distortions in national trade and pattern of production,have harmful effects on agriculture,fisheries and food production and adverse consequences for the environment and health and contributed to poverty and malnutrition

Diminishing water resources and deteriorting water quality ,associated with contamination by pathogens,human and animal wastes ,and agricultural and industrial chemicals and the breeding of vectors of diseases ,are also consequent risks to health through the biologcal and chemical contamination of food and water suplies

As the population of Greater Cairo,increases.,the depence on an efficient food distribution system became greater.This increased the prevalence of household food insecurity,associated malnutrition and health risks among the growing masses of poor people.

Microial,viral and parasitic diseases from contaminated food and water continued to be serious health problems.New agents of public health importance continued to emerge.The diarrhoeal diseases related to food and water ,causing high infant motality increased

Vector borne diseases from irrigation ,other water sources developments and uncontrolled wastewater in Greater Cairo increased.People used a very high quantities of pesticides to control houseflies and mosquetoes.

The above problems will be reflected to static and rising levels of infant and young child malnutrition and mortality as well as morbidity at all ages,but predominantly among the poor,the very young ,the aged and the sick.

For that the Government policies must be changed about its stratigies for population control,agriculture,food ,nutrition,fisheries,water and the environment to ensure good health and avoid environmental effects

Priority must be given to water pollution and then to food safety.the priority problem is the elimination or reduction of contamination by foodborne pathogens .Chemicals in food are a higher risk,and improved regulation and management of agrochemicals is required in agriculture and fisheries production and food storage and preservation.

The second priority is the need to increase food supply by raising production and at the same time reducing losses,using all available and appropriate technologies .

as a whole ,it is more than 3.2 in some slums areas ,it is 2.3 in.Egypt monshaet shamer kism,2 in Tebin ,and 0.6 in yhe modern parts (El-Zamalek and Kasre El-Nile.

Urbanization:

The urban population increased from 17% (1.9 million) in 1907 to 33% (6.3 million) in 1947, to 44 percent (16 million) in 1976 and 44 percent (21.1 million) in 1986, to 55% (67.5 million) in the year 2000.Egypt represents a classic case of unbalanced urbanization .Urban communities in general have suffered from a decline in capital investment ,particularly during the period 1960-1975 which has resulted a widespread deterioration of physical and social infrastructure.

Cairo is no exception than other large capitals of third world countries in its fast urban growth after the second decate of the twentieth century. Greater Cairo metropolis,Giza,Cairo,Kalubia progresses from being the 26th largest world metropolis in 1950 (2.5 million) to the 17 th rank in 1985 (8,5 million) and is expected to be the 12 th largest metropolis of the world by the year 2000 at 13.2 million inhabitants.

The living conditions of thousands of people in Greater cairo threaten their health,impose misery,and have potentially catastrophic social consequences,and condition for poor people are worse.

Some parts around or in great cairo continue to grow under conditions of economic stagnation oe even absolute deterioration ,they take on more of the qualities of their rural lands.

Figure 3:shows the greater Cairo directional population in growth trends till the year 2000

Table 5 : shows the surface area of garden/ capita and the total surface areas of gardens in each part of Greater Cairo.

The economic crisis is also forcing government to cut social expenditure.The result is often a decline in what were already very inadequate levels of investment in water,sanitation,garbage collection and health care.

In Greater Cairo as a best example for Overurbanization ,the majority of residential buildings fall outside any health and saftey regulation,and their siting and construction were never subject to any building or planning codes.In greater cairo 84% of building fall in unplanned growth or uncontrolled growth,some of settlements in Greater

Cairo are spontaneous or Chaotic settlement or sporadical growth..That means that 84% of the physical growth of Greater cairo can be considered as Squatter settlements. New commercial.industrial .and residential vonstructed by formal sector in Great Cairo seem to copy the design of similar buildings in the developed countries .little consideration being given to the climatic and cultural differences.The links between housing and health in the slums or Squatter settlements in greater Cairo are both commen and stronger ,showing a strong association between ill-health and both quantitative and qualitative shoetcomings in water supply,and sanitation.Inadequate shelter,poor ventilation ,lack of facilities for solid waste disposal,air and noise pollution and overcrowding are also likely to have negative consequences for health.In Greater Cairo between 40-60 % of the population are living in illegal settlements with little or no infrastructure or services or in overcrowded and often deterioration tenements and cheap boarding houses.Many health problems affecting poorer groups are associated with over crowding ,they include household accidents ,airborne infections ,acute respiratory infestions,pneumonisa and tuberulosis.In the slums settlements the average number of persons per roocm is between 2.7 to 3.6 .in very slum areas the number may be increased to 4 or more,in these urban villages inside and outside Great Cairo,it is commen for poor households to live in one room .House holds in these areas may have less than one square metre of interior space per person,and beds are often shared in most extreme cases even small rooms subdivided to allow multiple occupancy.

Such overcrowding ensures that diseases such as influenza.is easly transmitted from one person to another.There is a good links between respiratopry infe ctions generally dampness and indoor air pollution.Acute respiratory infections,the most common of all the illnesses are increasingly recognized as a major cause of mortality and morbidity.Acute bacterial and viral respiratory infection together with stomac diseases is related with the high increase of house fly population in these areas.The environment in these Squatter settlements in Greater cairo offers an important habitat for a wide range of disease vectors,which can be divided into arthropodes (including insects .spiders and mites) and vertebrates (including dogs and cats)Arthropodes can in turn be divided into four categories: those breeding on the body surface or in clothes,(including lice and scabies mites),those breeding in the house (including fleas,cockroaches, bedbugs) those breeding peridomestically or in containers and sewage (including ,mosquetoes and flies and those which are adventitious ,entiring the house to feed (including mosquetoes, and flies and scorpoions.).The impact on health of these vectors is very important in these slums and squatter settlements.The diseases they cause or carry include ,diarrhoeal disease,hepatitis A, relapsing fever,typhus,dosontaria...etc.A high proportion of people in these low-income settlements in Greater Cairo have intestinal worms.

Health Profile of residents in Greater Cairo:

The health profile in Greater cairo is very different according to the type of settlements.In Cairo we can find the following different settlements:

1-Urban villages;

In Greater Cairo we can find a large number of very slums settlement in and out Cairo which can be called the Urban villages. The best example of a village in the middle of Cairo inside a very modern part in the heart of Cairo (DOKKI)which is called Dair el Nahia.From interviews with the village dwellers many not -too-old people still remember when the whole Dokki district was being developed around the village on the agricultural land where some of the inhabitants were still breeding their animals.The area known as Dair el Nahia almost looking the Dokki square has a compact physical tissue that is more rural than urban with its dead-end and twisted streets ,small plots of land and encircling outer ring that still carries the old village name.We still can see a single milk farm squeezed on a small plot of land just across the street from National research centre.It was recent that many of the area's houses were still keeping their mud brick construction.However current housing stock is rebrick construction or concrete skeleton with reinforced concrete slabs.Such housing stock development matches the area's development life style that in no means relate to rural living .Most of the residents work outside the area in urban jobs and private workshops for car service.Transformation of the village buildings and life style gives another evidence that the area had been there for a period of time long enough to allow step by step and gradual rehabilitation and social change.The area is fully serviced with tap water,public sewage,electricity,telephone service and all other urban amenities.The area might in no way be called a Slum or Shanty town but better rather an area of special character : a folks district.

Another example is Awlad Allam settlement in the heart of Cairo,it can be clearly distinguished by its compact physical appearance though not as old as the forementioned village because its streets are straight and non of them is dead-end.Their legal status is not all clear as they were given only the right to use the land and not to own it and no building permits were ever issued to them or their fathers.The physical appearance of Awlad Allam housing stock shows a deteriorated living standard simply because the area was developed on individuals initials of the relocated poor families.The area did not last long enough so that its residents could have improved their incomes and rehabilitated their homes.The villages hous es still show mud walls,simple wood and brick construction and other clear rural development features such as single and two story structures,inner courtyards,and decorative features on the doorway and windows and other rural pits roam the streets of the area as a symbol of the rural life style that most of the people live.The area is fully serviced with tap water ,public sewage,electricity,telephone service...etc.Awlad Allam can be desribed as a slum area because of its deteriorated housing stock which the residents cannot legelly mend and improve due to their inability to gain building or improvement permits.In fact the resident cannot even paint their homes without a permit as it is against the law to improve the house in any form in an area that is intended for removal.

2-Chaotic growth:

In Great Cairo there are many chaotic settlement or what is called unplanned or uncontrolled growth.In these areas many thousands of houses in different physical structures can be found. Many dead-end streets, very large and very narrow streets,twisted streets,and small plots of land.The areas are not fully serviced with tap water,some streets or some parts are served with public sewage ,the other parts are free from public sewage net.Electricity is available through the public service or through private generators,.Most of the streets is muddy streets except the main streets in some cases.

Table 6,and figure 4 shows the Greater Cairo distribution of Squatter and Slums settlements by Kisms.

High quantities of garbage and sewage drainage are clear in all the streets where the public service is not available except in Esfalt streets.High population of house flies and mosquetoes are availabe at any time.

3- Helwan area:

Helwan is the best example for an Industrial area in third world.In this area we can find all types of settlements, Slums, planned subur bs,spontaneous ,chaotic ,sporadical and squatter settlements.In this area 3 large compannies for Ciment production are found. These companies inject the sky of this part with a high quantity of exhaust materials. For example these companies use every day 2400 tons of solar as source of energy.That means that they inject the environment every day by 2.7 tons of aldhydes,16.2 tons of Monooxide, 37 tons of hydrocarbons,6o.4 tons of Nitrogen oxides,O.78 ton of sulfur oxides ,8.4 tons of Organic acids and 40 tons of particulate. All of them use the Cairo sky as a dump for two million metric tons of cement and raw materials every year. Also each company inject the Nile river every day with 48000 cubic meter of industrial water.About 1000 tons of By-pass/ day which contain a high percentage of alkaloids are dumped in the same area in open dumps.

Beside these three companies for cement production,number of industries .i.e.metal,oil,fertilizers,ceramic,and aspestos inject Helwan area with heavy metals,dust,polycyclic organic matter,organic compoents,detergents,chlore gas,ammonia,fliorides,urea,asbestos dust...etc. In this area urban villages are available >Most of residents work in the arround industries.Most of the area might in no way called a slum or shanty settlement but rather an area of special character a folks district.Most of the area is fully serviced with tap water,public sewage ,electricity,but air is highly polluted,by dusts,cement materials,house flies,gasses...etc.

4- Shobra El-Khema area:

That is the second highly polluted area in Greater Cairo,in which we can find a large number of metal,oil,ceramics,textile and small factories distributed between houses for cars and battaries...etc..Industrial area now became inserted in a large number of settlements some of them are considered as urban villages ,others as chaotic area,some as sporadical growth,most of the area is uncontrolled or unplanned growth,all the area can be considered as squatter settlements.The environment in this area is highly deteriorated. More than 60% of the population are living in illegal settlements with little or no infrastructure or services and in overcrowded and often deteriorating tenements and cheap boarding houses.The population dencity of house flies and mosquetoes is very high,Air is polluted with heavy metals,dusts,polycyclic organic matter,ammonia, methane, organic components,flourides,formaldehyde,asbestos...etc.Most of the streets are very narrow,some are dead -end,sewage drainage is available in most narrow streets..Goats,chicken ,ducks and other rural pits roam the streets of the area-The streets are narrow,twisted,and have a physical tissue that is more rural than urban .The average number of persons per room is between 2-3 persons.It is common in some parts of Shoubra El-Khema for this number to rise to 4 or more among poorer groups.It is also common for poor households to live in one room ..In this many poor urban districts,households may have less than one square metre of interior space per person.

5-Modern parts or healthy areas. :

Only14% of the Greater Cairo area can consider as healthy area or modern area when compared with modern areas in the Third world.This part of Greatr cairo is small parts in Middle cairo called Gerden city, Zamalek ,small parts of El-Maadi, New parts in Misre El-Gedida and Madenat Nasser,Hiliobilis..The total inhabitants of this area are less than 1 million.It is well planned,The areas are fully served with tap water,public sewage,electricity,telephone service and all other urban amenities..The building seem to copy the design of similar buildings in the development countries.little considerations being given to the climatic and cultural differences.This also seems apparent in much of the planning of settlements and choice of buildings materials.

Great attention from the government is directed to these modern areas,The main air pollutants in these areas are exhaust materials from the around industries or from high number of cars in Greater Cairo,El-Mokatam play very important role in the air pollution by dusts.House fly population and mosquetoes dencity is higher that the dencity accepted by WHO.

The 76 squatter settlements arround this part are considered as the main sources of pollutants to this modern part .For that high voices are now directed to enforce the dessicion makers to take actionThis phenomena like the high voices of the Developed countries in The Earth Somet hoping to enforce the developing countries to take action to protect the Environment to avoid the health effect of Environment deterioration.

THE MAIN OBJECTIVES OF THIS STUDY:

1- The main objective of this study is to identify and briefly describe the major environment problems affecting health in thE Greater Cairo.

2- Rank these problems in periority order,in terms of the relative magnitude of the adverse impacts on human health caused by each.

3-Identify the major data gapds in understanding the health impacts of Greater Cairo.

4- As the state of environment in Greater Cairo is related by the increase of populatiuon ,it is necessary to put in consideration the deterioretion of the environment in the future

5- To throw high lights about the side effects of Environmental pollution on the next generation.

Identification and describtion of the major problems affecting the health of Greater Cairo population.

Higher Risk Problems:

The first higher risk problem is: Overurbanization and psychosocial health problems:

Virtually the government have failed to ensure that rabid urban growth in Greater Cairo is accompanied by the investment needed in the infrastructure and services.Many health problems affecting people in Greater Cairo are associated with overcrowding,they include household accidents,airborne infections,acute respiratory infections,pneumonia and tuberculosis.

Good housing and a suitable physical and social environment promote good mental and physical health.Where they are absent ,phychosocial disorders can become a major cause of morbidity and death among adolescents and young adults.

Among the most serious psychosocial health problems are **DEPRESSION,DRUG and ALCOHOL ABUSE,SUICIDE,CHILD AND SPOUSE ABUSE,DELINQUENCY ,and TARGET VIOLENCE (i.e. RAPE ,TEACHER ASSAULT)**.Many social pathologies are associated with poor-quality housing ,insecure tenure,or eviction from housing.**VANDALISM** and **VIOLENCE** contribute to a poor environment ,also with adverse effects on health.

PERSONAl VIOLENCE ,including **HOMICIDE,ASSAULT,SUICIDE SUICIDE ATTEMPTS,SPONSE** and CHILD ABUSE, is a growing problem throughout the squatter and slums settlement in Greater Cairo,and often primarily affects the poorer nembers of society.It is being increasingly recognized that the environment plays an important role in violent behaviour and the public health initiatives that were so effective in combating infectious disease should be utilized for combating violent behaviour.

Many of the physical characteristics of the housing and living environment have a major influence on mental disorder and social pathology through such stressful factors as noise,air ,soil or water pollution,overcrowding ,inappropriate design,inadequate maintenance of the physical structure and services,poor sanitation,or a high concentration of specific toxic substances .

The precise link between the different elements of the physical environment and the manifestation of social pathology is difficult to ascertain and to seperate from background or intervening factors.

As most of Squatter settlement population are people with low income ,previous data indicated that their is a good relation between housing quality,price,low income and prevalence of mental illness.in rundown areas..

The availabilty and acceptability of health care service ,social welfare services and other assistance programmes also influence the incidence of psychosocial problems.

The relationship between housing and mental disorder requires an understanding not only of the availability of housing but also of many other variable such as cost,structure,space/density,facilities and locationThere is a possitive correlation between three different patterns of disorders;withdrawal,agression and psychosomatic disorders..Deteriorating centres and urban villages and slums areas with declining economics are characterized by social disorganization and disintegration and creare scores of high -risk populations,migrants,children,women,the elderly,the homless ,street children.The physical and economic deterioration is also accompanied by a feeling of entrapment among particular income,age and ethnic groups which can make the problems more difficult to resolve.

Tables from 7-13 shows the distribution of crimes,felonies,drug crimes, in Greater Cairo by KISM at the years 1991 Ind 1992.

Children are especially vulnerable to deficiences in the provision of space,facilities and services.For instant,children's play is known to have a central role in learning ,motor and communications skills,problem-solving and logical thinking,emotional development,and social behaviour.In Greater Cairo,the public provision for safe stimulating children's play is very inadequate,especially in poorer districts..

The second higher risk problem is: water shortage and water quality:

The average consumption of portable water in rural areas is 72 litres/capita per day and for urban areas is 116 l/Capita/day.If water requirements for trades,industry,handicraft and total losses are included,per capita,urban water consumption is 213 L/day/Capta.,Fahmy 1988.

Domestic water budget for Egypt 1980- 2000 (source Fahmy 1988).

	Water requirements (billion m3/years)		
	1980	1985	2000
Requirements	2.25	2.42	4.62
Consumption	1.10	1.08	1.80
Sanitary drainage discharges	1.15	1.34	2.82
Gross loss from the system	1.78	1.87	3.47

The problem of maintainig water quality is particulerly acute in many slums and squatter settlements in Greater Cairo.Maintaing water quality is harpered by two factors; failure to enforce pollution controls at the mainpoint sources(especialiy industries and inadequacy of sanitation systems and of garbage collection and disposal.

Most of the disease agents that contaminate water and food are biological and come from animal or human beings.They include bacteria,viruses,protozoa,nd helminths and are ingested with water or food or conveyed to the mouth by contaminated fingers.Once ingested,most of them multiply in alemintary tract and are excreted with the faeces.Without proper sanitation,they find their way into other water bodies,from where they can again affect other peoples.Many of the organisms in this enteric group can survive for a long time outside the human body.They can thus survive in human sewage and occasionally in the soil and be transmitted to water and food stuffs.The more resistant organisms may be transmited mechanically by flies breeding in accumulations of domestic waste arround and in the streets of settlements.

Most of the diseases associated with water are communicable .They are usually classified according to the nature of the pathogen,but in considering health and the environment it is more convenient to classify them in categories according to the various aspects of the environment that human interaction can alter.The diseases associated with waterin these squatter settlements can be classified in five categories:

1-Waterborne diseases,these arise from the contamination of water by human or animal faeces or urine infested by pathogenic viruses or bacteria,which are directly transmitted when the water is drunk or used in the preparation of food.Cholira and typhoid are te classic example .

2-Water-washed disease:scarcity and inaccessibility of water make washing and personal cleanliness difficult and infrequent.Where this is so some diarrhoeal diseases and contagious skin and eye infections are prevalent.All waterborne diseases can also be water-washed diseaes,transmitted by faecal-oral routes other than the ingestion of contaminated water.This category of diseases also includes infestation with lice or mites which are vectors of various forms of diseases.

3-Water-based diseases:Water provides the habitat for intermediate host organisms in which some parasites pass part of their life cycle.These parasites are later the cause of helminthic diseases in people as their infective larval forms in fresh water find their way back to humans.

4-Water -related diseases;Water may provide a habiata for water-related insect vectors of disease.Mosquitoes bread in water specially in sewage drainage which is available in most streets of the slums,urban villages and chaotic settlements in and arround Greater Cairo table (14)..Now mosquetoes disturb most of the Egyptian inhabitants in Greater Cairo and increased the quantities of pesticides where are used daily for mosquetoes control borning a very difficult problem to be solved, this problem is the accumulation of daily pesticides used daily in each house .

5- Water-dispersed infections.This fifth category of diseases is special for the rich and modern parts of Greater CairoPeoples in these areas can be infected with agents can proliferate in fresh water and enter the human body through the respiratory tract.Some freshwater amoebae that are not usually pathogenic can proliferate in warm water and if they enter the host in large numbers can invade the body along the olfactory tracts and cause fatal meningitis.

Diseases arising from the ingestion of pathogens in contaminated water or food have the greatest health impact in Greater Cairo.They include those at the origin of classic epidemics i.e. cholera,dysentery and typhoid fever and a considerable variety of other microorganisms including protozoa i.e amoebae and viruses i.e. hepatitis A.They may be found in untreated water contaminated by human and animal excreta or remains or in water handled unhygienically after treatment specially in settlements which have no piped water in Greater Cairo (Zabalin Settlement)..In these latter situations,contamination of food is as likely as contamination of water and it becomes difficult to attribute responsibility to this or that pathway,through the primary cause undoubtedly rests with the availability of water.

Water borne diseases are the largest single category of communicable diseases contributing to infant mortality in slums and chaotic settlement in Greater Cairo.

Diarrhoea remains one of the most pressing health problems and usually caused by one of a number of waterborne pathogens .The average annual incidence of diarrhoea among children under five years of age is 3.5 episodes,many children have 10 or more episodes each year. Each episode lasts from 2 days to 2 weeks or more and may result in severe dehydration,the severity depending on the infectious organisms,the intensity of the infection,and such host factors as age ,nutritional status and immunity.

The weight loss that accompanies diarrhoea usually leads to acute malnutrition,and repeated episodes lead to chronic malnutrition.The risk of dying from diarrhoea is greatly increased in malnourished children.

Estimates of the numbers of people lacking access to safe and sufficient water supplies and adequate sanitation provide the best figures for the numbers of people at risk from water related diseaes.

Safe and sufficient water supplies and adequate sanitation in some parts of any chaotic settlement reduced infant and child mortality by more that 50 % and prevented a quarter of all diarrhoeal episodes..Increasing water suply to households reduced greatly the incidence of water-washed diseases,and improved sanitation could disturpt the cycle by which the agents of many waterborne and wate-based diseases are returned to food,water or soil.

It is estimated that 23% of Greater Cairo inhabitants lack access to safe and adequate water supplies and over 39% of people lack adequate sanitation.Most human excrement and household wastes end up in streets or in streems,ditches...etc. in several Slums settlement in the middle or arround greater cairo.

Official figures for the numbers of people adequately served often overstate the number actually served.For instant ,they may assume that all those with water taps in their settlements are adequatelyserved,but there are often so few communal water taps that people have to wait for a long time in queues and this tends to reduce water consumption to below what is needed for good healtas in some settlement in old cairo).In some settlements where no piped water the people buy the water through unsafe container in very high prices.Piped water systems in many settlements also function only intermittently for a few hours a day,which makes it especially difficult for households relying on communal taps.

The water in piped systems is often of doubtful quality because of contamination of old and leaky distribution pipes by groundwater and sewage especiely at the end of water net.Most of the people in the illegal settlements in cairo,draw water from piped distribution systems through illegal connection .**Leaky distribution mains present at additional hazard when the water pressure is low and pollution from contaminated groundwater or wastewater from leaking drains and sewers may enter through damaged joints or pipe fissures when the pressure drops.**

There is a strong correlation between reduction in diseasee incidence and improvement in water supply.In a study in Greater Cairo ,data indicated the the number of visits for diarrhoea dropped from 2.7 percent of this disease to 0.98 per cent following the sastallation of indoor water supply system in some slums area.

Pesticides are the agricultre chemicals that cause most health concern..Most of the problems of pesticides in drinking water have been found in both Rural and Urban Areas in Egypt.

Abdel-Gawaad 1993 studied pesticide residues in tape water. Out of 107 water samples 85 samples contained insecticides residues , 22 were free from endrin,dieldrin,lindane and total DDT, the maximum residue levels of endrin ,dieldrin,lindane and total DDT were O.001-0.015, 0.000-0.004.0.001-0.005 and 0.030-0.054 ppm respectively in Greater Cairo.While these levels are changed in Rural areas to be, 0.002-0.032, 0.003-0.008,0.000-0.007 and 0.050 -0.064 ppm respectively.

Organochlorine pesticide residues in Tap water in Greater Cairo and Rural areas

:

Area		Pesticide residues			
		endrin	dieldrin	lindane	DDT
Greater Cairo	Min	0.001	0.000	0.001	0.030
	mean	0.010	0.003	0.004	0.043
	Max	0.015	0.004	0.005	0.054
Rural	Min	0.002	0.003	0.000	0.050
	Mean	0.013	0.004	0.004	0.052
	Max	0.032	0.008	0.007	0.064

The guideline value of 0.05 mg/L has been recommended for lead in drinking water as reported by WHO 1984 ,while the Egyptian guideline value is 0.1 mg/litre.

Man'exposure to lead through water is generally low in comparison with the exposure through air and food as reported by WHO 1973.This statement is not correct under the egyptian condition.Monitoring of lead and other hevy metals in tap water was conducted in 8 governorates in Egypt to throw high lights about the interaction between water pollution with heavy metals and the public health taking in consideration that the Egyptian people drink daily 2.8 litres of water.Data in the following tables indicate that all the samples contained concentrations of lead varied between 0.118 to o.945 mg / litre exceeding the Egyptian and WHO levels.

The variation of water contents from lead varried according to the age of

tube lines,the absence of water tanks on buildings and the source of water (Nile or underground water).
The main source of lead in tap water may be attributed to several reasons i.e. the contents of water tubes from lead ,the lead part of tube which is normally connected to each house between the water meter and the main net of tubes in houses,the high content of water from chlorine compounds and due to the insertion of water pumps which is normally made from lead in Egypt

Levels of lead found in tap water in the different 5 governorates.

Level	Governorates				
	Ismailia	El Minia	El Swiss	El Behera	Sharkia
Urban area Maximum	0.276	0.236	0.473	0.324	0.748
Mean	0.131 ±0.138	0.236 ±0.000	0.322 ±0.098	0.298 ±0.086	0.604 ±0.116
Minimum	0.000	0.236	0.197	0.167	0.433
Rural area Maximum	0.355	0.197	-	0.533	0.845
mean	0.66 ± 0.067	0.146 ±0.037	-	0.421 ±0.07	0.610 ±0.129
Minimum	0.197	0.079	-	0.276	0.473

Levels of lead found in tap water in Great Cairo

Site		Level (mg/L)	Mean
Urban area New houses without-tanks	* Maximum	0.433	0.4216 ± 0.1052
	* Minimum	0.236	
	**Maximum	0.591	
	**Minimum	0.473	
New houses with tanks	* Maximum	0.473	0.4843 ± 0.049
	* minimum	0.433	
	**Maximum	0.551	
	**Minimum	0.512	
Very old houses	* Maximum	0.551	0.5711 ± 0.083
	* Minimum	0.512	
	**Maximum	0.709	
	**Minimum	0.603	
Rutal area Giza	Maximum	0.394	0.3256 ±0.107
	Minimum	0.197	
Qualiobia	Maximum	0.473	0.2314 ±0.068
	Minimum	0.197	

* Samples from houses without a connection of lead tube.
** Samples from houses with a conection of lead tube.

Abdel-Gawaad 1993 calculated the daily intake of the Egyptian person of lead through drinking water to be 1.316 mg/person (70 kg) ,as it is clear from the following table:

Table 4: Lead level in tap water µg/litre

Level	Lead level mg/L.	mg/person (70 kg)
Minimum	0.118	-
Mean	0.470	1.316
Maximum	0.945	-

Data also in the following two tables show that the maximum levels which were detected in water samples for Fe,Cu,Li,Mn,Zn,K and Na were 0.184,0.336,2.618,0.884,11.016,11.71 and 13.98 mg/ litre respectively,while the minimum levels of the same elements were 0,0,0,0,0,0.794 and 10.24 mg / L. respectively.

The guideline values of 1.0,1.5,1.0 and 15 mg/litre,has been recommended for Fe,Cu,Mn and Zn in drinking waer in Egypt respectively.No maximum levels are conducted by thge Egyptian Authoroties for Li,K and Na..

Data indicate that the maximum levels which were detected for Fe,Cu ,Mn, and Zn were well below the acceptable levels recommended by Egypt.While the levels of Mn was more than the acceptable levels in only 6.9 % of samples tested.

Now measurable amounts of heavy metals in our drinking water present a variet of problems.If a chemical is non-toxic to human being and causes no harm to living cells ,residual amounts in water or food could be tolerated.

As sources of good quality drinking water diminish at an alarming rate,there is an urgent need to protect the still usable sources from degredation .Where water quality has dropped below acceptable levels,water treatment will be needed.

The third High risk Problem is Food contamination:

Despite progress in science and technology,contaminated food and water remain to this day a major public health problem.Foodborne diseases are perhaps the most widespread health problem in Egypt and specialy in Greater Cairo and an important cause of reduced economic productivity.Measurable amounts of pollutant esidues in our food now present variety problems.

The food quality and duantity affect human health not only through their central role in influencing people's nutritional status and resistance to disease but also through injuries or diseases associated with working in this sector and with the contamination of food and water arising from food production ,distribution,handling and preparation

Agricultural change has often been particularly rapid in Egypt,often with major and unforeseen health effects involving a greater need for a health -related infrastructure.The failure to develop such an infrastructurehas led to an increased risk of contamination of the food and water supply.

The safety of the increasingly complex technological base of the food industry requires regulations and institutional means to ensure their enforcement.In Egypt this regulatory infrastructure of inspectors,scientists and authories is inadequate.

The best example for that is the 10th Of october city in which most of the food factories which produce the main quantities of food to Greater Cairo, it is esimateed that 138 felonies about unsafty food were recorded in this city at 1990.

Tables 1 to 6 show the number of accepted and non accepted samples of fod,the total number of official inspection about food quaIt,tne number of convention minutes ,and the No. of accepted and non accepted imported food bulks.

Most of the diseases agents that contaminate food and water in Greater Cairo,are biological and chemical agents

Foodborne diseases are caused by a wide range of agents ,and can result in mild indispositions or life-threatening illnesses.The true scale of their impact on health remains unknown since only a small proportion of cases come to the notice of health services and even fewer are investigated.

Biological contaminants are the main causes of foodborne diseases and are responsible for a wide range of such diseases(i.e.

salmonellosis,brucellosis ,amoebiases,campylobatcriosis,poisoning by toxin-producing microorganisms such as staphylococci and clostridium sp.Parasitic diseases such as toxoplasmosis,taeniAsis and cysticercosis are very important.

Most foodborne or waterborne diseases can cause diarrhoea and food as a vehicle my controbute to the transmission of up to 70% of all episodes of diarrhoea.In addition ,within the home there are likely to be numerous interconnections and interactions among water .sanitation,flies,animals ,personal hygiene and food that are responsible for diarrhoea transmisson.

Some biological contamination of food can be climinated or considerably reduced by improvement in personal hygiene,safe piped water,good quality sanitation,effective animal health programmes,the application of technologies such as pasteurization and irradiation and effective control of health and safety aspects of food production.

Foodborne diseases will remain a serious problem in Greater Cairo.One reason why many bacterial foodborne diseases have become an increasing public health and clinical problem is linked to agriculture practice..A second reason for the increase in certain food-borne diseases is the rapid growth in consumption of ready-to-eat food products ,what is called food street.The absence of intrinsic safety factors and absent of official inspection increase health danger in Greater Cairo.Hapatitis A is common throughout Egypt ,Some of cases were reported annualy from these ......cases are in Greater Cairo.

Food containated by foodhandlers (**Hawkers or Pedlars**) may also reason fror the transmit of many diseases,many cases of hepatitis A are known to be so associated.

Some foodborne infesctions may lead to chronic conditions such as joint disease,immune system disorder,heart and vascular diseaes,disorder of the renal system,and possibly even cancer.

Mothers now in most of these settlement do not bear the entire responsibility for the preparation of the family meals.Methods of food preperation that in the pased ensured the safety of the food have disappeared in recent years.People eat more often in food service establishments or from street food,where the food is prepared in advance in large quantities and where food-handlers are unaware of the special precautions required under such conditions.The lack of education of food-handlers is actually a serious problem in Greater Cairo,.Many of foodborne diseases that occur are due to errors in food preperation or lack of personal hygiene onthe part of the food-handlers.Their lack of knowledge ,and the use of raw food materials that are already contaminated,increase the risk of cross -contamination and prolifration of microrganisms in food.

FOOD SAFETY

When we want to throw high lights about Food Safety it is necessary to throw high lights about food ***quantity,*** *food* ***qu[illegible] [illegible]nd food management.***

Food quantity

Food demand in Egypt is annually increasing at a rate of 4.8% versus a modest annual increase in local food production of 2.5%

This gap betwwn food production ,tables 1 to 13 and consumption will remain continuously expanding due to the limitations of the agricultural production capabilities versus the increasing population growth rate.This gap is filled by imports ,table 14 and 15 ,hence the additional negative effects of both the everlasting devaluation of the purchasing power of our currency and the international increase in prices of food commidities.

Further more,these limited resources are maldistributed within the community due to the vast variants in per-capita income,percapita expenditure allocated to nutrition,and improper nutritional habits as well as geographical distribution and urbanization.

Moreover,additional maldistribution occurs within the same family according to the age and sex,besides the ignorance and /or neglect of the extra and specific needs of different vulnerable groups.

While food supplies are sufficient to meat the Egypt's aggregate minimum requirements,they are so inequitably distributed among the different governorates and among the people of the same governorate because of income disparties that the lives of hundreds of thousands are affected..Underdevelopment and malnutrition in many slums settlements in Greater Cairo or in many villages all over Egypt will remain the greatest problems posed by the relationship of population,food and health. There is no single formula for dealing with malnutrition.In terms of numbers it affects mainly the low-income urban and mainly rural poor groups,especially among infants,preschool children and women.The major dietry deficiency is that of protein.Many dietry deficiencies are related to environmental factors,in the sense either of limited access to foods that enable the deficiency to remedied or of pollutants or pathogens in environment exacerbating their effects.Communcable diseases remain principal cause of sickness and death,but it is not sufficiently recognized that the resistance of children and adults to infectious diseases often depends on their nutritional state since this may have a profound effect on the development of immunity

Interaction between nutrition and infection to produce the "manutrition/infection complex" create the greatest public health problem in Egypt.Infection infuences nutritional status through its effects on the intake,absorption and utilization of nutrients and in some cases on the body's requirement for them..A child's rate of growth is retarted by too little food and/or too many infections or parasites..Malnutrition may result in lower immunity .Infection can lead to loss of appetite,decreased efficiency of food and nutrient utilization,increaed energy requirements and decreased growth.The relationship between diarrhoeal diseases and physical growth has been clearly shown.These interrelations produce the malnutrition and infection cycle so prevalent in Egypt..The vulnerability of malnourished people to environment health risks is clearly documented in Egypt.**Hence the importance of improved water supplies ,sanitation and safe food to reduce water-related and foodborne diseases and programmes to control diseases vectors supported by education and health care.** For that the author tried to throw high lights on Food through several dimentions,**food production, food quality and food management.**

Case Study

AGROCHEMICALS IN EGYPT

INTRODUCTION

It is now recognized that the activities of mankind produce detectable and deleterious impact upon the atmosphere and bioaphere..The pollution of the bioshere by our technological civilizatiomn does not just threaten the long-term survival of the animal and plant species that inhabit the Earth.

The natural biota perform many essential functions for agriculture,forestry and other aspects of human welfare such as preventing the accumulation of organic wastes,clearing water and soil of chemical pollutions such as pesticides ,recycling vital chemical elements within the ecosystem,producing biotic nitrogen for fertilizers,buffering air pollutants and moderating climatic change,conserving soil and water ,preserving genetic materials for agriculture and forestry and supplying food via the harvest of fish and other wild life.

Agrochemicals can influence all these essential functions by reducing species diversity and modifying food chains,changing patterns of energy flow and nutrients cycling (including nitrogen) reducing soil,water and air quality and changing the stability and resilience of ecosystem.

The study of the circulation of toxic substances and other pollutants in the ecosphere shows that they do not move in identical patterns between its three compartments of atmosphere,soil and water

HIGH LIGHTS ABOUT THE PROBLEM OF ENVIRONMENTAL POLLUTION BY AGROCHEMICALS IN EGYPT:

From about 7OOO years B.C.,the ancient Egyptian concept in soil and plant protection depended on the natural methods by avoiding the favourable condition for pest infestation,i.e.protection is better than control.But if the infection occured ,the control procedure used to depend on two essential alternatives.Biological control by natural enemies and / or the mechanical control such as collecting and burning the insects.

The ancient Egyptians knew about farming since the stone age (Neolithic Period).A lot of agricultural villages have been discovered which due to 6000 years B.C. either in Delta or in Upper Egypt.The ancient Egyptian monuments proved that farmers at that time were very well knowledgeble by the agricultural sciencies and practice as well.Among these practices was saving water for irrigation by constructing dams and various water reservoirs,measuring water devices ,resigning and digging the canals for irrigation.They also took care of their soil as an important element in agricultural production The history decumented that they used for the first time all over the world the bird IBIS as a bioassay animal to examine water pollution. The history documented that this bird does not drink water if it is wholesome or tainted.(**For more details : Abdel-Gawaad,AA.A.and Khatab,H.A.1985:Soil and Plant Protection Methods In Ancient Egypt: 2nd Int.Cong.Soil Poll.,Part II 19-32).**

The outlook of the Egyptian idiology is changed as a result of series of wars which took place in middle east during the last half century . Taking into consideration the tremendous out break of population and the difficult economic situation ,the Egyptian government has to look forward to invade desert ,coating the old valley and Sinai.

After 9000 years ,we discovered that our environment in Egypt was injected in the last thirteen years with 690000 metric tons of pesticides.The quantity of pesticides used increased from 2143 metric tons in the season 1952/1953 to 23398 metric tons in season 1960/1961 .The maximum quantity of pesticide used was at the season 1971/1972 in which 35259 metric tons were used. (Table

All groups of pesticides (chlorinated hydrocarbons ,substituted phenols,organophosphorous compounds ,carbamates ,pyrethroids,natural organic compounds, organic oils , organicsulphur compounds,di-nitrophenols,antifeedants,organothiocyanate...etc were used.All methods of application for pesticides were also used ,i.e.hand atomizers,bucket pumps,knapsack sprayers,barrel-sprayers,power sprayers,knapsack air carrier sprayers.mist sprayers ,mid size air carrier sprayer ,aircrafts ...etc.(**For more data please see :Abdel-Gawaad A.A. 1985 Survey of pesticides used in Egypt. 2nd Inter.Cong.Soil.Poll. Part ii :33-86.**

Environmental chemistry of pesticides in the Egyptian Environment:

Pesticide residues are reactive .The minerals and organic components of soil cause pesticide transformations such as reduction and isomeration,and the soil surface may act as an inert base for light-energized reactions.However,most of degredation are associated with soil moisture,water reacts with many pesticides as a reactors often are strongly affected by PH.Water can also act as a reaction medium in the isomerization of organophosphorous compounds and in photodegredation.Light energized a variety of degredative reaction in solvent water,including oxidation,reduction,elimination and isomeration as well as hydrolysis,The products of nonbiological degredation frequently are idebical to their metabolites formed by living organisms.

Microorganisms play an important factor in the breakdown of pesticides,under aerobic or nonaerobic conditions. Many microorganisms are capable of converting pesticides by :oxidation,reduction,dehalogenation,De-alkylation,ring hydroxylation,ring cleavage,condensation or conjugate formations......etc.When oxygen is available,the final products of degredation will be carbon dioxide,water,sulfate,nitrate,phosphate, chloride....etc

Some pesticides can be degraded in the environment to more toxic compounds than the parent materials.(For more details please see,(**Abdel-Gawaad,A.A.1975:SOIL POLLUTION BY INSECTIUCIDE RESIDUES.D.Sc. Thesis,Germany).**

OCCURRENCE-IN THE EGYPTIAN ATMOSPHERE:

Our previous data only at the season of spraying cotton cultivation(Juli and August)showed that concentration of O.P.pesticides were very high (131.9 ng/m^3)at the time of spraying and still high for few days after spraying to be (21.9 ng/m^3)after a week.

The indoor concentration in the sprayed area varied between (69.7 ng/m^3) at the time of spraying to (10.2 ng/m^3) after a week of treatment.

The total solid materials (TSM) in the air of the agriculture areas are contaminated all over the year by traces of O.P. pesticides. The concentrations of these residues in the TSM varied between 0.1 ppb to 23 ppb, (for more details:**Abdel-Gawaad,A.A.1991;Ecotoxicological Impact of organophosophorous pesticides in Egypt,Scientific report for Greenpeace)**

OCCURRENCE IN NILE RIVER AND MEDITERRANEAN SEA WATER:

The Nile river previously brought a large quantities of disolved nutients and organic matter into the southeastern Mediterranean sea (60-180 million tons of sedement).
Since completion of Aswan hydrocomplex,reduction in the Nile river flow has caused significant change in the destribution of the physico-chemical properties of the sea water as well as in the formation and distribution of the water masses in the region located north of the Nile Delta. In recent years changes have been recorded in the dynamics and destribution of water temperature .From 1966 the sediment run off Nile begane dropping sharply due not only to reduction in the volume of river water reaching the sea (now 2.3-2.8 Milliar m^3 /year),(it was $16x10^9$ cu m at 1964) but also due to a significant reduction in the suspended particles in the flow.The reproduction of the shrimp in the area has changed significantly and food supplies for the young shrimp have deteriorated. Shrimp catches in 1966 were half what they had been in 1963. Commercial fishes have also decreased in number. Thus all links of the trophic chain have been affected from the phytoplankton to the pelagic and benthic fishes.
Chlorinated pesticides were detected in both Nile river water and fishes. The sites elected were in order of decreasing pesticide concentration in fish of each site: El-Mahmodia canal>Abo-ElGheit canal > El-Mansoura >Assiut>Fraskour >Edfinna>Cairo>Aswan.Organochlorine residues found in the fish included BHC,lindane,endrin,o,p DDT and its metabolites which were much higher than other organochlorine insecticides. Organophosphrous pesticide residues were not detected in the Nile water and fishs.
Our data indicated that according to activities of aeroplanes in spraying the cotton fields(about 1-1.2 million fedan /year) and due to the special canal irrigation system which is used in Egypt,all the water sources are polluted by pesticides used in the season by direct or indirect applications,i.e.leaching of pesticide residues,washing hands and bodies,washing containers......etc

The concentration of pesticide residues detected in underground water or surface water varied between 3 ppb to 19 ppb.The concentration depends on

the type of water sources and the time of spraying.High concentrations (19 ppb) were detected in canals and canals branches which are directly sprayed,while the lowest rates were detected in Nile river water (4-9 ppb) and traces (1-3 ppb) were detected in under ground water.
It can be calculated that between 6.9 to 53.2 tons of O.P. pesticides can be transported yearly through the Nile river to the Mediterranean Sea.

SIDE EFFECTS OF WATER POLLUTION BY PESTICIDES ON FISH:

Fresh water fish *Tilapia nilotica* was exposed to polluted water of different concentrations of chloropyrifos.The LC $_{50's}$ recorded for different exposure time intervals were 25.0,20.0,16.5 and 14.0 ug/L for intervals of 24,48,72,96 hr exposure respectively.
On the basis of $LC_{50's}$, for 48 hr,the safe concentrations (Sc) was 0.31 mg/L. **Abdel-Gawaad,A.A.A.1991:Ecotoxicological impact of organophosphorous pesticides in Egypt;Scientific report for greenpeace).**

OCCURRENCE IN SOIL:

Our previous results indicated that from 690450 metric tons of pesticides from all groups,345225 metric tons find their way to pollute the Egyptian soils.Soil samples from 213 villages in 8 centers:6 in Kalubia governorate(benha,Kafr Soukre,El-Khanater,Toukh,Kalube ,Shebien, and two centers in El-Menofia Governorate (Shebien El-Kom and Menof were collected, Please see the following tables (1-4)
Results indicated that all the tested samples contained pesticide residues.Dieldrin,DDT,endrin and lindane were detected in all tested samples.About 23 compounds were detected as breakdown or unknown products.Traces of some organophosphorous compounds were also detected in more than 50% of the samples.The mean level of endrin residues in Moshtohor village varied between (0.03-0.50 ppm),while it was (0.03-0.12),(0.02-0.14),(0.01-0.6),(0.01-0.10),(0.01-0.05),(0.01-0.04),(0.01-0.o6),(o.01-0.08),(0.01-0.06),(0.04-0.06),(0.05-0.04) and (0.30-0.8) ppm for chlordane, lindane,aldrin,parathion,dursban,malathion,endosulfon,

THE TRANSFER OF AGROCHEMICALS IN FRESH WATER' RESOURCES:

Our previous results about the leaching of pesticide residues from Egyptian soils indicated that leaching of these residues differed according to soil type,where 29.71 % of lindane was leached from sand soil,but 13.99 % was leached from loam soil and 13.33 % from sandy clay loam.Leaching also depend on the type of pesticides ,thimet and temik were leached greatly than *the* other organochlorine pesticides where 34.09%,3.30 and 10.60 of thimet and 47.12% ,42.3o and 56.14 % of temik was leached from sand ,loam and sandy clay-loam soils respectively.

The effect of the special canal irrigation system which exists in parts of Egypt,on the persistence of pesticide residues has been studied. Four pesticides PP211,dyfonate,endrin and kepone ,which have been tested at seven different experimental stations for their effect in controlling the cotton leaf worm,were leached from different soil types.The quantities of pesticides leached were affected by soil type and type of pesticides.Pesticides and their breakdown products were leached more readly from light soils than from heavier soils.

The Chlorinated hydrocarbon pesticides and their breakdown products were leached more readly than organophosphorous pesticidesLakes and Nile river water can undoubtedly be contaminated through run off water from adjacent treated agricultural fields.Also ,water in deeper soil strata may be contaminated by pesticidal residues depending on the type of the soil and on the type of pesticides.

The soil materix is interpersed with pores of great range in size and shape.These pores produces complex pathways through which water and dissolved constituents move.These pathways are constantly changing as the soil dries out and films of water on the surface form new connections between pores that remain full.Such changes in water contents significantly affect both water flow and pesticide distribution.

In Egypt there is special canal irrigation system.The fields are flooded every period varied between 7-15 days by quantity of water varied between 300-400 m3/feddan.By using leaching model under fieldconditions,results indicated that all the tested pesticides can be leached from the soil models.The percentage of pesticide residues in the leached water varried according to the type of soil and pesticides.The percentage of pesticides which were leached from the tested models varied between 8.8%to 36.8 % of the added dose by the end of 5 irrigation ,(for more details,Abdel-Gawaad,A.A.,M.A.Hammad and F.H.El-Gayar1971:Effect of canal irrigation systems used in Egypt on the persistence of soil insecticides.Int.Pest Control,July-August,8-28. Abdel Gawaad,A.A. 1981 SOIL POLLUTION BY PESTICIDE RESIDUES:8-Side effect on pollution of water sources.Ist Int.Cong.Soil Poll.and Prot.from pest.Residues.PartJI 435-453)

The daily intake of the Egyptian people of lead through respiration is varied greatly according to rural or urban areas.While the daily intake of Egyptian person in middle Cairo through respiration is 0.043 mg / person it was 0.009,0.02 and 0.0003 mg/person in Dokki,shobra El-khema and Moshtohor Village, the daily intake of the Egyptian person from water is 1,316 mg/person where the Egyptian person drink 2.81 litre/day.The daily intake of lead through meal diet was estimated to be 0.592 mg/person.That means that the daily intake of the Egyptian person from lead is varied between 2.911 and 2.246 mg/person.Data show that daily intake of the Egyptian person is below the acceptable daily intake which is recommended by WHO.WHO established a PTWT of lead of 50 ug/kg B.W.(=3.5 mg/person 70kg).

Because of the special concern for infant and children WHO later evaluated the health risks of lead to this group and established a PTWT 0.025ug/kg B.W.This level refers to lead from all sources.(. **for more details;Abdel-Gawaad,A.A.Faten I Zahran,Z.M.Seleim and A.El-MousallamyTHE STATE OF HUMAN HEALTH AND ENVIRONMENT IN THIRD WORLD:V-Monitoring of heavy metals except lead in tap water.J.Egyp.Soc.Toxicol. 9:33-36,Ibed,VI-Toxicity and monitoring of lead in tap water,J.Egypt.Soc.Toxic.9; 55-58,Ibed,VIII-The daily intake of lead by the Egyptian people.J.Egypt.Soc. Toxicol.;10, 33-35. ,Abdel-Gawaad,A.A. and A.Shams El-Dine 1989,THE STATE OF HUMAN HEALRH AND ENVIRONMENT IN THIRD WORLD:II-Insecticide residues in total diet.J.Egypt. Soc. Toxicol .4: 79-84.).**

CARCINOGENIC RISK OF PESTICIDES IN EGYPT:

Epidemiological studies in humans exposed to chemicals have indicated the possible existance of some relations between exposure to certain chemicals and the invidence of cancer in Man.The extensive use of pesticides in the last 5o years has raised much concern with respect to their possible carcinogenic risk.

Experimental animal work has indicated such possibility in specific instance.In Egypt,the risk is more prominent because of the huge amounts of pesticides used(690000 metric tons since 1952),the lack of proper protective measures during handling and application and the loose control on the residue of such pesticides in food and feed. added to that,

FRESH WATER POLLUTION BY AGROCHEMICALS:

Due to the extensive use of agrochemicals in the last fifty years,Egyptian fresh water was polluted by pesticide residues,nitrate,nitrite, and heavy metals

Out of 50 fresh water samples,41 samples contained insecticide residues,9 samples were free from endrin,dieldrin , lindane, and total DDT,the minimum and maximum residue levels of endrin,dieldrin,lindane and total DDT were (0.001-0.015),(0.000-0.0040,(0.001-0.005) and(0.030-0.054) ppm respectively.

Tap water samples which were taken from 8 Governorates in Egypt were analyzed by using atomic absorption of Fe,Cu,Li,Mn,K and Na. Data indicate that the maximum levels which were detected in water samples for Fe,Cu,Li,Mn,Zn,K and Na were 0.184,0.336,2.518, 0.884,11.016,11.71, and 13.98 mg/litre respectively,while the minimum levels for the same elements were 0,0,0,0,0.024 and 2.42 mg/l respectively.

Data indicate that the maximum levels which were detected for Fe,Cu,Mn, and Zn were well below the acceptable levels recommended by Egypt.While the levels of Mn was more than the acceptable levels in only 6.9 % of the samples tested.

The guideline value of 0.05 mg/l has been recommended for lead in drinking water as reported by WHO 1984 while the Egyptian guideline value is 0.1 mg / litre.

Monitoring of lead in tap water was conducted in 8 governorates in Egypt to throw high lights about the interaction between the level of lead in drinking water and the public health taking in consideration that the Egyptian people drink daily 2.8 litres of water.Data indicate that all the samples contained concentrations of lead varied between 0.118 mg/l to maximum level of 0.945 mg/l exceeding the Egyptian and WHO levels.The variation of water contents from lead varried according to the age of tube lines,the absence of water tanks on buildings and the source of water (Nile water or underground water).The main source of lead in tap water my be attributed to several reasons,i.e.the contents of water tubes from lead,the lead part of tube which is normally connected in each house between the water meter and the main net of tubes in houses,the high content of water from chlore compounds and due to the insertions of water pumps which is normally made from lead in Egypt.

for dieldrin and endrin were 0.0014311 and 0.0011053 mg/kg B.W respectively.While the DDT residues were the largest quantities of residues in both human and powder milk but the estimated daily intake of (0.0055124 mg/kg B.W.) was less than the established ADI.

The average daily intake of some insecticide residues for the Egyptian infant in his first year was estimated based on the infant's average daily intake of different foods as assessed in a previous survey,the detected residue levels of some organochlorine insecticides in these groups of food,and the average weight for Egyptian infants during the first year of life.Results indicated that the estimated daily intake (EDI) for dieldrin and Endrin were 0.002187 mg/kg B.W. and 0.000626 mg/kg B.W. which exceeded the acceptable daily intake (ADI) established by the FAO/WHO.

The EDI of DDT and lindane residues were below the ADI being 0,02 and 0.008 mg/kg B.W. respectively as established by the FAO/WHO .Furthermore,the main bulk of pesticide residues intake is obtained from the different types of milk.

The average daily intake of some pesticide residues for the Egyptian persons and for infants during his first year of life (6 kg) was estimated based on the average daily intake of milk.

The estimated daily intake of Aldrin and dieldrin,chlordane ,DDT,endrin, heptachlor,lindane and dimethoate in all milk samples for Egyptians were 0.000041,0.000032,0.001079,0.000023,0.0000660,0.000006 and 0.000016 mg/kg B.W. respectively.Aso ,the estimated daily intake of the same residues in milk for Egyptian infants were 0.000601 mg/kg for aldrin and dieldrin,0.000474 mg/kg for chlordane,0.016031 mg/kg for DDT ,0.000345 mg/kg for endrin,0.009803 mg/kg for heptachlor,0.000096 mg/kg for lindane and 0.000243 mg/kg for dimethoate.While the acceptable daily intake for that pesticides are 0.0001,0.0005,0.02,0.0002,0.0001,0.008 and 0.01 respectively,(For more details:A.E.Ezz,Z.M.Seleim, and A.A.Abdel-Gawaad,1991:THE STATE OF HUMAN HEALTH AND ENVIRONMENT IN THIRD WORLD:XI-Average daily intake of some pesticide residues for milk fed Egyptian infants.J.Egypt. Soc.Toxicol 7,115-124.,Ibed;IX-Egyptian infant average daily intake of some pesticide residues during his first year of life,J.Egypt.Soc.Toxicol. 10,33-35 .,Abdel-GawaadA.,A.El-Mousallamy,M.A.Fatah.,N.A.Labib,Z.M. Seleim, and A.Ezz 1993;THE STATE OF HUMAN HEALTH AND ENVIRONMEN IN THIRD WORLD:IV-Average daily intake of pesticide residues through milk for Egyptian.10:53-57).

Data also indicated that all the bulk and packed milk samples tested were free from 5 PCB's residues(Archlor 1016,archlor 1221,archlor 1242,archlor 1248 and archlor 1254),Results also show that no malathion residues were detected in all samples tested.Dimethoate residues were detected in 14.3 % of packed milk samples,while bulk milk samples were free from dimethoate,(**Abdel-Fatah,M.N.A.Labib,Z.M.Seleim,A.El-Mousalamy,A.E.Ezz and A.A.Abdel-Gawaad 1992:THE STATE OF HUMAN HEALTH AND ENVIRIONMENT IN THIRD WORLD:VII-Monitoring of PCB's and organophosphorous pesticides residues in milk.J.Egypt Soc.Toxicol**

5-AVERAGE DAILY INTAKE OF PESTICIDE RESIDUES BY THE EGYPTIAN PERSON:

The amount of pesticide residues consumed by the average person in the average diet was calculated.Results indicated that feeding habits and behaviour of the Egyptian people play an important role in their daily intake of pesticide residues,high quantities of drinking water and bread are consumed daily and these would be the main sources of intake.In fact bread was the source of more than 5o% of the pesticide daily intake.The daily intake of endrin,dieldrin,lindane and total DDT from bread was 0.0960,0.0624,0.5280 and 0.5760 mg / person.

The total daily intake of pesticide residues was 0.1671,0.0955,0.7018,and 0.9578 mg endrin,diedrin,lindane and total DDT / person respectively,while the acceptable daily intake for the fore-mentioned insecticides is 0.014,0.0007;o.7 and 1.4 mg/person.(**Abdel-Gawaad A.A. and A.Shams El-Dine 1989:THE STATE OF HUMAN HEALTH AND ENVIRONMENT IN THIRD WORLD:II-Insecticide Residues in Total Diet Samples.J.Egypt .Soc .Toxicol. vol.4 pp79-84.)**

6-SIDE EFFECT ON THE NEXT GERNERATION:

The average daily intake of some pesticide residues for milk fed Egyptian infants(first three months of life) was estimated based on the average daily intake of milk as was assessed in a previous survey and the detected residue levels of some organochlorine insecticides in samples of both human milk and powder milk formulas.The results show that the estimated daily intake.

water and bread are consumed daily and these would be the main sources of intake.In fact bread was the source of more than 50% of the pesticide daily intake.
The daily intake of endrin ,dieldrin,lindane and total DDT from bread was 0.0960,0.0624,0.5280 and 0.5760 mg/person.
The total daily intake of pesticide residues was 0.1671,0.0955,0.7018 and 0.9578 mg endrin,dieldrin,lindane,and total DDT/person respectively,while the acceptable daily intake for the fore-mentioned insecticides is o.014,0.007,0.7 and 1.4 mg/person **Abdel-Gawaad,A.A.and A.S.El-Dine 1989:THE STATE OF HUMAN HEALTH AND ENVIRONMENT IN THIRD WORLD:Insecticides residues in total diet samples J.Egypt.Soc.Toxic vol 4,79-84.**

4-PESTICIDE RESIDUES IN MILK:
A total of 525 samples were collected from greater Cairo(Cairo,Giza and Qualiobia Governorates) during the autumn season:asit follows the summer period during which the maximum use of pesticides takes place for controlling cotton pests.Results indicated that aldrin residues were detected in 28,6 and 86,7 % of packed and bulk milk respectively.Residues levels ranged from 0 to 0.1024 and from 0 to 0.1049 mg/l. in both packed and bulk milk.
Dieldrin residues were detected only in packed milk.The residue levels ranged from o to 0.0184 m/l..only 14.3 % of packed milk samples contained dieldrin. Chlordane was detected in 85.71 and 93.3 % of both packed and bulk milk samples respectively.The residue levels ranged from o to o.11 and 0 to 1.27 mg/l. respectively. Only 14.29 % and 26.67 % of the packed and bulk milk samples respectively contained DDT .Residues levels ranged from o to 11..99% and 0 to 3.78 mg/l. were detected respectively.Packed milk contained endrin in 14.29% of samples at levels ranged from o.o to o.36 mg/l.while no residues were detected in bulk milk samples.Heptachlor residue levels ranged from 0.03 to 2.13 and from 0 to 1.014 mg/l. in both packed and bulk milk samples.Hundred percent of packed milk and 73.3 % of bulk milk were contaminated with heptachlor residues.Lindane residues were detected in 85.77% and 80% of both packed and bulk milk respectively.The residues varied between o to o.oo9 mg/l and 0 to 0.011 mg/l respectively.

372

5-Side effect on animals:

Mephospholane was administered orally to male rats (Rottus norvegious),while the controls recieved salineTween 80 only.This effect was concerned with the content of deoxyribonucleic acid (DNA) and Ribonucleic acid (RNA) of rat testes,liver and kidney at a dose of 20ug/100 gm body wieght,the period of adminstration was 150 days.Mephospholan caused variable changes in morphological and distribution of the neutral RNA and the inhibition of feulgen staining was more complete in nuclei from 150 days of treatment.The changes in DNA content could be attributed ,not only to differences in the chromatid number,but also to physiological changes.Chlordane caused a decrease in DNA and RNA content at a dose of 20 ug/100 gm body weight for 150 days of treatment.

Methomyl caused a decrease in DNA and RNA contents of liver,kidney and testes of male rats .(for more details: **:El-Makkawi,H.K.,A.A.Abdel-GawaadandH.A.Makkawy.1981:Chronic effect of methomyl adminstration on DNA and RNA of rats.Ist Int.Cong.Soil.Poll.and Prot.from Pest.Residues.PartII,495-499.,El-Makkawi,H.K.,A.A.Abdel-Gawaad and A.F..El-Laithy 1981:Histological studies on the effect of deoxyribonucleic acid (DNA) and Ribonucleic acid (RNA) in male rats.Ist.Int.Cong.for soil Poll. and prot.from Pest.Residues.Part II ,640-658.**

SIDE EFFECTS OF PESTICIDE RESIDUES ON THE EGYPTIAN PEOPLE: :

The problem of environmental pollution by pesticide residues has become one of the major problems which face both the developed and developing countries.Numerous individuals,societies,public organizations,governmental agencies,has become involved in the evaluation of the benifits and risks of the use of pesticides to increase agricultural yield and the risks which the pesticides may pose to human beings and ecosystem.

In Egypt it is neccessary to take into consideration the balance between the need to feed humans and the need to protect man and his environment.But practicaly,most of the attention is directed to increase food production with very little or no attention to the hazards to the environment.

As malnutrition continues to remain the major national public health problem ,pesticide usage has to increase in order to solve the national food deficiency problem.The role of pesticides in health is like a two edge sword.they can be used with skill to help prevent malnutrition directly by increasing crop yields or indirectly by controlling vectors of diseases or they may be used carelessly to induce illness and death by adding the insult of pesticide toxicity to the injury of malnutrition.

Optimal nutrition is mandatory to avoid the potentially increased absorption which may occur through dermatological or other nutritional pathogies as malnutrition may render the body more accessible to pesticides by weaking natural barriers such as skin ,respiratory epithelium and GIT mucose.Hence pesticides enter the blood stream more quickly and in large quantities enhancing their toxicity.

Vitamin A and C deficiences affect the integrity of the skin and its vascular system,proteins,niacin and linoleic acid deficiencies cause skin lesions, deficiency in B group of vitamins affects the skin ,mucous membranes and mucocutaneous junctions of eys ,nose and mouth,Vitamin deficiency makes the epithelial linning of the respiratory tract more permeable ,chronic malnutrition affects ,the GIT in general and especially its absorptive function,leading to uninhibited and unconjugated absorption of pesticide directly into the blood stream.

Pesticides may infuence the dietry and nutriional status by the decrease of appetite,induction of weight loss,alteration of nutrient requirements and affect micro and macro nutrient storage sites such as the liver..

Furthermore,they may affect specific metabolic pathways,increase excretion of nutrients or their metabolites,compete for a specific blood-binding site of a micro nutrient (a pesticide may require a protein fraction such as albumin as a carrier and displace vitamin A,-bind with any moiety of nutritional significance (dieldrin binds with hemoglobin and albumin),trigger a metabolic effect which increases the risk of disease (DDT induces hyperlipoproteinemia as it is transported in low density lipoproteins, may injure the microsomal fractions necessary for enzyme induction,which in turn are required for metabolic and detoxifying processes,and be distribution in organ systems which have nutrient digestive,utilization,absorption and excretion functions(i.e. dieldrin is excreted into bile and pancreatic juice,which may then influence dietry nutrient absorptions

Pesticide toxicity is minimally increased at one-third normal dietary protein intake, but is markedly increased for carbaryl,parathion,and

and captan at one -seventh that intake, below one-seventh the toxicity of heptachlor and dimethoate is unchenged.The susceptibility to the toxic effects of lindane was doubled after reducing casein intake and inducing growth stunting in rats.On the other hand,increased protein intake affords protection against pesticide toxicity as was observed for dieldrin and DDT.The peoples who are exposed occupationally to pesticides have altered plasma amino acid concentrations.Dieldrin increased urinary phenylalanine by 50% and alters the concentration of ten other amino acids.

Organochlorine pesticides being soluble in adipose tissue are mobilized during weight loss and starvation leading to elevated plasma,renal and hepatic levels.

The potential of metabolic hazards induced by pesticides periodically leaking into the circulation during weight loss are to considered,especially with starvation,preoccupation of weight loss and significantly during pregnancy and lactation with the risk of cross contamination to progeny.

Vitamin C deficiency significantly impairs o-methylene induction and stimulation of glucuronic acid system by DDT and DDT like pesticides.Dieldrin causes the reduction of microsomal enzymes when vitamin C deficiency is induced.

DDT ,chlordane,lindane, toxaphene, methoxychlor,and dieldrin reduced liver content of vitamin A.It is hypothesized that vitamin A deficiency may increase the toxicity of pesticides.

Chlorinated hydrocarbons pesticides,mainly DDT and its metabolites interfere with calcium absorption and metabolism by disrupting the function of vitamin D mediated intestinal calcium absorption.

1- *PESTICIDE RESIDUES IN FOOD STUFFS IN EGYPT:*

Now measurable amounts of pesticide residues in our food present a variety of problem .More than 1000 samples from food stuffs were collected from 11 governorates (Alexandria, Behera ,Gharbia ,Dakahlia, Sharkia ,Kafr El-Sheikh,Kalubia,Monofia,Cairo,Giza and El-Fayum),to be analysed for pesticide residues.Unacceptable residue levels of pesticide residues were detected in 100%,85.7%,81.8%,80.0%,66.6%,63.0%60.0%,50.0%,50.0,36.3 and 24.6% of the samples from Cairo, Behera, Gharbia, Kafre El-Sheikh,Dakahlia ,Sharkia, Giza, El-Fayoum, Alexandria ,Monofia and Kalubia respectively.(**Abdel-Gawaad,A.A.and A.S.El-Dine 1989:THE STATE OF HUMAN HEALTH AND ENVIRONMENT IN THIRD WORLD:1-Pesticide residues in food stuffs.J.Egypt.Soc.Toxic vol 5,49- 52.,Ibid:Insecticide residues in total diet samples:J.Egypt.Soc.Toxic.4:79-84).**

2-*PESTICIDE RESIDUES IN IMPORTED FOOD*

The level of pesticide residues in various imported diet samples,randomly collected from different parts of Egypt were determined.Most of the tested products contained organochlorine insecticides i.e. endrin,dieldrin,DDT,lindane and traces of some unidentified compounds.The levels of these residues in some products were higher than the FAO/WHO maximum residue limits.Particularly,the level was higher in the case of endrin and DDT in cereal grains,endrin in dried milk and DDT in frozen liver.However,pesticide residues in most of the analized samples were within acceptable level:(**Abdel-Gawaad,A.A.and A.S.El-Dine 1989:THE STATE OF HUMAN HEALTH AND ENVIRONMENT IN THIRD WORLD:1-Pesticide residues in food stuffs.J.Egypt.Soc.Toxic vol 5,49- 52).**

3-*PESTICIDE RESIDUES IN TOTAL DIET SAMPLES:*

Pesticide residues were detected in total diet samples randomly collected from Cairo.More than 23 pesticide residues and their degredation products were detected by GLC. Endrin,dieldrin,lindane and total DDT were the main residues detected in most samples.The amount of pesticide residues consumed by the average person in the average diet was calculated.Results indicated that the feeding habits and behaviour of the Egyptian people play an important role in their daily intake of pesticides residues.High quantities of drinking is the continued use of some highly persistent pesticides whose use has been prohibited in most other countries,and are reputed to have cancer producing potential.

This study is an attempt to explore the possible carcinogenic risk of the excessive use of pesticides in Egypt.The amount of pesticides used in each governorate in Egypt since 1952 and cancer deaths since 1964 were collected from the archives of the central Agency for Public Mobilization and Statistics.

Data indicated that most of the pesticides used till the mid sixties were chlorinated hydrocarbons.There was a steady increase in the cancer deaths in Egypt which followed the increase of use of pesticides.Such increase was more prominent in the governorates where the use of pesticides was more than others.

In these cases the cancer death rate was more among villagers than among dewellers and in both cases,the cancer death rate was more among males than among females.These data could point out to the fact that the cancer death rate was higher among those who are ocupationally exposed to pesticides namely male villagers.

The increase in the number of death cases by kidney and liver failure is clear now in Egypt and mainly can be attributed to water and food contamination by Agrochemicals.(**For mor details,E.Ezz and A.A.Abdel-Gawaad 1985: Possible carcinogenic risk of pesticides in Egypt.2nd Int. Cong.Soil Poll. and Prot. from Pest.Residues.PartII,87-108.**

Other Toxic agents in Food:

Food processing becomes of increasing importance as the distance between producer and consumer increases and renders the consumer more dependent on the food-processing industry.There is increasing public concern about the safety of chemical additives in food,but little evidence that in general they represent a significan risk to human health.The public often forgets that traditional food preservation usually involves the use of chemicals.Many colours and flavours as well as antioxidants and antimicrobials are synthetic duplicares of natural substances.

A number of chemical substances may occure in the food supply owing to contamination,environmental or otherwise,and their effects on health may be serious.For instance,lead-soldered food can may contain food with higher amounts of lead that in raw commodities and unsoldered cans.

The continued release of persistent toxic elements such as cadmium and mercuy into the environment will inevitably lead to rising levels of these substances in various foodstuffs and eventually to levels that may be harmful to human health.

Micotoxins causes serious adverse health effects in human being in Greater Cairo..Epidemiological studies show a strong correlation between high incidence of liver cancer and the exposure of the population to aflatoxins.Studies suggest that aflatoxins in food and hepatitis B virus are co-carcinogens and that the probability of liver cancer is high in Greater Cairo ,where both are prevalent.

Case Study

Hazards of Pesticides

Amr et al 1992 reported that ,the different hazards of pesticides to which individuals are exposed include aplastic anemia ,red cell aplasia ,leukemias and mutagenic susceptability.The study was conducted to detect any subtle haematologic and chromosomal changes at any early phase especially in the group with a history of prolonged exposure.

The study was conducted on 1000 male workers with a mean age of 47.2 years and with different durations of exposure to various forms of pesticides during their formulation..A control group of 15 normal and apparently healthy subjects who had never been occupationally exposed to pesticides were investigated similarly as the exposed group.The studies groups had been subjected to different investigations,full blood picture,cytochemical studies,and chromosomal analysis through detection of chromosomal aberrations and detection of sister vhromatid exchange.

This study showed a significant increase in chromosomal aberrations among the exposed group of subjects compared to the controls irrespective to the duration of exposure ,age,or smoking habit.Through 11 cases out of 84 workers were considered to be hypersensitive and liable for mutagenic chages.

The study recommended routine chromosomal analysis for each worker engaged in pesticide formulation during the first few years of work.,Hypersensitive individuals should be transferred to other occupations not chronically exposed to pesticides.

Case Study

Level of heavy metals in Blood

El-Samra et al 1993 reported that a study was conducted on Egytians not occupationally exposed in Greater Cairo and on farmers from Mounofia Governorate in lower Egypt and Beni-Swef in upper Egypt as rural population.The aim was to estimate levels of lead ,cadmium and manganese in hole blood.

The total number of the examined population was 825 sbjects of both sexes,aged between 7 to 60 years,and of different socioeconomic standards and habits.Investigations included blood analysis for lead,cadmium and manganese levels.

The results show that lead ,cadmium and manganese levels of non-exposed Egyptians ranged from 13.25 to 65.84 ug/dL,0.12 to 1.16 ug/dL. and 0.09 to 4.22 ug/dL with a mean of 27.87 ,0.515 and 2.436 ug/dL ,respectively.

Of the whole group 12.12% of them have a lead blood level less than 15 ug/dL.,28.85% of them have a blood lead level ranging from 15-25 ug/dL. ,while 59% of the total have blood level greater that 25 ug/dL., the highest level was 65.84 ug/dL.

In the case of manganese,26% of the whole sample have blood manganese level ranging from 0.09 to 1 ug/dL.,42% of the whole populaton have blood manganese level ranging from 1 to 2 ug/dL.,and 32% of the total have blood manganese level more than 2 ug /dL.The highest level was 4.22 ug/dL.

Egyptian non-exposed smokers have a significantly higher lead and cadmium blood levels compared to those of non-exposed Egyptian non-smokers (32.503 and 0.814 ug/dL. versus 29.2o4 and 0.424 ug/dL. respectively even female smokers have a significantly higher blood cadmium levels compared tothat of non-smoker's females(0.694 versus 0.403 ug/dL.).

The study results show that there is a direct relation between the number of packs smoked during the whole life and mean blood cadmium level,compared to that of the non-smokers (0.692 versus 0.424

ug/dL.).On the other hand ,the results show that neither sex ,age ,nor smoking have a significant effects on blood manganese level.

Children in this study were 134 child aged 7 to 12 years.Their main lead,cadmium and manganese blood levels were 22.113,0.41 and 2.145 ug/dL.,respectively.Urban children in the presen study ,have a significantly higher mean blood lead level copared to that of rural children (22.203 versus 19.565 ug /dL). In case of cadmium and manganese,there was no difference between urban and rural children.

Egyptian non-exposed males have a significantly higher blood lead and cadmium levels (29.462) and 0.616 ug/dL.) compared to the non-exposed Egyptian females (27.498 and 0.447 ug/dL.).

Non exposed urban population have a significantly higher levels of lead,cadmium and manganese,compared to the rural non-exposed subjects (29.69 % ,2.411 and 1.411 ug /dL. versus 26.73,0.482 and 2.209 ug /dL.,respectively

The results show that there is a direct correlation between age on one hand and blood levels of lead and cadmium of the non-exposed males and females ,on the other.

Side effects of foodborne diseases:

Besides their acute effects ,fooborne diseases may also cause other serious health problems.Diarrhoea experienced over a period of time can lead to undernutrition which ,in severe cases ,may cause impairment of the immune system,thus waking the body's resistance to further attacks of diarrhoea and other infestious diseases.Some foodborne diseases,listeriosis and toxoplamosis diseases are particularly dangerous during pregnancy as they can be fatal to the fetus,or may cause severe deformation.

Some foodborne infections may lead to chronic conditions such as joint disease,immune system disorders,heart and vascular diseases disorders of the renal system and possibly even cancer.

Food and drinking water are frequently contaminated in Greater Cairo with pathogens.Lack of basic sanitation in most of the arround areas of Greater Cairo,and the use of Sewage drainage to cultivate vegetables arround cairo are the main source of pathogenes into the food -chain.

Fore the majority of foodborne diseases their etiology and mechanisms for their prevention and control are well known.However,this knowledge is 0ften not applied in practice,even by the health professions,and large sections of the public remain ignorant that diseases such as diarrhoea,hepatitisA and poliomyrlitis are to great extent foodborne

The problem of food contamination as well as the growth and survival of foodborne pathogens,is further aggravated by lack of knowledge about basic food safety measures,lack of fuel for cooking and inappropriate food sorage facilities.

According to the absence of the official food control infrastructure (legislation and enforcement mechanisms) as well as the voluntary control measures implemented by the food processing industries have contributed greatly to the unsafety of food suply.

The life styles has been changed greatly in the Greater Cairo.Mothers do not bear the entire responsibility for the

preparation of the family meals.Methods of food preparation that in the past ensured the safety of the food have disappeared in recent years.Food street is famous,where the food is prepared in advance in large quantities and where food-handlers are unaware of the special precautions required under such conditions.The lack of education of food-handlers is actually a worldwide problem that concerns both domestic as well as professional food handlers.Many of the foodborne diseases that occur are due to errors in food preparation or lack of personal hygiene on the part of the food-handlers.Their lack of knowledge,and the use of raw food materials that already cntaminated,increase the risk of cross-contamination and proliferation of microorganisms in food.

Also international trade in food and animal feed also plays a major role in the spread of contaminants .Some strains of salmonella have been introduced in Greater Cairo through imports of contaminated feeds of animal and vegetable origin.Animals given these feeds have in turn contaminated the environmrnt (soil,Nile river,surface water,wild birds and animals) and their faeces.Since then,the microorganisms have established themselves widely in the environment,including domestic and wild animals.

veterinary pharmaceuticals have been a key element in increasing animal productivity.High quantities of vaccines and therapeutic drugs have been used in Egypt for animals which are under more stress and are more at risk from communicable diseases

As a means of intensifying meat production,use is made of growth promoters.Hormonal anabolic agents are widely used in Egypt for promoting growth specially in poultry

Thyreostats are still in use and primarily cause an increase in water content of the intestines and the musclemeat,which results in fraud with low quality animals and unfair trade.

Food additives:

Environmental chemicals:

A number of chemical substances may occur in the food supply as a result of environmental contamination.Their effects on health may be extremely serious and have caused great concern in recent years,specially for street foods.

Serious consequences have been reported when foods contaminated with heavy metals such as lead ,cadmium or mercury have been ingested over extended periods of time.Lead affects the haematopoietic ,nervous and

renal systems..When lead pipes or lead-lined water storage tanks arc used,the lead exposure from drinking water is appreciable .Similarly,food in lead-soldered cans may contain significant amounts of lead.
Fish are the major dietry source of heavy metals (specially mercury and pesticides..

Case Study:

Evaluation of COSHARY as a safty public food:

Abdel-Gwaad et al 1993 evaluated Cosharry, the second public food in Greater Cairo.as safe food.The primary estimations show that there is in Greater Cairo about 5000 seller for this type of public food most of them are Hawkers or Pedlars.The number of Coushary shops in Greater Cairo are more that 423 shops.This public food is made from rice (75%), Lentil,(17 %),Macaroni (6 %) ,onion (1.4 %) and some of tomato soup.The students in the schools and the workers out side the factories and peoples out their work prefere to eat this low in prize food The main health risk problem from this type of food is the impact of environment polltants on it.This food normaly is cocked in large quantities to be sold all over the day,encouraging microorganisms to increase to its high levels after 6 hr.The second Health risk problem is that most of the seller of this food use the crowded streets to sell this product.High quantities of dusts and heavy metals find their way to this food which has no cover.The third and important Health risk problem is the hygienic factor.These seller are out of control from hygeinic view.Most of these peoples have no hygeinic certificates.They paly and important role for the distribution of microbes through a large numbers of chilren,workers and public peoples,through this un covered street food which is highly contaminated with lead ,dusts ,house flies and micoorganisms.These peoples play also as important role in distributing many diseases through their behaviour in washing all the plates and spoons in one container all over the day.Data in table ....1....show the heavy metals levels in this public street food all over the Great Cairo.It is clear that lead headed the other heavy metals in all samples.There was a good corelation between the heavy traffic streets than in the low traffic ones.

While table ......1.....show clearly the total numbers of microorganisms which were found in samples taken from random streets in Greater Cairo.Results clearly indicated that samples in squatter or slums areas contained high numbers of microorganisms than in the other areas.Samples which were taken early in the orning contained microorganisms lower than samples taken in mid day or at night.Samples which were taken in summer were highly polluted when compared with the others in winter.

Samples taken from high standard shops were some what free from high concentration of lead and heavy metals. The total numbers of microorganisms through all the seasons were nearly the same and in all cases less than their number in the samples which were taken from Street Hawkers or Pedlars..

The fourth high task problem is INDOOR POLLUTION :

Any person passes 2/3 of his life inside some sort of a building ,so an unsanitary building can affect the health as follows

1- Over crowding resulting in:

a- increaed incidence of diseases transmitted by droplets starting from common cold up to T.B.

b-Increased incidence of diseases transmitted by contact ,especially skin diseases such as scabies and hementic diseaeses such ss ring worm.

c- Increased incidence of diseases transmited by insects such as flies and lice

d-Mental and social strain.

2- Insufficient illumination and lack of sunshine result in:

a-Increased incidence of Rickets in children,which is a typical slum disease.

b-Increases incidence of accidents

c- Mental strain.

3-Increased dampness inside houses resulting in:

a-Increased incidence of rhumatic affections,especially in the heart.

b-Destruction of the building itself by time.

4- Lack of safe water supply and sanitary disposal of sewage and refuse resulting in :

a-Increased incidence of intestinal diseases ,starting from diarrhae up to cholera.

b-Other much as addiction crime,delinquency which are always associated with slum area.

The height of the house should not exceed 1.5 times that of the width of the street to allow free circulation of air penetration of sunshine and to prevent overcrowding in the street.

The height of the ceilling should be at least 2.7 meters ,the surface area of the floor of any room should not be less than 4 sq.meters.

Side by side and back to back buildings ,should not be allowed,but most of the buildings in the slums and squatter areas are side by side and back to back buildings.

Indoor pollutants varied greatly from place to place in each of the 76 squatter setlements in Great Cairo.Indoor air pollution constitutes amajor health risk and comprises combustion ,such as N0x, CO,CO^2 ,respirable in Slums areas particles ,soot,smoke NH^3,formaldehyde,methan...etc.The

main pollutants fall into two main classes,organic and inorganic chemicals and 90% is based on petroleum and and natural gas.,while in the overcrowded areas and in Industrials areas the main pollutants are dusts ,gases and organic matterials and inorganic oxides.A variety of chronic diseases have been related to miscellaneous contaminants expoures(asbestos-related diseases,ciment,arsenic and lead intoxication,carbon monoxide poisoning ,benzene,arsine and phosphenehaematological effects...etc).

Oil fuels are widely used in most of the houses all over great Cairo,and several millions are regularly exposed to potentially harmfull emissions.The production of sulfur dioxide ,carbon monoxide,smoke, hydrocarbons contaminate indoor air.It is estimated thet exposure to pollutants is 4o times greater in slums areas than in modern parts in Greater Cairo.In these areas,girls and women inhaling larger concentrations of pollutants over long periods than men.Chronic effects include inflammation of the respiratory tract caused by continued exposure to irritant gases and fumes.

In most of the squatter areas people use a high quantities of pesticides to control high population of house flies ,mosquetoes .flees ...etc.the accumulation of these pesticide residues in their bodies is an additional health problem for these peoples.

Also in these areas a high quantities of particulates are available in indoor air.Dust in Indoor air causes respiratory tract diseases,chronic brochitis and emphysema.

In a recent study by Salem 1990,thirty three mite species were found inhabiting in house-dust,Tables from 1-36...Fifteen samples of house dust mites were collected monthly from houses of both healthy people and from houses of people suffereng allergy inGreater Cairo..In the case of patient people ,27 mite species aere xtrated .In the case of healthy people ll mite species were collected.Fifty eight patients (58%) out of one hundred patients showed positive skin reaction to mite and dust.

Fifty five patients were positive to Tyrophagus sp. ((45%).Fifty patients were positive to flock dust (86%).Thirty three patients were positive to mixed house dust (56.8%).The most common species of mites which were collected from house-dust of patients with bronchial asthma were *Dermatophagoides farinae* and *Tyrophagus putrescentiae*.,tables (27-29).

Nine cases (18%) out of 50 normal cases gave skin mitereaction.Nineteen cases (42.8%) out of 42 patients with negative skin reaction showed blood eosinophilia more than 500 cells /cmm.

While thirty patients (51.7%) had blood eosinophils more than 500 cells/cmm out of 58 patients with positive skin reaction.

Case Study.

Indoor pollutants

Ali 1992 (**Source** AliE.A. :Combusion air pollutants in Cairo houses,Egpt.J.of Occup.Medicine,16.2.141-146) reported that ndoor air quality with reference to combusion generated air pollutants was examined in some Cairo houses representing different incomes.These houses are equiped with various appliances using gas and kerosene.Investigated pollutants include nitrogen oxides ,carbon dioxide and smoke .Pollutant concentrations sometimes found to exceed air quality standards .For example nitrogen dioxide exceeded the 100 ug/m3 recommended limit for outdoor air.Furthermoe ,houses equiped with kerosene cookers were the most polluted premisies.Pollutant concentrations decreased with distance from the kitchen.Morover ,better ventilation was found to greately improve indoor air quality.,table 1 and 2.

Nearly same results were obtained by Ali 1989 (**Source Ali,** O.F. ,El-Sayed El-Sherif,M.A.El-Sherif and Saad N. Motawea:Indoor Air quality and human exposure assessment in an Egyptian village).E.J.of Occup.Medicine 13.2:161-170.) but in rural areas like the squatter settelements arroun greater Cairo.Table 3 shows marked increase in indoor /outdoor concentration of air pollutants in the houses exposed to biomass fuel emissions than the non-exposed houses using gas stoves in cooking.Table 4 presents results of measurements of indoor air quality in the houses using biomass fuel and those using gas cook stoves.,Figure 1 illustrates a ange of CO_2 concentrationbetween 400-700 ppm in houses using gas stoves while it reaches a value of 3700 ppm in some houses cooking with biomass fuel.While figure 2 shows peak values of NO_2 and NH_3 concentrations to be 0.42 and 0.99 ppp in homes using biomass fuel while the maximum concentration detected in the cotrol households were 0.02 and 0.14 ppp respectively.

Table 5 shows significant dfference in prvalence of health problems between women using biomass fuel and those using gas cooking stoves.Problcms related to child bearing such as repeated abortions,neonatal deaths and low birth weight babies were more frequent .Also respiratory infections,asthma and eye infections were more among group exposed to biomass combustion

Foreign body in the eye cataract ,muscle cramps ,fainting and burns were only reported among biomass fuel users.
Table 6 represents the health effects of exposure to toxic roducts among preschool children .Respiratory infections,asthma,fever and eye infections were significantly higher.
Convulsions and burns were observed only among children living close to fire place and cooking oven.

The fifth Higher risk problem is **Cairo Wastes:**

Garbage collection services are inadequate in most of 76 squatter settlement in Greater Cairo,except in the modem areas. It is estimated that 40 % of domestic wates,table 1 in modern areas is left uncollected .While in most of the aquatter settlement not less than 60% of the generated solid wastes is left uncollected.In some slums areas about 90% of the generated garbage is not collected.It accumulates on streets and in the open spaces beteen houses ,causing serious health problems.One of these serious problem is the increase of wild cats and dogs in all the streets in which these wild animals find enough food to live,causing some serious health problem.

Mean numbers of cats and dogs in the streets in greater Cairo:

	Mean No. of Cats / street	Mean No. of dogs / street
Garden city	3.2	2.4
Shoubra	6.1	7.2
Ein Shams	7,2	9.1
Sayeda zeinab	2.9	4.6
El-Maadi	1.9	3.6
Imbaba	7.3	10.5
Helwan	2.8	5.3
El-Zabalin	8.9	18.3
El-Haram	3.2	4.9

The second serious problem from these high qantities of garbage in the streets is the increase of house flies dencity which infest the Egyptian peoples by more than 42 diseases.The population of house flies,tables ....2..... in the modern parts of cairo is higher than the accepted dencity proved by WHO.The pollution dencity in some slums areas increased to be more than 40 times which is accepted by WHO.

From this problem another serious problem raised,this problem is the extensive use of pesticides to control medical insects.Each familly all over Cairo used a high quantity of pesticides. The residues of these pesticides which accumulate in the bodies of the Egyptian people causing serious health problems.

Beside this serious problems ,peoples prefer to burn these garbage in the streets to avoid their side effects.This behaviour increases outdoor and indoor air pollution by suspended particulate matter,carbon monoxide, nitrogen and sulfur oxides ,hydrocarbons,aldehydes,phenols,hydrocarbon compounds...etc.

Greater Cairo produces every day about 6000 metric tons of garbage /day or 2.2 million metric tons/year. It is expected that these quantities will be increased to be 8250 metric ton /day and 2.1million tons /year at the year 2000.,the distribution of garbage all over the Kisms in Greater Cairo is tabulated in tables....1.

Air pollution in Greater Cairo.:

Almost 60% of air pollutants in the modern parts of cairo (only 16%) of Great cairo are contributed by vehicular emmissions,aggravated by the use of lead -containing fuels ,poorly maintained vehicles and long life of vehicles.Air pollution from motor vehicles is caused by gases escaping from the combustion chamber to the crankcase ,gases emitted from the exhaust pipe ,and evaporation losses from the carburettor and fuel tank.

Although transportation accounts for 5o% of the total energy in use in Great Cairo,Exhaust from automobiles produce the same quantities of air pollutant at the industries which are located in two indusytrial areas ,one in Helwan and the other in Shobra El-Khema.,In Greater Cairo 1,039,485 cars move in the streets of Greater cairo and most of them concentrated in the center of the city .especially in Ramsis square and Tahrer Square.Industry used in the forementioned areas 1.3 million tons of Petrol ,and in the same time Cars in Egypt use 1.2 million tons of petrol.In Greater cairo 126 factories are concentrated in the two industrial areas and pollute the Greater Cairo atmospher with hundred tons of Aldehydes,carbon monoxide,hydrocarbons,oxides of netrogen,oxides of sulfur ,organic acides ,particulates and lead oxides.

Automobile exhaust is usually identified with the presence of carbon monoxide ,a product of incomplete combustion that reduces the body's ability to transport oxygen into tissues with lead ,which increases the burden of this metal in one's system and with hydrocarbons,some of which are cancer producing.Numerous additives such as antioxidants and antiknock compounds and detergents ,give gasoline special characteristics.

Other major contaminants emitted by automobiles are nitrogen oxides.They are harmful not only by themselves but also because they produce photochemical smog by their interaction with hydrocarbons under the influence of sunshine,ozone one of the most dangerous contaminants ,is produced in this manner.Automobiles also emit carbon particles,oil and nonvolatile products derived from motor oil.A plastic bag held to the tail pipe of an idling car to catch the exhaust yielded more than 100 trillion particles per second.

STUDY CASE

Air Pollution in different part of GREATER CAIRO

Air pollution in Down Town::

Air pollution in down town is at least three folds the maximum permissable international limits in most major large cities and industrial areas.There are great differences in air pollution in the Greater CairoThis part of Cairo is the only highly polluted part because of the high intensif of Trafic.Internal combustion based equipment consume oxygen,and add carbon dioxide ,if incomplete,carbon monoxide is also added as well as a host of organic and inorganic pollutants.These includesheavy metals such as lead(due to the use of leaded fuel),cadmium,sulpher and nitrogen dioxides and a variety of organic pollutants depending on the extet of combustion..The situation and its effect are worsened by the environmental conditions in this part,the climatic conditions prevailing in Egypt,mainly low surface wind speeds(which is lowered further by unplanned construction of buildingd),low rain fall (o to 5 ml month average),and high temperature (27+ 7 Co monthly average),lake of the destruction of existing plant life that consumes carbon dioxide,and liberates oxygen,industrial emmission that is upwing tto Greater Cairo,and social and economic problems and lack of public participation.
The total numbers of vehicles moving in Egypt are 1.616.363.Of this high quantity,28.76 % are moving in Greater Cairo,(Please see Tables NO 1,2 3 , and 4 .
Official data showed that the average TSP,Smoke,SO2,No2,Ozon,Co (street level),Lead in Cairo center is higher than the same averages in residential ,industrial areas. (table 5).Results indicated that some levels are more higher 10 times than the standards of Egypt.
While Table (6,8) indicates that the concentration of heavy metals in center of Greater Cairo was were very very low if compared with the industria areas tested.These informations is based on air quality monitoring program run by the Mionistry of Health.

Nasrallaet al 1992 reported the Cairo urban air is heavily polluted with suspended particulates reching more than 24 h air quality standard during 100 % of measured days This TSP concentrationwas found to be associates with sulphur dioxide concentrations of about double the WHO annual recommended limit of 53 ug/m3.Moreover the rate of total sulphation reached a maximum value of 39.8 mg/100 cm2 30 d during Sept 1989.This work was conducted in 6 districts in Greater Cairo,These districts are Dokki (site 1),Attaba square (site 2),Monira (site 3),Heliopolis (site 4),Nasr city (site 5), and Imbaba (site 6).,Table 9..10 shows seasonal concentrations of total suspended paryticulates and investigated compounds in Cairo atmosphere,ug/m3 ,19990.While table ....shows the rate of total su;phation .

Emara et al 1990 reported that five hundred and and five traffic policemen ,busdrivers and garage mechanics from Greater Cairo,were examined.Examination included ful history taking,clinical examination of heart and chest,electrocardiographic recordings,pulmonary function tests and estimation of blood lead and carboxyhaemoglobin.The results in tables .....9.-..19..... show that the frequency distribution of chronic non specific respiratory diseases (CNRD) and cardiovascular diseases increase with age,duration of employment and in smokers.Hypertension and ischaemic heart diseaes increasedsignificantly with age,for policement.The same was observed beteen Ischaemic heart diseases and dration of employment,in policemen also.A directly proportional relation was found between isachaemic heart diseaes and carboxyhaemoglobin levels,the same was found between hypertention and blood lead levels.The results of ventilatory function tests showed that FVC% was unaffected,while FEV1 % was reduced in the examined group.There was also a directly proportonal relation of blood lead levels wioth duration of employment as well as carboxyhaemoglobin levels with both duration of employment and smoking.Smoking proved to play an important role in development and frequency distribution of cardiovacular and respiratory disorders,it also influenced carboxyhaemoglobin levels. Policemen group was themost affected ,if compared to drivers and mechanics in all the studied paramiters.

Investigation of autoexhaust pollutants around cairo-Alexandria highway was conducted by Ali 1990.It has been found that the concentrations of gaseaous pollutants such as carbon monoxide,nitrogen oxides and sulphur dioxide were dropped with distance from the road faster than lead particulate possible due to the floating dust.Figure ...1.... shows the variation of pollutants concentrations with distance from the edge of the road,while figure 2...shows the pollutant concentrations at different distances expressed at percent of their concentrations at the edge of the road.

Air pollution in Helwan:

STUDY CASE

Official data show that the level of ,smoke ,SOx and N0x Ozon.C0 and lead are lower in their levels than in Helwan. Only TSP levels were more than in the centre of cairo.,while the depositions of heavy metal were more than their deposition in the center of Cairo.

Nasralla et al 1985 studied air pollution in Helwan at different distances around Helwan Cement stacks.High levels of pollution which can cause damaging effects on health ,soil and vegetation were recorded in the surrounding areas.Physical models were used to predict concentrations of pollutants downwind (Helwan cement industries.Results indicated thet NO^2 concentrationsexpressed as ppm NO^2 at distances from 300 m to 2 km downwind of kiln were varied considerably from day to day and from location to others.The recorded concentrations were in the range of 0.03 ppm to 0.25 ppm.These concentrations are within the limit of air quality standards of 0.2 ppm set for 30 minutes.,but still higher than the 0.05 ppm N0x ,the annual quality standard.

Concentrations of SOx downwind kiln stacks during period of measurement were raning between 80 ug/m^3 to 460 ug /m^3 (3o minutes average).(Table .....shows the maximum predicted concentration of SOx

.

Tables ..1.. ..2 &.3 shows the measurement values for suspended particulates ,where recorded concentrations reached more than 10 times any standards set to protect residential industrial areas.This is confirmed by the 30% depletion of incomimg solar radiation over helwan areas

Table (2) shows the measured values for suspended paticulates where recorded concentrations reached more than lo times any standards set to protect residential industrial areas.It is confirmed by the 30% depletion in incoming solar radiation over helwan area.Tables...3.. shows the predicted paticlate precipitations downwind Helwan stacks while table .4.shows the recommended buffer zones around Helwan cement companies.

Experiments was conducted to study the effect of exposure to cement on development of degenerative changes on conyunctiva whether directly in industry or indirectly through air pollution.

The study of Khalil et al 1987 was conducted to studythe effect of exposure to cement on development of degererative changes on conyncyive whether directly in industry or indirectly through air pollition.A total sample of3625 were submitted to conjunctival examination ; 2o51 exposed of 26 non exposed workers ,970 exposed and 340 non exposed inhabitants .The degenerative changes were detected among 87.5% of exposed versus 1202% of non-exposed workers and among 4506 % of exposed vesus 1105 % of non exposed inhabitants.The significance of occupational expsure to cement dust on development of degenerative changes of conjunctive of exposed workers and inhaitants was stressed through comparison betweeen the different studied groups..Tables .1,.2 and...3. show the degenerative changes of conjunctiva among exposed cement and non exposed control workers and the degenerative changes among cement workers according to years of work.All family members of cement workers aged 9-65 years attending the factory outpatient clinic for non ophthalime complaint during the period of the study were examined for conjunctival degenerative changes.The family members were classified according to residence into two sup-groups:1-Those living within the near by area of cement factory (970) and who were indirectly exposed to cement dust through atmospheric pollution by the factory chimney wastes.2- those living away from the pollution risk area (more than 20 km (340)Results in table .... show the degenerative changes of conjunctive among exposed and non exposed families.

High prevalence of conjunctival degenerative changes was found among the directly exposed workers (87.8 %) to in cement factory and the indirectly exposed inhabitants through atmospheric pollution (66.4%).

A survey in areas close to cement industry in helwan has shown that 29% of school chilren suffer from lung diseases compared to 9 % in rural areas.

The mortality rate due to chest diseases in Helwan area is 19% for all classes .

The main sources of air pollution are high sulphur heavy fuel used in power generation and in some industrial processess.In complete combustion and emissions of heavy metals such as lead from and in efficient transport sector.,and specific industrial processes.

From 8.5 million metric tons of heavy fuel (Mazot),consumed by power plants (47 % ,Public Industry 15% ,Private Industry, Commercial and housing, Helwan consumed 3.9 million metric tons.

From Natrual Gas,Industry used 6.6 metric tons /year.Power plants consumed 64% ,Public Industry 21% and Private industry ,commercial and housing used 15%,while Helwan consumes 2.3 million metric tons, The industry consumes about 0.3 mt E Diesel fuel.The Commercial and housing sector consume 2.4 mt E kerosene and 0.8 MT E Butagas per year.Where is a minor industrial consumption of secondary products 0.9 MT E and Coal 0.1 MT E.Mazot contents of sulphur is very high 2.5-2.8 % and diesel 1.2%

The three cement plants (Tourah ,helwan and National) in the Helwan areas emit large amounts of dusts.The present estimation of dust is estimated to be 2 million metric tons /year

Side effects of air pollution by Cement in Helwan:(Study Case by Abdel-Gawaad 1990.

Health Risks in the highly polluted areas (Industrial areas):

1- Health risks in Helwan:

For the public living and working ouside the factories gates,in Helwan,the health risks vary consideralbly,depending on the distance from the factory,the relationships with the factory workers,and susceptability to pollutants ..For instance,workers families may be subject to high levels of exposure to hazardous substances ,such as lead,iron,asbestos,cement...etc,brought home on workers clothing .Infants and children may particularly at risk because of their greater susceptability.Exposure is often higher for people who live close to the factories or make use of water sources contaminated by industrial wastes.

Industral pollution has many indirect effects .Industrial liquid wastes for instance pollute the Nile river in this part of Cairo,by 750 kg heavy metals per day=278 metric tons of heavy metals per year.These high quatities of heavy metals which find its way to water sources in this area reduced fish catches and pollute fishes with heavy metals,

In Helwan most of the areas arround the Cement factories ,are used as main dump for many thousands tons of pypass.

Certain industrial and institutional wastes are catagorized as hazardous or toxic because of the special care needed for their storage and disposal to ensure that they are isolated from human contact and stored in ways that prevent them from contaminating the human environment.

The nature of hazardous wastes varies greatly in Helwan according to the type of industry,some are highly fammable ,others are highly reactive,others are pypass,others are meneral oxides...etc.It is calculated that more than 5000 metric tons of these materials are concentrated arround these factories.,

The nature ,amount and the wide distribution of these hazardous materials and their potential danger to health did not attract the attention of the decisson makers until now.Most of the wastes have been dumped arround this area without control,and without any attention that these wastes can pollute the air and water resources in this area..The cost today of having to deal with the result of many years of inadequate control run into thousands of million of L.E.

Other example of the careless disposal of industrial wastes is water pollution by heavy metals.Cairo only pollute the water resources by 278 metric tons of heavy metals /year,93 metric tons of oil / day or 33945 metric tons /year and 35000 tons of T.S.M/ year.

Many health problems affecting poorer groups living in these areas in overcrowding situation.,these are associated with overcrowding,airborn infections,acute respiratory infections,pneumonia and tuberculosis.

.These cement factories use the sky as dump for 2 million metric tons of cement dusts.

In this part of Greater Cairo,there are a large number of slums settlements,.the most of thes settlemnts are new and were appeared over the last 3o yearsThe infrastructure and services in these settlement are very poor.

Air pollution in Shobra El-Khema:

STUDY CASE

Ali 1990 studied air pollution in Shobra El-Khema.The studied pollutants were sulphur dioxide,smoke and particulate.Sulphur dioxide annual mean concentration reached 0.08/L ppm.Maximum concentrations of sulphur dioxide were recorded during summer months contradicting those reported in European cities.Smoke concentrations reached an annual mean concentration of more than 150 ug /m^3.The background rate of dustfall over a control site was 14 g/m^2. 30 d.,This rate of dust precipitation reached 76 g/m2 30.d over the heavy industrial sector close to the Ismailia canal.Tarry matters reached their highest concentrations in dustfall over the heavy industrial sector during sumer months.Data in table ....1.... shows significant concentrations of sulpur dioxide and smoke found in Shobra El-Khema . ___1.. Data in table ..2..shows the dust precipitation in the same area.Table ..3...shows the seasonal variation in chemical composition of dustfall over Shobra El-Khema:

HEALTH RISKS ON THE NEXT GENERATION:

The infant and yound child have different structural and functional characteristics from those of the older child and adult.These represent stages in normal growth and development and may affect their vulnerability when exposed to chemicals.they include:

Larger body surface area in relation to weight,higher metabolic rate and oxygen consumption and hence greater intake of air per unit body weight,different body composition,greater energy and fluid requirements per unit body weight,special dietry needs,including the dependnce of the infant on milk.

Chemicals enter the body of the infant and young child through the alimentary tract,the respiratory tract,or the skin.those that traverse the mammary gland are potentially important contaminants of human and artificial milks.Water used in the preparation of infant formulae is also a possible source of chemicals for young infant.Special behaviour characteristcs of young children are important in determining exposure to chemicals.

Generally ,chemicals,both organic and inorganic are absorbed more readily by the infant than by the adult.The organic compounds undergo biotransformation less readily in the infant,and the kidneys are immature and less able than those of the adult to excrete chemicals,whether inoranic or the polar products of biotransformation.Thus a greater proportion of a similar dose of a chemical per unit body wight is likely to accumulate in the body of the infant compared with that in the older child or adult.

Exposure to chemicals during early postnatal development can be associated with dose-effect and dose-response relationships,which differ from those resulting from exposure in later years.

The exposure of the infant to chemicals can give rise ,not only to immediate effects ,but also to manifestations due to the disturbed maturation of organ systems and their altered response to other environmental influence.

Variations that exist in the health and nutritional status of children reared in different social and cultural environment may influence exposure and modify response to chemicals in the environment.Recognition of this will assist in the identification of children at risk and enable appropriate preventive and remedial meaures to be adopted.

Case Study

Hussein 1988 studied the potential health hazards of air pollutants in Helwan among schoolchildren aged 12-15 years.Three studied groups of schoolchildren in 3 different areas :kafr El-Elw ,Helwan, and Shebin El-Kom in which ; the boys are more than girls in the three samples.The mean weight of boys aged 12 and 13 years in Helwan are higher than in Kafr El-Elw and Shibin El-kom.There was no significant difference in the mean height per age of boys aged 12 and 13 years in the 3 studied groups.Aso the same for the girls.

The history of parasitic infestations ,there is no significant difference between the 3 studied groups,table .. 1 ...

Past history of respiratory troubles are proportionally the highest in Kafr El-Elw and lowest in Shebin El-Kom,where there is significant difference between Kafr El-Elw and Shibin El-Kom and between Helwan and Shibin El-Kom., table 2

Symptoms of upper respiratory tracts are also higher in Kafr El-Elw,while the lowesr in Shebin ,where there is significant difference between Kafr El-Elw and Helwan, and between Kafr El Elw and Shibin El-Kom as regards the uper respiratory tract symptoms,while there is no significant difference between the 3 groups according to different types of symptoms of URT except the back nasal catarrh which is significant difference between Helwan and Shebin El-Kom ,tables 3 .& 4 ....

The lowest respiratory tract symptoms is significant higher in Kafr El-Elw than in Shibin,but no difference from that in Helwan,which is also significantly higher than Shibin El-Kom,specially in cough either dry or expectorated ,table . 7 & 8 ..

Chest examination reveals a highly significant difference between the abnormal findings in Kafr El-Elw and Helwan school children and that found in Shibin El-Kom schoolchildren,but no statistical diference between the abnormal findings in Kafr El-Elw and Helwan ,table.....

According to eye troubles,it was found that: there is significant difference between the 3 groups as regards post history of conjunctivitis and blepharitis,except that of blepheritis between that in Kafr El-Elw and Helwan ,table.. 5 . .Symproms of eye troubles are significantly different in between Kafr El-Elw and Shibin El-Kom on one hand and between

Helwan and Shibin El-Kom ,but not between Kafr El-Elw and Helwan,except itching and burning eye symptoms which are not significant different between Helwan and Ahibin El-Kom ,tables. 6,9 & 10.By clinical examination of the eye there is sgnificant difference,as regards abnormal findings clinically between that in Kafr el-Elw and helwan and that in Shibin El-Kom ,Table .....

According to skin troubles,it was found that: there is a significant difference of the abnormal skin troubles between Kafr El-Elw and both Helwan and Shibin El-Kom ,but not between Helwan and Shibin El-Kom,which are mainly dryness of the skin,Tables 11 , 12 & 13

By clinical examinationof the skin of the schoolchildren examined,the significant findings were that dryness of the exposed skin shows highly significant difference in Kafr El-Elw than that in both helwan and Shibin El-Kom.And itching marks reveals a significant difference between that in Kafr El-Elw and Helwan.and that in Shibin El-Kom but not between that in Helwan and Kafr El-Elw,

Allergic diseases inschoolchildren in Kafr El-Elw and Helwan were higher than that in Shibin El-Kom which are statistically significant diference.

The percentage of schoolchildren with allergy ,but without family history of allergy is higher in Kafr El-Elw ,which is significantly differ from that in Shibin El-Kom but ot that in Helwan ,table 14.