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Assessment of Water Quality Hazards in Egypt

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Assessment of Water Quality Hazards in Egypt

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March 1995

TERMS OF REFERENCE

This document was produced at the request of the Advisory Committee formed to guide the NWRC/USAID project entitled "Water Quality Monitoring, Data Management and Information Dissemination in Egypt." It is intended to be a working paper, assisting the Advisory Committee in its responsibility for identifying major water quality concerns in Egypt.

The assignment for the document was given on January 15, 1995 at the workshop which initiated the Advisory Committee. This draft was submitted in advance to the committee members for discussion at the second workshop, scheduled for March 24-25.

The purpose of the document is to assemble data in support of the generalized identification of water quality concerns carried out during the first workshop, held on January 14-15, 1995. The concerns were ranked on the basis of the data.

The results and suggestions for subsequent actions are presented in a short main body of this report. A longer annex includes a description of the methodology and the background data.

These concerns, categorized in terms of the risks posed to people, agriculture and the environment, form the basis of identifying water quality monitoring and management programs that would ensure that water of sufficient quality and quantity is available to Egypt in the future.

Dr. Jane Harris, PRIDE team leader, coordinated the preparation of the paper. Mr. Phillip Brown, PRIDE water quality specialist, and Dr. Gamal Abdel Nasser, a member of the NWRC's National Water Quality Conservation Unit, contributed information related to agricultural pollutants. Dr. Fatma El Gohary, a local consultant, contributed information concerning industrial pollutants. Dr. Harris contributed information on pollutants from domestic and urban sources.

The work was supervised by Dr. Mona El Kady, NWRC deputy chairman and director of the National Water Quality Conservation Unit and co-chairman of the Advisory Committee, Dr. John Woods, PRIDE project manager, Chemonics International, and Mr. Donnie Harrington, project officer, USAID.

SECTION I
INTRODUCTION

The National Water Research Center (NWRC) has recognized a need to increase the flow of accurate, up-to-date water quality information within Egypt. The audience for the information is primarily water quality managers; these are the people in public and private agencies who have responsibility for decisions and actions that affect water quality. At the same time, there is a need for more widespread information dissemination on this subject; therefore, additional efforts will be needed to disseminate water quality information to the general public, nongovernmental organizations, educational institutions, and others.

Responding to this need, PRIDE, under contract to USAID, is providing technical assistance to the NWRC to establish a National Water Quality Conservation Unit (called "the unit" in this report) within the NWRC. The unit's purpose is to promote the free flow of water quality information in Egypt.

The objective of this document is to assist in the process of determining what kinds of water quality information are most needed. To achieve this objective, existing data has been organized within a framework allowing a systematic evaluation of important water quality concerns facing the Egyptian people. The framework involves the four following steps:

- Identify available data
- Describe the hazards present
- Determine the pathways by which susceptible populations could be exposed
- Describe the potential consequences of exposure

With the most important problems identified, existing data collection and analysis programs can be assessed in terms of their ability to describe these high priority problems and to describe efforts to control the problems.

Egypt Water Quality Impact Assessment, Phase I (Welsh & Mancy, 1992) and *Phase* II (Kelly & Khalil, 1993) provided considerable water quality information for this paper. The results of the National Water Quality Conservation Unit Advisory Committee workshop provided the basis of this study. Previous work (PRIDE, 1994a,b,c) assessed health risks from discharges of wastes into the environment of greater Cairo. The present work is more specific in assessing only water quality-related effects, but covers all of Egypt, not just Cairo. The results of the previous study were used where appropriate.

The importance of supporting priority rankings with numeric data is recognized, particularly for rankings used to assign resources. However, this document provides an assessment that is primarily qualitative, rather than quantitative, and stops short of a comparative risk assessment . A quantitative risk assessment would include an assignment of probabilities of exposure to sensitive populations and calculation of a numeric value of the risk of specified consequences. Reliable statistics are not available, and could not be developed within the short time allocated to the preparation of this document.

The aim of this work, then, is to organize information to identify pollutant hazards rather than quantify the risk of a particular consequence. Even without quantifying risks, systematically comparing the possible effects of degraded water quality from different sources and in different

regions of Egypt will give a much better indication of the relative impacts than has previously existed. The main body of this report presents the results of applying the approach described above. Existing information, which forms the basis of this assessment is presented in Annex A.

This document is intended to be used as the first step in a process of increasing the flow of relevant water quality information in Egypt. The next step is to evaluate the implications of this hazard assessment and define a water quality monitoring/management strategy.

The unit does not have water quality monitoring resources and will not be involved in the collection of samples. However, NWRC institutes that do have sampling resources can use the results of this assessment to modify or implement their existing data collection programs, if needed. The unit can provide support within the NWRC in areas where more information dissemination needs are identified.

SECTION II
HAZARD ASSESSMENT

Using the data collected during PRIDE's Phase I and Phase II projects and the results of the National Water Quality Conservation Program First Advisory Committee Workshop in Port Said, Egypt, on January 14-15, 1995, the assessment described below was made.

A. Workshop Results

In the workshop, the participants were divided into three small discussion groups dealing with water quality concerns in:

- Agriculture (Group I)
- Domestic/urban development (Group II)
- Industry (Group III)

The objectives of each of these groups were to define five specific water quality concerns in their respective area and to determine how a national water quality monitoring program be used to reduce or eliminate these concerns through proper management.

With the conclusion of these presentations, it was clear that the five major water quality concerns in Egypt could not be readily identified and that a systematic approach had to be taken to identify hazards, pathways, and effects of pollution.

These exercises indicated that water quality concerns, in terms of hazards, were different for different water uses. The hazards listed by each group are as follows:

Group I (Agriculture)
1. Salinity (EC, SAR, TDS)
2. Pesticides and herbicides (due to long half-lives)
3. Heavy metals (only near sources)
4. Water-borne diseases
5. Fertilizer application (due to low recovery and high application rates, and seepage/runoff)

Group II (Urban/domestic)
1. Parasites, pathogens, viruses (I)
2. Heavy metals (IV)
3. Nutrients (II)
4. Salinity and physical properties (V and VI)
5. Organic substances and suspended material (III)

Group III (Industry)
1. Public health
2. Agriculture—quality and production
3. Aquaculture
4. Ecology

The results of the discussion groups, were that, while these concerns could be valid for Egypt as a whole, they may not hold true for specific areas. This point was brought out in the

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presentation of Group III (Industry) in which different concerns were described for specific areas. Of the three groups, Group II's (Domestic/urban development) matrix approach, which compared in a qualitative way the potential of hazards affecting people, economics, and agriculture, was the best methodology used for prioritizing concerns. This matrix is presented in Table 2.1

Table 2.1 Scoring matrix presented by Group II for potential hazards to water quality from the domestic/urban area

Hazard/ Effect	Health Risk	Economic	Food Production	Total	Rank
I	5	3	3	11	1
II	4	3	0	7	3
III	2	3	0	5	5
IV	4	2	4	10	2
V	3	1	7	6	4
VI	2	4	0	6	4

I	Parasites, pathogens, bacteria, and viruses
II	Nutrients (phosphorus and nitrogen)
III	Organic substances (dissolved and suspended)
IV	Heavy metals
V	Salinity
VI	Physical properties (color, smell, suspended solids)

B. Methodology

The workshop recommended that a working group be given the following tasks:

- Characterize hazards based on available data and information from water managers.
- Develop regional priorities for water quality parameters and pathways.

To meet this requirement, the matrices of Group II were adopted, modified, and used to help assess the effects of hazards on people, agriculture and the environment in seven regions of Egypt:

- Upper Egypt
- Fayoum
- Greater Cairo Area
- East Delta
- Middle Delta
- West Delta
- Northern Lakes

Seven potential water quality hazards were evaluated in terms of their effect on public health, agriculture, and the environment. Each of the hazards listed were evaluated based on

regional water quality data as well as the professional judgment of Egyptian water quality experts. Indicator parameters listed in parentheses were used as a basis for scoring.

- Parasites, pathogens, and viruses (E. coli)
- Nutrients (nitrates, phosphorous)
- Trace metals (trace metals)
- Salinity and physical properties (salinity)
- Oil, grease, and petrochemicals (BOD, COD, and oil and grease)
- Pesticides and insecticides (pesticides)
- Oxygen-demanding substances (BOD, COD)

Because of lack of data in many areas, a simple scoring approach was taken with comparative hazard effect scores of:

3	High
2	Medium
1	Low
0	Hazard

Scores were recorded in a matrix, as shown in Figure 2.1

Region _____				
Hazard	Health Risk	Agriculture	Environment	Total
Pathogens				
Nutrients				
Trace metals				
Salinity				
Oil & Grease				
Pesticides				
Oxygen-demanding substances				

Figure 2.1 Matrix used for ranking hazards within each of seven regions of Egypt.

C. Results

Results of the assessment are shown on the following pages. The assigned values were summarized in two ways, by parameters, shown in Figure 2.2 , and by affected sector, shown in Figure 2.3.

Figure 2.2 shows the total score for each water quality parameter within each region and the total score for the region. The regions are sorted from the lowest score, Upper Egypt, to the highest score, in Northern Lakes. Pathogens generally have the highest scores for all regions, followed by trace metals. Other parameters vary by region, with nutrients causing effects in the

Delta and Northern Lakes, and salinity effects greatest in Fayoum. Pesticides and oil and grease scores are similar for most regions with exceptions in the Northern Lakes, where pesticide effects are higher and in Cairo, where oil and grease effects are higher. Oxygen-demanding substances pose the greatest hazard in the Northern Lakes and the West Delta.

The scores clearly indicate that water quality effects increase from the south, in Upper Egypt, to the northern delta and Fayoum area, with the most substantial effects in the Northern Lakes near the Mediterranean Sea. In the delta region, the West Delta is most affected, followed by the East Delta, with the Middle Delta less affected. Water quality effects in Cairo were lower than any region except Upper Egypt.

The rankings, summarized by region and parameter, are shown in Table 2.2 . Narrative ranks of "high," "moderate," and "low" were assigned for each parameter, based on the summed score for agriculture, health and the environment in each region.

Table 2.2 Summarized rankings for each parameter within each region.

	Upper Egypt	Fayoum	Cairo	East Delta	Middle Delta	West Delta	Northern Lakes
Pathogens	Low	High	Low	Moderate	Moderate	Moderate	Moderate
Nutrients	None	Moderate	Low	Low	Low	Low	Moderate
Trace metals	Low	Moderate	Low	Low	Low	Low	Moderate
Salinity	None	Moderate	None	Low	Low	Moderate	Low
Oil & Grease	Low	Low	Moderate	Low	Low	Low	Low
Pesticides	Low	Low	Low	Low	Low	Low	Moderate
Oxygen demanding substances	Low	Low	Low	Low	Low	Moderate	Moderate

The following scale was used:
7-9 High 4-6 Moderate 1-3 Low 0 None

Only pathogens in Fayoum were rated "high." Salinity was assessed as of no concern in Upper Egypt or in Cairo. The lack of effect in Cairo was mainly a result of the relatively low use of water for irrigation in greater Cairo. Nutrients were also of no concern in Upper Egypt. All other parameters were considered to be of "low" or "moderate" concern. The Northern Lakes and Fayoum had the largest number of parameters listed with "moderate" concerns. The West Delta had somewhat more concerns than the East and Middle Delta.

Figure 2.3 shows that of the three sectors, agriculture, health, and the environment, the environment is most affected by these hazards. In each of the seven regions, agriculture was rated as least affected, followed by health; the environment was rated as most affected in all regions except Upper Egypt, where environment and health scores were identical. The results are tabulated in Table 2.3

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Table 2.3 Summarized rankings for each affected sector in each region

	Agriculture	Health	Environment
Northern Lakes	None	High	High
Fayoum	Low	Low	Moderate
West Delta	Low	Moderate	Moderate
East Delta	Low	Moderate	Moderate
Middle Delta	Low	Moderate	Moderate
Cairo	Low	Low	Moderate
Upper Egypt	None	Low	Low
The following scale was used:			

15-21 High 8-14 Moderate 1-7 Low 0 None

Environmental concerns were viewed in the past as luxuries available only to developed countries with rich citizens. Less developed countries were more likely to sacrifice their environments for short-term goals that allowed exploitation of resources by poor citizens. A growing number of governments have come to recognize that protection of their water, land, air, and biological resources is essential for continued survival. This need for present-day protection to ensure future resources has encouraged many citizens to support government actions to develop and enforce laws that protect the environment. The rankings here indicate that Egyptian environmental resources are the sector most vulnerable to water quality hazards.

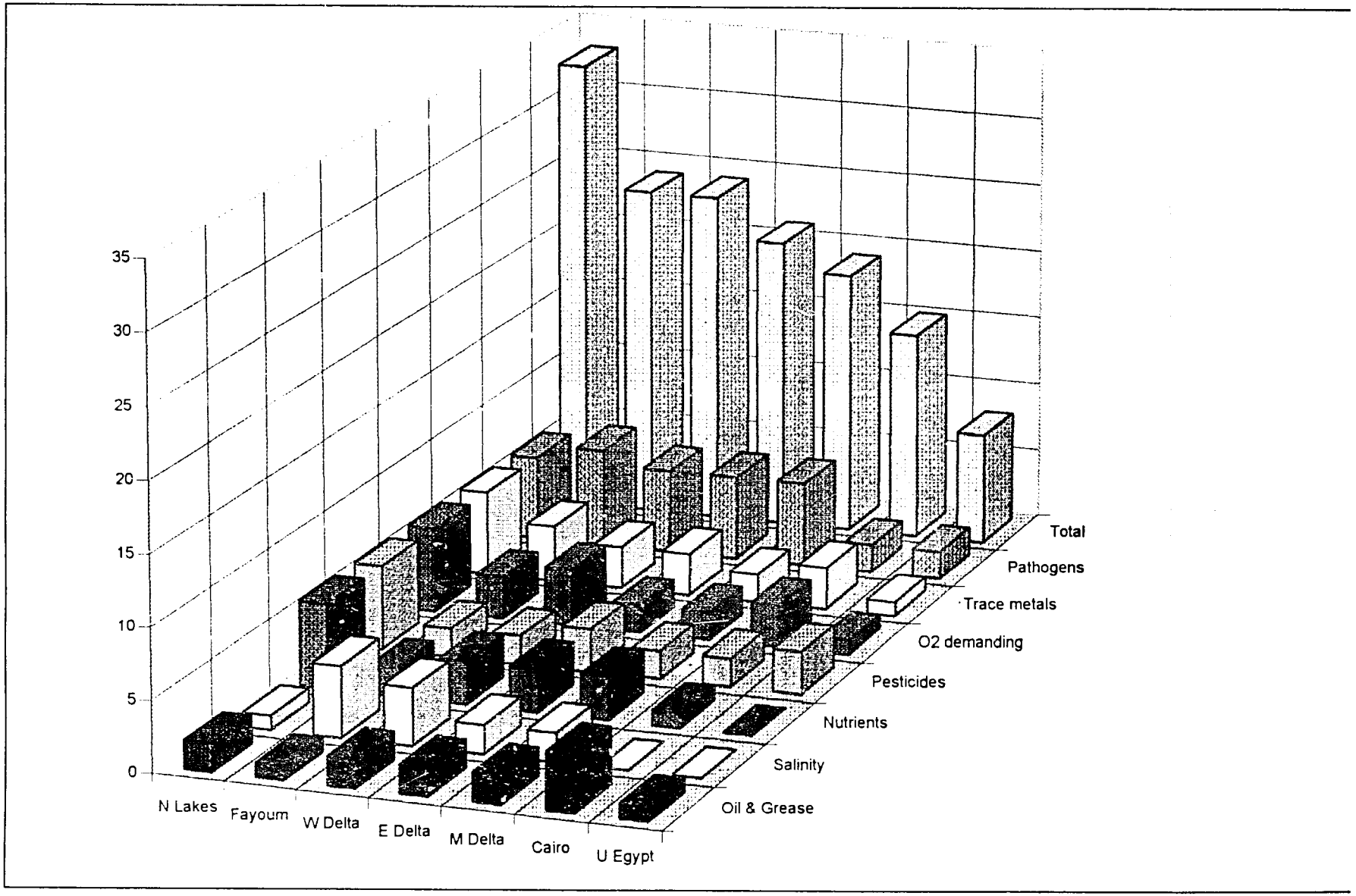

Figure 2.2 Scores for each parameter by region. (Highest scores = Worst effect)

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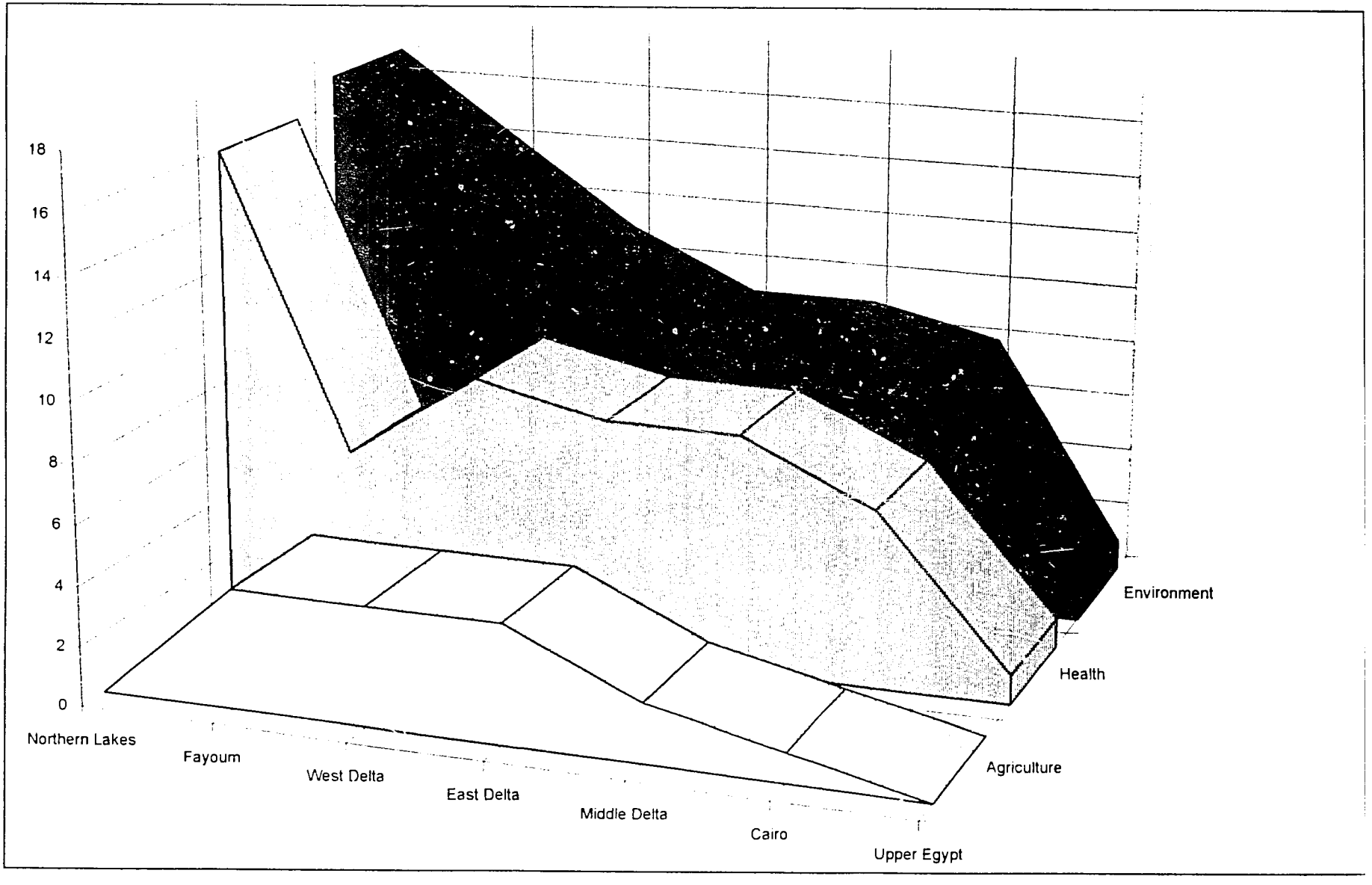

Figure 2.3 Ranking by affected sector for each region (Highest scores = Worst effect)

SECTION III
MANAGEMENT STRATEGY

A. Concepts

The purpose of organizing water quality information in this way is to provide support for decisions about water quality management. Water quality management can be achieved in three areas:

- Hazard identification
- Source elimination
- Determination of general risk management alternatives

Some of these concepts are currently being investigated by the Strategic Research Program (1995). Programs which could be developed in each of these areas are as follows:

Hazard identification. Although considerable work has been done or is being planned in this area in Egypt, more research is required. Possible projects in this area include:

- **Monitoring system implementation.** In Egypt, monitoring protocols vary by institute or organization. A systematic approach such as that developed for the Advisory Committee on Land Drainages and Drainage Related Water Management, (Elassiouti, 1995) could help meet the needs of the country.

- **Conduct research.** Conduct research in areas that have been adversely affected by industrial and wastewater pollution. Much of this research should center around the determination of the consequences of water quality hazards. This information is needed to quantitatively address risk to people, agriculture, and the environment.

Source elimination. Without enforcement of existing laws (Law 48 of 1982) together with the development of more effective laws, source elimination will not be accomplished. Because of uncertainties in terms of the exact consequences of using contaminated water, it would be best to start on the small scale rather than on the national level. On this scale, the benefits of these programs can be quantified and appropriate actions expanded to a national scale. Specific projects for source reduction are as follows:

- **Modify legislation.** Work with the GOE to design and develop an effective system of regulations that can be implemented within the Egyptian system. This may call for the modification of Laws 48 of 1982, Law 4 of 1994, and others, such as the irrigation law. In addition, the GOE should look at these laws as an integrated package for water quality management. This is not being done at present.

- **Recycle at source level.** Recycling could provide benefits from both industrial and agricultural sources. Recycling cooling water could substantially reduce effluent volume requiring treatment. Recycled water at the farm level and mixing drain water with fresh water from canals on a small scale would help eliminate irrigation with non-agricultural pollutants found in major drains. This would allow for the effective use of all water while at the same time reducing water logging.

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- **Construct treatment systems.** Develop small-scale treatment systems, such as wetlands, for secondary, or even primary treatment of domestic waste from the villages and pre-treatment for various industries. Such systems can be used to reduce BOD, sediment, heavy metals and other pollutants.

Risk management. It is important for water managers and government officials to understand the risks contaminated water poses to the public, agriculture and the environment. Steps can then be taken to manage risks to reduce negative consequences. Programs which could be developed include:

- **Inform the public of hazards.** A communication/education campaign for water management officials and the general public would inform them of the hazards of using contaminated water from drains for irrigation and domestic purposes. By educating people, the improper use of contaminated water for agricultural and domestic purposes would decrease, therefore, the risk will be reduced. If effective, with time, the campaign could be expanded to the entire nation using additional tools, such as the mass media.

- **Develop a land irrigation strategy.** A land irrigation strategy could be developed within small areas and implemented by local managers and farmers. Standard land irrigation design methods have been developed to prevent the build-up of heavy metals and agricultural chemicals in soils and plants. These consider both concentration and total load of chemicals applied with the irrigation water. One such method is the Land Limiting Constituent (LLC). This analysis is an all-inclusive design method to control the accumulation of toxicants during waste reuse on land (Kalbermatten et al, 1988). Recommended limit values for heavy metal concentrations in soils and yearly loading rates can be based on a variety of existing guidelines or criteria. One such set of criteria was developed by the Council of the European Communities (1986).

- **Promote pest control management.** Non-chemical methods would reduce the use of pesticides and insecticides.

- **Maintain and modernize the potable water system.** Improperly maintained water systems lead to breaks in the integrity of distribution networks that provide the most direct pathway for exposure of urban residents to pathogens.

B. Role of the Water Quality Conservation Unit

The role of the Water Quality Monitoring Unit mainly falls within the risk management area. At this time, there are no clear methods for water quality information in usable form to reach local water managers. Most water quality monitoring data is used for research. It is important that there is such a unit to serve water managers and other potential water users with viable information that can be used for planning. These issues should be addressed in terms of long-term and short-term goals.

The next step would be to provide a comparative assessment of the risks of contaminated water to people, agriculture, industry, and the environment. To complete such a task is beyond the scope of this report and without a comprehensive database on the health, agricultural, or other effects of pollution, it is not possible. However, in order to effectively monitor and manage water quality, certain generalizations must be made. Some action will be required before

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sufficient data have been assembled. These actions should be based on the best assessment of what is often insufficient data, but the lack of data should not prevent action.

One of the weaker points of this evaluation is the lack of information on the potential consequences in Egypt of these water quality hazards to people, agriculture, and the environment. Much information is available, as demonstrated by reports such as the Draft Report on the Pollution of the Nile (Egypt's Case) (SRP,1995) and The Comparative Environmental Risk Assessment for Cairo (PRIDE,1994). Future assessments needs should be expanded so that the risks of water quality contamination can be delineated in more detail. Relating quantitative data on hazards to data on health, agricultural, and environmental consequence is an important next step in this evaluation.

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ANNEX A

ASSESSMENT OF WATER QUALITY HAZARDS IN EGYPT

Technical Information Used in Hazard Assessment

March 1995

Attached to:
Assessment of Water Quality Hazards in Egypt
Prepared for the 2nd Advisory Committee Workshop
National Water Quality Conservation Program

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ANNEX A
ASSESSMENT OF WATER QUALITY HAZARDS IN EGYPT

A. Introduction

This annex presents most of the technical information used to develop the hazard assessment described in the main body of this report. The methodology for a more complete assessment is also described in the following section. The assessment conducted for this report is not complete because data on exposure were not available.

B. Methodology

The primary aim of this effort is to organize existing information on water quality in Egypt so that decisions can be made to help improve water quality management.

The methodology adopted is shown graphically in Figure 2.1. The major steps are described as follows:

- Locate sources of water quality information.
- Identify sources of discharge of potential contaminants into water resources—these sources constitute hazards to water users.
- Identify pathways by which people, agriculture, or the environment are exposed to constituents of water that could cause harm to them (constituents could be physical, such as temperature or suspended solids, chemical, such as chloride or phenol, or biological, such as algae or Salmonella).
- Describe the consequences of exposure to the constituents.
- Develop a ranking of geographic areas that would help determine where the greatest needs for management intervention exist. One of the important aspects of management intervention is developing more information through water quality monitoring.

The objective of this methodology is to characterize as fully as possible the hazards presented to water users in Egypt. Pathways, exposure estimates, and consequences were described to the extent possible with existing data. The methodology followed is similar to that used for formal risk assessments, although a major difference exists. In formal risk assessments, a value is assigned to risk, defined as the product of exposure times consequence. In this study, no numeric values have been calculated; but the information has been organized for relative ranking of the hazards.

Sources of contaminants have been divided into three categories: industrial, agricultural and domestic/urban. This classification was chosen primarily for data-gathering convenience, although there are benefits to the analysis procedure because each category is associated with "typical" contaminants.

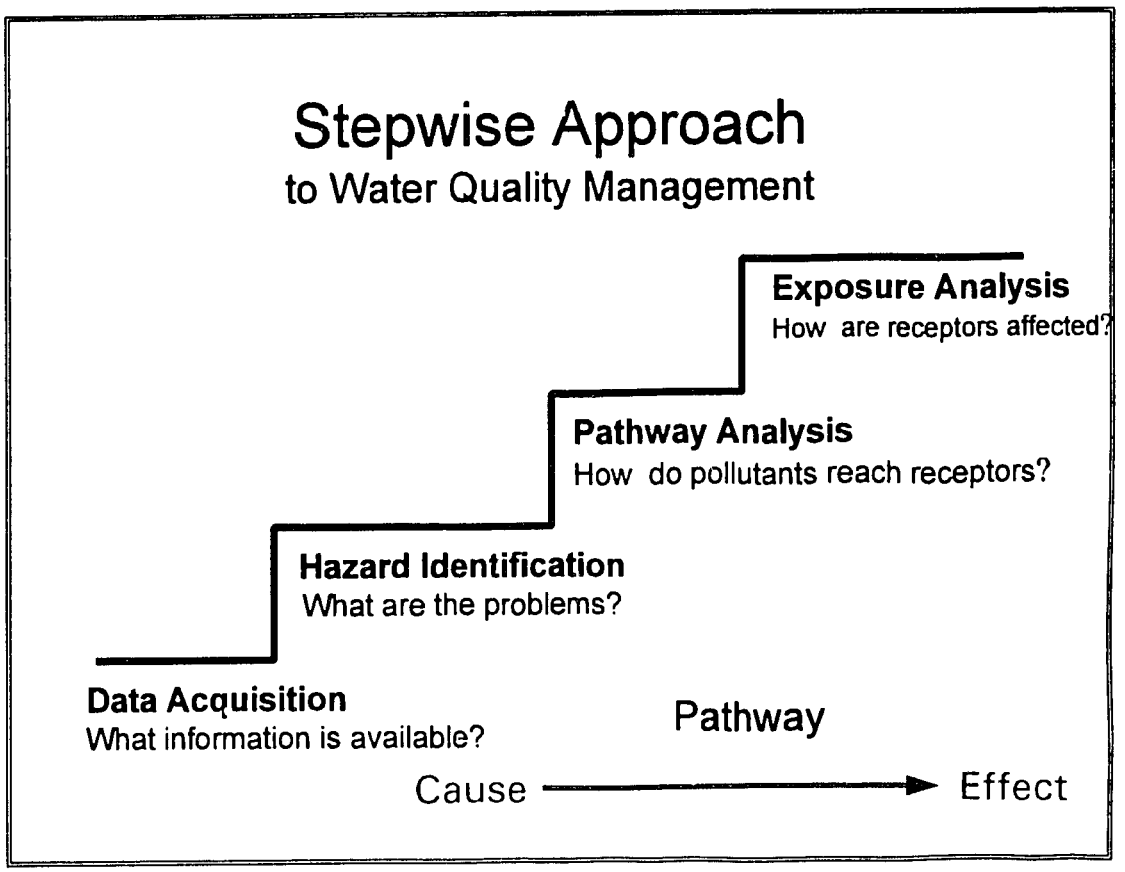


Figure 2.1 Graphic description of the methodology applied to this assessment of water quality hazards in Egypt

C. Description of Egypt's Water Resources

The Nile River flows about 6,650 kilometers from its headwaters in Burundi through five other countries before its discharge into the Mediterranean Sea. Its last 1,600 kilometers lie within Egypt. Egypt is entirely dependent on this water, which originates outside the country.

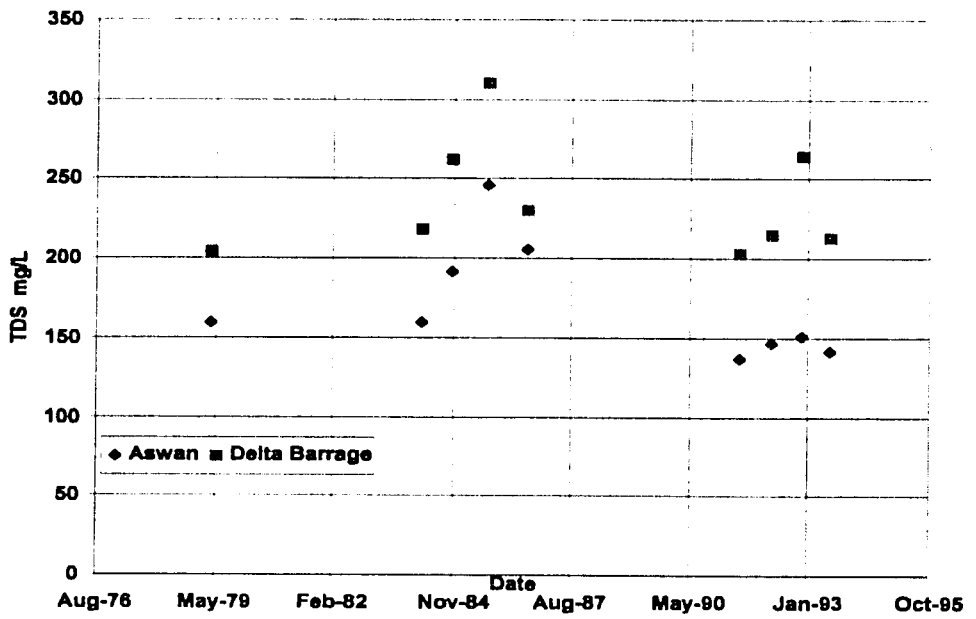
Egypt achieved relative water supply stability through the 1959 Nile Water Agreement with Sudan, which allocated 55.5 bcm/yr to Egypt with completion of the High Aswan Dam in 1968. At the Delta Barrage downstream of Cairo, the average annual flow is about 33 bcm, a net reduction of about 21 bcm from Aswan, reflecting the extensive agricultural diversions and return flows in the Nile Valley, the export diversions and the municipal and industrial use in and above Cairo. At Cairo, flow rates range from about 60 million cubic meters per day (mcm/day) during the closure period to 160 mcm/day in summer, with an average of about 90 mcm/day.

The estimate of the 1990 population of Egypt was 56 million people, 95 percent of whom occupy the Nile Valley and Delta which comprise only 4 percent of the land area of Egypt. The net water supply to this area is equivalent to the release from the High Aswan Dam, approximately 55 bcm. The current ground water pumpage of 4.5 bcm/yr is recharged from the Nile River and from infiltration of diversions and water applications. Minimal ground water is exchanged with the surrounding deep aquifers. Rainfall is an insignificant water source in the

Nile Valley and Delta, with rainfall rates declining from a maximum of 200 mm/yr at the northern coast to about 20 mm/yr near Cairo and to less than 5 mm/yr in Upper Egypt.

In Egypt, since the construction of the High Aswan Dam, the quality of the Nile has depended primarily on the water quality and ecosystem characteristics of Lake Nasser, the reservoir impounded behind the dam. Since its construction in 1968 (PRIDE, 1992), the dam has been the single most important hydraulic structure in Egypt.

Water quality in the water released from the dam shows little degradation. Total dissolved solids concentrations are generally measured around 170 mg/L at the first sampling site

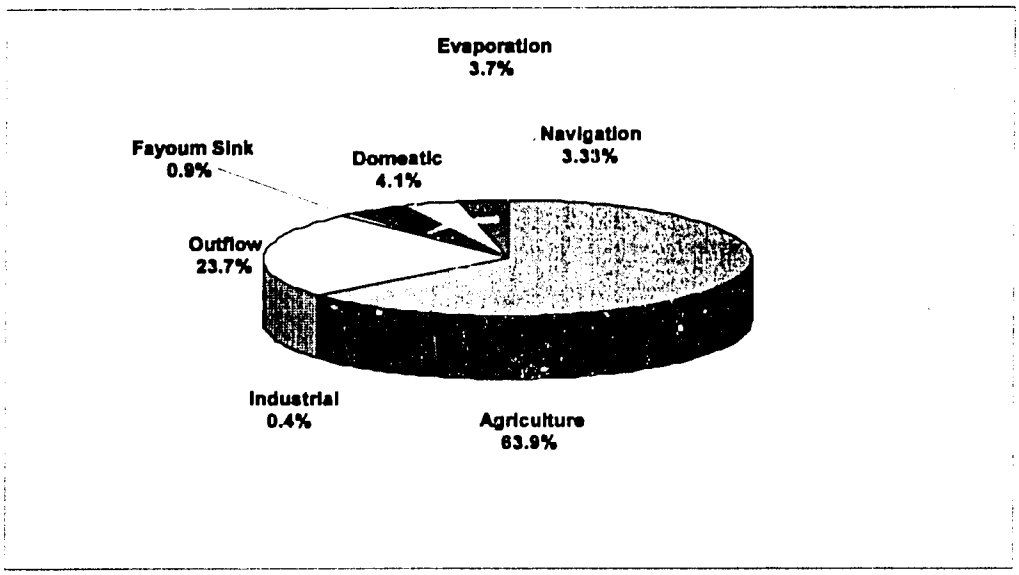


downstream of the dam. Figure 3.1 shows TDS concentrations in the Nile River at the sample site nearest the dam's outflow have been in the range from 137-246 mg/L for each sampling exercise from 1979 through 1993.

Figure 3.1 Total Dissolved Solids Reported by the Nile Research Institute in the Main Stem of the Nile River Near the Outflow From the High Aswan Dam and About 950 kilometers Downstream Near the Delta Barrage

The measurements taken over the period 1979-1993 do not indicate that TDS concentrations are increasing, either in water released from the dam or in water after it flows through Upper Egypt. The high concentrations measured in the mid-1980's are probably a result of drought conditions in the Nile basin.

Figure 3.2 shows the predominance of agricultural water use in Egypt. In 1990, nearly 93 percent of the Nile's net water use was for agriculture, including 64 percent consumptively used by crops, with another 29 percent indirectly allocated to agriculture for drainage outflow and



evaporation, irrigation distribution channels, and drains. Only 7 percent is used for municipal, domestic, industrial, and navigation needs combined.

Figure 3.2 Consumptive Water Use in Egypt

An estimated 17 bcm of the agricultural drainage, municipal and industrial waste discharges are returned annually to the system. Much of the discharge is not treated to remove or neutralize pollutants.

Drains receive the irrigation water excess through the soil to a subsurface drainage system. The quality of drainage water is affected by chemical constituents of the soil, toxic substances used for animal or plant pests control, and domestic wastes effluent from side bank habitation. Outlets from drains in Upper Egypt are discharged to the Nile. Drains in the delta discharge ultimately to the Mediterranean Sea.

Upstream sections of canals have water quality similar to that at the point of diversion from the Nile. Some canals undoubtedly receive illegal discharges that could affect water quality, at least locally. Most of these canals are major sources for drinking water treatment plants, many canals contain excess fertilizers, molluscicides (as in the case of Bilharziasis control), and herbicides which find their way to other water bodies.

D. Sources of Pollution

D1. Industrial

Although modern industry has existed in Egypt since the early 19th century, industrial exploitation of natural resources became significant only after World War I. Food processing, textile manufacturing, and cement and fertilizer production were the main industries. Industrial

development in the early 1950s took a new course, shifting away from the traditional agrarian base to heavy industries, such as steel, machinery, and chemicals. An important feature of Egypt's industrialization at that time was the concentration of new industries in the metropolitan areas along the Nile Delta: north and south of Cairo, particularly in Helwan and Shoubra El Kheima, Kafr El Zayat, Talkha, and in the 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 1960s are of Russian or Czechoslovakian design, while the most recent factories are mainly western European in origin.

The government of Egypt reportedly owns and operates 367 industrial facilities. Table 4.1 lists government-owned industries and the ministries responsible for each. This is important information when considering the implementation of industrial pollution control programs.

The Ministry of Industry is the major owner of governmental facilities in Egypt. It owns 72 percent of the 367 public industries, followed by the Ministry of Economics with 9 percent, and the Ministry of Supplies with 8 percent. Ownership of the remaining 11 percent is split between the Ministries of Defense, Electricity, Agriculture, Housing, and Health (RNPD, 1989).

In 1956, all major industries were nationalized. Because the trend during that period was to support industrial development and seek rapid returns on investment, inadequate attention was paid to the long-term issue of environmental deterioration. An added problem was that most new industries were state-owned, making enforcement of government regulations almost impossible. Although Law 93 on wastewater disposal was promulgated in 1962, its regulations and standards were not applied to public sector industries, inspection was discouraged, and rules not enforced. Out of fear of hindering industrial development, no industry was ever prosecuted under this law. As a result, untreated wastewater has been discharged ever since into the Nile, lakes, drains, and the Mediterranean.

In 1983, the Ministry of Industry's General Organization for Industrialization (GOFI) scheduled an urgent action plan to control pollution of the Nile from the liquid wastes discharged by 25 industrial plants belonging to the ministry. This plan was modified in 1985 to include 188 industries classified into three categories, according to their effluent discharge points. Priority was given to industries discharging into the Nile, followed by those discharging into canals, drains, and sewer systems, in that order. Apart from the Egyptian Coke Company (Tibeen), which installed a facility for treatment of phenolic waters, very little has been implemented.

At present, industrial use of Egypt's water is estimated to amount to 3.7 bcm/year. Out of this total, 2.1 bcm/yr is used as cooling water and 0.6 bcm/yr is used as process water. By the year 2000, the industrial use of water is estimated to increase from 2.1 to 6.7 bcm/yr for cooling water and from 0.6 to 3 bcm/yr for process water (GOFI, 1985a). 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. Whether or not these projections are reached, it is clear that growing industrialization is taking place in the short term, resulting in an increase in the volume of effluents and toxic wastes, and in the variety of toxic contaminants discharged into the river system. The situation calls for the implementation of pollution control measures for existing industries, and information and monitoring systems for industrialization.

Table 4.1 Public Industries in Egypt

Ministry	Industrial Sector	Number of plants
Ministry of Industry	Oil & Soap	24
Ministry of Industry	Starch & Glucose	6
Ministry of Industry	Sugar & Distillation	9
Ministry of Industry	Milk Products	9
Ministry of Industry	Canning Food	5
Ministry of Industry	Soft Drinks	10
Ministry of Industry	Beer	2
Ministry of Industry	Macaroni	8
Ministry of Industry	Leather & Tanneries	3
Ministry of Industry	Tobacco	6
Ministry of Industry	Fertilizer	7
Ministry of Industry	Plastic & Rubber	5
Ministry of Industry	Pesticide	2
Ministry of Industry	General Chemical	12
Ministry of Industry	Matches	3
Ministry of Industry	Pulp & Paper	16
Ministry of Industry	Textile, Spinning & Weaving	80
Ministry of Industry	Jute	4
Ministry of Industry	Non-Metallurgical Mining	11
Ministry of Industry	Heavy Industry	15
Ministry of Industry	Aluminum	1
Ministry of Industry	Transportation Industry	5
Ministry of Defense	Heavy Industry	1
Ministry of Defense	Transportation Industry	1
Ministry of Industry	Miscellaneous	22
Ministry of Economics	Ginning of Cotton	33
Ministry of Agriculture	Wine	2
Ministry of Agriculture	Onion & Vegetables Dehydrating	5
Ministry of Supplies	Rice Mill	5
Ministry of Supplies	Flour Mill	25
Ministry of Petroleum	Petrochemical	3
Ministry of Health	Pharmaceutical	6
Ministry of Housing	Cement	8
Ministry of Electricity	Power Station	13
Total		367

D1a. Sources of Pollution From Aswan to Cairo

During its course from Aswan to Cairo, the Nile River receives considerable amounts of industrial wastewater.

In Qena, the most significant sources of pollution are the cane sugar industry. The impact of these wastes on the water quality of the river is significant.

In Sohag, the hydrogenated oil and onion drying factories are potential sources of pollution.

D1b. Greater Cairo Sources of Water Pollution

Greater Cairo and Helwan has a population of some 15 million and includes areas that are industrial, commercial, residential, or mixed. Heavy industry is generally located around Helwan and Shoubra El Kheima with various large individual factories located throughout the city.

Many small industries are spread throughout the city; wastewater discharges from these industries are generally low in volume. However, short discharges of highly toxic material may cause problems. Some districts are also centers for specific types of industry, such as tanning (Ein Sierra), and the combined discharges from such areas can present a problem.

Industry in greater Cairo comprises 75 percent public and 25 percent private sector factories. Of the public sector factories, some 80 percent are under GOFI. The other 20 percent are under different ministries, such as Health and Housing.

- 23 chemical industries
- 27 textile and spinning industries
- 7 metal industries
- 32 food industries
- 29 engineering industries
- 9 mining and refractories industries

These industries consume some 162 mcm /year of water and discharge some 127.5 mcm/yr of effluent, comprised of the following:

- 55.5 mcm /year discharge to the sewers
- 6.5 mcm /year to underground and superficial drains
- 24.5 mcm /year to canals
- 21.0 mcm /year to drains
- 20.0 mcm /year unidentified

The most polluting effluents enter the sewers from the following sources:

- Oil at 57,300 mg/lire 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/l and suspended matter at 3,700 mg/litre from tanneries in South Cairo
- Detergent at 2,160 mg/lire 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 galvanizing companies (pH values 0.67 and 1.3)
- Alkaline discharges from a concrete products company at pH 12.6
- Iron at 4000 mg/litre from the steel pipe and fitting factory

Effluent characteristics from some industries sampled by the NRC is given in Table 4.2

Table 4.2 Effluent Characteristics from Industries Sampled by NRC (Greater Cairo) (All results in mg/l except pH and flow). Source NRC

Manu-facturer	No of Samples	Flow m^3/d	pH	BOD	COD	S.Solids	Oil/ Grease	Heavy Metals
Cement	1	320	9.6	5	16	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
Chemica l	4	175-136000	7.4-10.0	30-7500	60-1400	110-1210	43	
Pharma-ceutical	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	

In general, industrial wastewater in greater Cairo represents 23 percent of total industrial wastes in Egypt. GOFI stated that some 0.75 tons/day of heavy metals are discharged, representing 46 percent of the total heavy metal discharge of the industrial sector. Oils and lubricants exceed 93 tons/day and suspended matter 97 tons/day. This shows that the greater Cairo area is by far the major source of industrial wastes, followed by Alexandria, and that the most polluting industries are probably the chemical and food industries (Tables 4.3 and 4.4.).

Table 4.3 Yearly Water Consumption, Effluent Volumes, and Polluting Loads by Region (Source: Nile Research Institute)

Region	No.	Water mcm/year		Pollution Loads (t/day)				
		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 Gov'nment	24	7	5	2	3	3	5	0.3
Total	331	636	550	270	388	168	296	1.92

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Table 4.4 Average Water Consumption, Effluent Volumes, and Polluting Loads for Industry throughout Egypt (Source: Nile Research Institute)

Industry	No.	Water mcm/year		Pollution Loads (t/day)				
		Use	Eff	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	6.6	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	388.6	168	296	1.65

It should be mentioned, however, that projects being undertaken by CWO and GOSD involve the construction of an extensive sewage network and six major treatment plants. Three are located on the east bank, two on the west bank, and one at Helwan. These plants will significantly reduce pollution within the city and provide the potential for effluent and sludge reuse in agriculture. Four of the treatment plants (Zenein, Helwan, Abu-Rawash and Berka) are already in operation and the others are under construction at Gabal El-Asfar and Shoubra El Kheima. By 1996, total treatment capacity is expected to reach 3,280,000 m^3/dy (Table 4.5).

Table 4.5 Treatment Plant Capacity within the CWO Project Area

Name	Location	Treatment	Capacity cm/day
Gabal El Asfar	East Bank	P+S	1,000,000
Berka	East Bank	P*	600,000
Shoubra El Kheima	East Bank	P*	600,000
Helwan	East Bank	P+S	350,000
Abu Rawash	East Bank	P	400,000
Zenein	East Bank	P+S	330,000
Total Capacity			3,280,000

* Commissioned as primary treatment plants, secondary treatment units under construction

P = Primary treatment S=Secondary treatment

D1c. Sources of Pollution Along Rosetta Branch

With regard to Rosetta branch, the potential source of pollution is the wastewater discharged from the following factories at Kafr El-Zayat:

- Salt and soda
- Super phosphate
- Pesticides

D1d. Sources of Pollution Along Damietta Branch

The major source of pollution is Talka fertilizers factory.

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D2. Agriculture

In the Phase I Report (Egypt Water Quality Impact Assessment: Phase I (PRIDE, 1992), considerable effort was made to document agricultural source of pollution. This report was based on available water quality information. The report identified the following major impacts of agricultural activities on water quality:

- Changes in salinity
- Deterioration due to chemical fertilizers and pesticides
- Possible eutrophication of water bodies due to increase in nutrients from fertilization

It is estimated that almost 2.3 billion cubic meters of drainage is returned to the Nile annually. The salinity of this drainage water is much higher than original irrigation water from the river.

Cultivated areas are serviced by an agricultural drain network, which is about 17,500 km long. Major drains are:

Upper Egypt Drains

These drains discharge into the Nile via gravity. The areas served by these drains are relatively small due to the narrow width of the Nile Valley. The main drains are Nagaa Hammadi drain (57,000 feddans), Sohag main drain (56,000 feddans) and Abou-Teeg drain (75,800 feddans).

Middle Egypt Drains

The main drains in this area are:

- Mohit drain, which extends the entire length of Middle Egypt, with several outlets to the Nile.
- Ben Khaled drain, which serves 11,400 feddans and discharges into Bahr Youssef by gravity.
- Menstat El-Dahan serves 21,00 feddans and also discharges into Bahr Youssef.
- Dir Tanhoria serves 50,000 feddans and discharges into Bahr Youssef by a pump station.
- Sakoul drain serves 65,00 feddans and discharges into Bahr Youssef by a pump station.
- Mazoura drain serves 30,00 feddans and discharges to Bahr Youssef by a pump station.
- Wadi and Batts drains discharge into Lake Karoun.

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Nile Delta Drains

The Nile Delta drains consist of 22 drain catchments, covering an area of 4.72 million feddans. Each of these consists of single or multiple zones and drain catchments defined as follows:

Region	Single Zone Drains	Multiple Zone Drains
Eastern	Upper Serw Lower Serw Mataria Farskour	Bahr El Baqar Bahr Hadous
Middle	Sabal Tala Burullus Tira No. 7 Lower no. 8 No. 11 Zaghloul	Gharbia Main Drain Drain No. 1 Nashart Drain
Western	Barsiq Tabia Qalaa	Edku Drain Omoum Drain

Single zone catchments drains and main drains are either directed to pumping stations or gravity flow toward the main outlets.

These drains in Upper and Middle Egypt are sources for contaminated water to the Nile River and Karoun Lake. The Nile Delta generates an estimated 17.7 bcm of flows to agricultural drains, mixed in varying proportion with domestic and industrial wastes. Under 1990 conditions, nearly 3.37 bcm with an average salinity of 1,167 ppm, was reused after mixing with fresh water, while 12.8 bcm was discharged to the Northern Lakes and the sea. Mixing increases the amount of water available by diluting the less saline drainage water, making it more suitable for irrigation use. A mixing ratio of about 1:1 is sought, with a final quality of 600 to 800 ppm, although in many cases, a larger proportion of fresh water is required. In the past, little or no concern was expressed regarding other potential contaminants in these waters. Recently, however, the Drainage Research Institute of the NWRC began a program that expands analysis of drain water samples to include other potential contaminants.

D3. Domestic/Urban

The constituents of the domestic and urban input to wastewater are pathogens, nutrients, suspended solids, salts, and oxygen-demanding material. Trace metals can exist at concentrations high enough to cause concern in sewage sludge.

A study conducted by the World Bank (1993) described water supply and sewerage/ sanitation service levels in Egypt. Present levels of service are shown in Table 4.1.

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Table 4.1 Present Service Levels for Water Supply and Sewage
(Source: World Bank, 1993)

Area	Population millions	%	% of Population Served Water [a]	Sewage
Cairo	11.1	20.2	95	70
Alexandria	3.3	6.0	98	40
Canal Cities	1.1	2.0	96	35
Other Cities	8.5	15.5	80	30
Total Urban	24.0	43.6	90	50
Rural Villages [b]	31.0	56.4	45	3
Total	55.0	100.0	65	24

(a) People receiving water from a "piped public system," through house connection or public standpipe.
(b) The distinction between rural and urban is determined by the administrative status of the community. Densely populated communities with up to 30,000 inhabitants may be classified as rural, although they exhibit few rural characteristics in the traditional sense

Coverage rates for sewage are much less than those for water supply. They are expected to increase rapidly in the medium term, as the expansion of sewage networks is given priority. Cairo has the best sewage service in the country, with about 77 percent of its population connected. Alexandria reportedly has only 40 percent of its current population connected. Works under construction in 1993 were expected to increase this coverage to the 65-75 percent range by the year 1995. Sewage service rates in smaller towns are estimated at less than 5 percent.

The population not connected to a sewer system relies on individual means for the disposal of excreta and wastewater (latrines, septic tanks, etc). No hard data exist on sanitation, but evidence indicates that on-site solutions are often ill-designed and poorly maintained.

Lack of sewage systems or effective on-site disposal has led to widespread surface ponding of wastewater and the contamination of drainage channels, particularly in those areas where piped water is available through house connections. The situation is especially critical in the delta area where high population densities, impervious soils and high ground water tables make the application of low-cost, on-site sanitation options difficult. In many areas without sewage service, the availability of water through house connections has, in fact, led to a deterioration of overall environmental and public health conditions, particularly in the poor neighborhoods of the large cities and in the densely populated towns and villages in the delta.

The Ministry of Public Works and Water Resources (MPWWR) lists eight wastewater treatment facilities in all of Upper Egypt, from Aswan to El Fayoum (PRIDE, 1992). These treatment facilities discharge 290,000 m^3 per day. There are approximately 30 operating wastewater treatment facilities in the delta, discharging more than 413,000 m^3 per day of treated waste. An additional 335,000 m^3 would be treated by El Mansoura (120,000 m^3), Kafr El Ziat (90,000 m^3), Samanod (15,000 m^3), and Damanhor (110,000 m^3), but those facilities were listed as "not operating." If these values represent only domestic sources and only 24 percent of the population is served, then the total daily production of domestic wastewater would be 4,325,000 m^3, of which 3,287,000 m^3 are untreated.

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E. Identification of Hazards

E1. General

The following presents broad categories of potential hazards from water quality contamination.

E2. Parasites, Pathogens, and Viruses

A wide variety of human pathogens may be found in surface waters, mainly from human and animal excrement. Pathogens found in human excrement, whether urine or fecal material, come from persons who are infected by a disease. However, infected persons do not necessarily always show symptoms of the illness. Some persons, following infection by a particular disease organism, may harbor the pathogen in their bodies for the rest of their lives without showing any ill effects.

Most human pathogens can be classified as either viruses, protozoans, helminths (intestinal worms), or bacteria. Virtually every sizable body of water contains some pathogens; however, it does not follow that bathing in a stream, drinking water from a lake, or swimming in the ocean will automatically cause illness. Healthy individuals must first come in contact with pathogens, the pathogens must gain entry into the body, and the dose of pathogens must be sufficient to overcome the body's natural defense mechanisms. Under special circumstances an infection can develop from a single virus, protozoan, or helminth, but the minimum infective dose for bacteria is between 100 and 100 million, depending on the species. Parasites such as shistosomiasis, linked with water, are also of considerable concern in Egypt.

E3. Trace Metals

Trace metals are often present in ionic forms. Most of the amounts in water originate from human activities. They are of concern because of their toxicity to microorganisms and ultimately to humans. Trace metals include arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc. They come from a variety of sources: plumbing and gutters (cadmium and zinc), animal wastes (copper and zinc), paints (zinc), print ink (zinc), pesticides (mercury and zinc), and wastewaters from various industries.

E4. Oxygen-Demanding Substances

Oxygen-demanding substances are those substances which are oxidized in water. The two measurements most often associated with these substances are biochemical oxygen demand (BOD) and chemical oxygen demand (COD). These measurements are used as indicators for expressing stream pollution loads and in comparing conditions in a stream at various points.

Included in this category are a broad range of inorganic and organic substances. The chemical and biochemical transformations that substances may undergo in aquatic environments can cause substantial changes in the original compositions. These changes may affect the capability of biota to take up the substances. Only substances which can be taken up by biota, or are "bioavailable," can be toxic.

Sources for oxygen-demanding substances are the food industry, petrochemical industry, sugar cane refineries, domestic/urban effluent, and organic contamination from pulp and paper mills and textile processing.

E5. Pesticides

Pesticides include insecticides, fungicides, herbicides and algicides, although the term pesticides is often understood as "insecticides." Common pesticides include:

Insecticides
- Chlorinated hydrocarbons: aldrin, chlordane, DDT compounds, dieldrin, endrin, heptachlor, methoxychlor, lindane, toxaphene, hexachlorohexane (HCH)
- Organophosphates: diazinon, malathion, parathion

Herbicides
- Carbamate: carbyl
- Chlorinated hydrocarbons: 2,4-D; 2,4,5-T, Silvex

Fungicides
- Copper sulfate, ferbam, ziram

Algicide
- Mainly copper compounds

Water quality problems appeared shortly after the introduction of synthetic organic insecticides. Many of the early insecticides—such as DDT, toxaphene and dieldrin—belong to the chlorinated hydrocarbon compounds group. They are very stable in the environment and, similar to trace metals, can accumulate in the food chain. Organophosphates are degraded much more quickly than chlorinated hydrocarbons, but are more expensive.

E6. Nutrients

Nutrient elements in water usually exist in ionic forms. The two most important nutrients are nitrogen and phosphorus.

Various forms of nitrogen exist, for example, proteins, ammonia, nitrite, nitrate, urea, and nitrogen gas. Plants and some groups of bacteria synthesize proteins from inorganic forms of nitrogen (ammonia, nitrite and nitrate). Bacteria break down complex proteins into ammonia, nitrite and nitrate through a process known as nitrification.

Phosphorus is discharged to surface waters from domestic where detergents containing phosphorus are often an important factor in increasing the nutrient content of wastes.

Excess concentrations of these nutrients often come from human activities. One of the effects of the High Aswan Dam has been to increase the amount of synthetic fertilizer applied to Egypt's agricultural land. Fertilizers are designed to act as a source of nutrients.

E7. Salinity

While most human activities that affect water quality tend to increase the amount of dissolved salts in the water, the largest source of salinity is through irrigation water. Sea water intrusion is also a significant source in areas near the coast.

Excess water applied to agricultural fields drains through the soil, taking most of its salt load, but losing some of its water through evaporation and plant use. Because of the large volumes of water used for irrigation, the increased salt load is substantial. Domestic and industrial uses of water also tend to increase salinity.

E8. Oil and Grease

Available data on oil and grease reveal that the highest concentrations are found in areas where shipyards, docking facilities, and oil refineries are located. The concentration decreases downstream from these areas. This decrease may be attributed to dilution, vaporization, biodegradation, and/or sedimentation. The concentration of total oil and grease in water samples collected from midstream around Cairo was found to be around 2.5 mg/l (Moursy, 1983). The most polluted areas in the Cairo region are around the iron and steel factory, boat docks, and electric power stations (Moursy, 1981). At the port of Lake Nasser, on the other hand, oil and grease concentrations of up to 15.2 mg/l were detected. This is probably due to the presence of docking facilities and oil spills from ships (Moursy, 1983).

F. Pathways

Yearly, billions of tons of natural and synthetic chemicals move through Egypt's air, water, and soil environments. Most of these chemicals are transformed into other compounds through physical, chemical, and biological processes. A pathway assessment evaluates the chemical fate and transport of these substances.

In broad terms, the major pathways to receptors for pollutants are via:

- Air
- Soil
- Surface water
- Ground water

Each of these are interrelated to some extent. For instance, air pollution from a cement plant, when deposited on the ground, can have an adverse effect on soil and water resources. Water quality monitoring and management programs should be developed with an understanding of these pathways.

In this paper, hazards transported through the water environment are of primary concern. In Egypt, hazards such as water-borne diseases, agricultural chemicals, trace metals, and other substances are transported to receptors via:

- Drains discharging untreated industrial waste and sewage directly into the Nile River or clean water canals

- Irrigation canals which contain wastes and untreated industrial/municipal/domestic discharges

- Drains within the Nile Delta region whose waters have been contaminated by agricultural, industrial or domestic discharge and are used locally by farmers or mixed with canal water for reuse in agriculture

- Shallow ground water aquifers which have been contaminated from industrial and domestic effluent via seepage from lagoons or direct discharge onto the ground (by means of spills, leaky underground tanks or pipes, etc.)

- Through the food chain (fish and agricultural products)

G. Exposure Assessment

Exposure is defined as contact with a chemical or physical agent or it is the process by which an organism acquires a dose (Suter et al, 1993). Dose is a measure of exposure and can be defined as:

- The amount of a chemical ingested
- The amount of a chemical actually taken up
- The product of the ambient exposure concentration and the duration of exposure

Exposure can occur via:

- Respiration of air and water (inhalation exposure)

- Absorption through skin by direct dermal contact (dermal exposure)

- Ingestion of water and food (oral exposure)

Exposure to any particular chemical substance may occur on a one-time basis or accumulate over time.

The development of a comprehensive exposure pathway assessment for potential pollutants in the Nile River system for all of Egypt is beyond the scope of this report. However, perhaps the best comparable approach to this topic in Egypt was completed by PRIDE (1994) in Comparing Environmental Health Risks in Cairo, Egypt. For this assessment, the chemical quality of surface water in the Nile at Cairo, treated water at CWA, and analyses of tap water in Cairo residences were used to determine the dose of various chemicals to the population of Cairo. In addition, the dermal exposure from working, swimming, bathing, and washing articles in the Nile and canals was also evaluated qualitatively. The report concluded that such exposure could cause disease from water-borne parasites. The report stated that while this was a cause for concern, the actual risk was low, as few Cairo residents are exposed to surface water. Exposure of the general population of Cairo to various chemicals by eating contaminated fish was also investigated.

When applying such an assessment to the entire country, dose concentrations will vary considerably, depending on location, user habits (i.e., bathing, fish consumption), source of water, and other factors. For instance, it is expected that direct contact of the general population

with the canal, drain, and Nile water is more prevalent in rural areas than in the Cairo vicinity. Such contact would allow for greater exposure to water-borne organisms which cause disease. Consuming untreated well or canal water can also increase the annual dosage of trace metals, pesticides, nitrates, microbiological agents, and other chemicals. This especially holds true in the direct vicinity of industrial areas or near points where untreated wastes are disposed. Although not well documented, crops irrigated with contaminated water in Helwan and other industrial areas show signs of wilting and depletion, due to overdoses with chemicals.

H. Consequences

H1. General

The following presents the potential effect of water quality hazards on people, agriculture, and the environment.

H2. Parasites, Pathogens, and Viruses

Discharge of untreated or partially treated wastewater is one of the main causes of water pollution. It follows that, while neither recreational waters nor public water supplies need be absolutely free of pathogens to be safe, the higher the concentration of pathogens, the greater the probability that health problems will develop. Water-borne disease occurrences are common, even in the United States, where excellent sanitation and safe waste disposal are available to a much larger part of the population than is true in many less developed countries.

Another concern is the infection of humans, animals and plants from land application of water contaminated with pathogenic organisms. It is clear from many studies that under favorable conditions, enteric pathogens can survive for extremely long period of times in crops and in water.

In addition, contaminated irrigation water has introduced a number of water-habitat diseases which are vector-borne. These include schistosomiasis (bilharzia), from snails; malaria, filariasis, and arbovirus, transmitted by mosquitoes, and onchocerciasis (river blindness) and trypanosomiasis (sleeping sickness), from flies.

H3. Trace Metals

Since trace metals cannot be broken down, they can accumulate in the food chain of the ecosystem. The process begins when trace metals exist in low concentrations in water and sediment, then build up in higher concentrations in aquatic plants and animals. The subsequent consumption of these organisms by other organisms produce successively higher concentrations, until the concentrations in the organisms at the top of the food chain are sufficiently high to cause toxicity. Cadmium contamination is a major factor in high blood pressure in humans. A bone disease similar to rickets, "itai-itai," is caused by cadmium ingestion. Mercury poisoning is also well documented.

Metals are indestructible and have the potential to accumulate in the body, thus leading to chronic effects. Metals can be eliminated from the body only by excretion. The rate and pathway of excretion vary greatly from one metal to another. The biological half-life of arsenic in man is short, on the order of 5 to 10 hours. For methylmercury, it is about 70 days, while for cadmium the estimated half-life is around 20 years. It may also vary for the same metal in different tissues.

The half-life of lead in blood and soft tissues is on the order of a few weeks, versus an estimated biological half-life of about 10 years in bone.

Water contaminated with trace metals can have an adverse effect on crop production due to the phytotoxic effects of some heavy metals. In Egypt, the majority of research on the effects of irrigation water with high trace metal concentrations has been in the evaluation of wastewater reuse.

H4. Oxygen-Demanding Substances

The principal effects of these substances is to deplete available oxygen and decrease biological activities in surface waters. Oxygen dissolved in water is essential to many of the organisms making up an aquatic ecosystem. When the dissolved oxygen concentration falls too low, fish, benthic invertebrates, and other organisms are unable to survive.

A related category of substances are toxic substances. While they cannot be considered oxygen demanding, they are similar in that they produce conditions that cause death in aquatic organisms. The number of toxic inorganic and synthetic organic compounds which are produced by industry is constantly growing. Such substances are being produced in new forms so rapidly that the toxicologists cannot keep up with them. Many are corrosive, poisonous, inflammable or explosive. They enter humans and their environment by means of complex and interrelated pathways. They often become concentrated through the food chain, with minute quantities magnified thousands of times as they are consumed by higher forms of life. All forms of life are now exposed to increasing amounts of potentially toxic materials. Toxic organic substances have been found to be carcinogenic and are of major concern in solvents and other petrochemical products. A separate category for toxic substances was not included in the hazard assessment because almost no specific information exists on toxicity in Egypt.

H5. Pesticides

Water quality problems appeared shortly after the introduction of synthetic organic insecticides. Many of the early insecticides, such as DDT, toxaphene, and dieldrin, belong to the chlorinated hydrocarbon compounds group. They are very stable in the environment and, similar to trace metals, can accumulate in the food chain. For example, mollusks, which feed by filtering large volumes of water, have been shown to contain DDT with concentrations millions of times higher than the concentrations in surrounding water. Organophosphates are degraded much more quickly than chlorinated hydrocarbons, but are more expensive.

In the early 1950s, research began to define the nature of water quality problems caused by agricultural pesticides. Runoff from agricultural lands has been shown to be a major source of low-level pesticide contamination of surface waters. For many pesticides, concentrations in the sediment are higher than those in the overlying water. DDT is the most notorious pesticide. Due to its low cost and effectiveness against a variety of pests including disease-vector insects, it was used widely in the 1950s to 1960s, so much so that DDT was found in the Arctic, where it had never been used. Fish-eating birds and birds of prey, at the top of food chains, suffered the most. Since DDT reduces the thickness of bird eggs, making the eggs more easily broken, the population of birds of prey in the United States reduced sharply. Several species nearly became extinct. Production of DDT up to the 1960s was about 100,000 tons per year, and its half-life in the environment may be as long as 20 years. Hence, despite the fact that DDT has been banned

in many countries, a substantial amount of DDT will persist in the environment for many years to come.

H6. Nutrients

Excess nitrate in water is a concern primarily because the digestive process in some animals, most notably in human infants and ruminants, converts nitrate to toxic nitrite.

Under normal natural conditions, phosphorus exists at very low levels and is usually a limiting factor for bacterial and algal growth. Thus, when agricultural runoff containing even low levels of phosphorus is discharged into water bodies, algal blooms can occur. As a consequence of using detergents containing phosphorus, water bodies and streams receiving raw or treated household wastewaters have turned eutrophic, as increased phosphorus contents accelerate the growth of bacteria and algae in the water. The result has been aesthetic problems and decreased dissolved oxygen (DO) in water. The term eutrophication describes a condition of lakes or reservoirs involving excess algal growth, which may eventually lead to severe deterioration of the water body. Eutrophication is related to the residence time of water in a reservoir or lake, with increased residence time increasing the tendency toward eutrophication.

H7. Salinity

Saline water affects public health, agriculture, and the environment. In terms of public health, unpalatable salts may become toxic when present in high concentrations. Salinity also affects crops, since plants actively absorb soil water leaving most of the salt behind. Salt concentrations increase over time, thereby reducing the availability of soil water for crop uptake, reducing yield. The effect of excess salinity on the environment is also of concern. High concentrations of salts in water can be toxic to some species of fish. The effects of salinity, especially in agriculture, are well documented in the literature.

H8. Oil and Grease

Oil and grease in waterways and drinking water supplies pose threats to public health and the environment. Many petrochemical substances are considered carcinogenic and affect human life expectancies. The effects of oil and grease on fish and fowl are well documented in the literature. Excessive amounts could affect population size and specie diversity. Floating oil and grease also prevent the penetration of sun, inhibiting photosynthesis and affecting phytoplankton.

I. Hazard Assessment Procedures

The exercise undertaken for the Advisory Committee consisted of integrating the information presented above. Hazards were identified from data on pollutant sources. A qualitative pathway analysis included knowledge on Egypt's water resource system, transport processes, and contaminant factors. Rough estimates of exposure were made on the basis of information integrated from Egyptian demographic data and generalized procedures used in risk assessments.

For each of the regions identified by the Advisory Committee, scores were assigned to the hazards posed to agriculture, health, and the environment for the seven hazards identified. The scores were based on a qualitative assessment of exposure averaged over the entire region. Those regions where a specific, but localized, problem has been identified were generally given scores

that were somewhat higher than usual, but lower than if the entire region had experienced the problem.

The ranking is presented as a preliminary estimate based on expert judgement. Additional discussion will be sought; but these preliminary results can be used to aid decision making about water quality management. Future steps should include additional research, but action should not be limited to academic studies. Activities that reduce the amount of pollutants that reach the water system are needed.

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