ENVIRONMENTAL HEALTH ASSESSMENT:

A Case Study Conducted in the City of Quito and the County of Pedro Moncayo, Pichincha Province, Ecuador

WASH Field Report No. 401
PRITECH Report No. HSS-133IR
October 1993

PRITECH
Technologies for Primary Health Care

WATER AND SANITATION for HEALTH PROJECT

Sponsored by the U.S. Agency for International Development
Operated by CDM and Associates

WASH Field Report No. 401
PRITECH Report No. HSS-133IR

ENVIRONMENTAL HEALTH ASSESSMENT:

A Case Study Conducted in the City of Quito and the County of Pedro Moncayo, Pichincha Province, Ecuador

Prepared jointly by the WASH Project
and the PRITECH Project
for the Office of Health,
Bureau for Research and Development,
U.S. Agency for International Development,
under WASH Task No. 315A
and PRITECH Assignment No. HSS-133IR

by

(in alphabetical order)

Gustavo Arcia
Eugene Brantly
Robert Hetes
Barry Levy
Clydette Powell
José Suárez
and
Linda Whiteford

October 1993

This activity was jointly conducted by the WASH Project and PRITECH (Technologies for Primary Health Care). PRITECH is operated by Management Sciences for Health, in cooperation with the Academy for Educational Development, Inc.; the Department of International Health, School of Hygiene and Public Health, Johns Hopkins University; the Program for Appropriate Technology in Health; the Centre for Development and Population Activities; and Creative Associates International.

Water and Sanitation for Health Project
Contract No. 5973-Z-00-8081-00, Project No. 936-5973
is sponsored by the Office of Health, Bureau for Research and Development
U.S. Agency for International Development
Washington, DC 20523

Technologies for Primary Health Care (PRITECH) Project
Contract No. AID/DPE-5969-Z-00-7064-00, Project No. 936-5969
is supported by the Office of Health, Bureau for Research and Development
U.S. Agency for International Development
Washington, DC 20523

RELATED WASH REPORTS

Environmental Health Assessment: An Integrated Methodology for Rating Environmental Health Problems. Field Report No. 436. Prepared by Eugene Brantly, Robert Hetes, Barry Levy, Clydette Powell, and Linda Whiteford. October 1993.

Public Participation in Urban Environmental Management: A Model for Promoting Community-Based Environmental Management in Peri-Urban Areas. Technical Report No. 90. Prepared by May Yacoob, Eugene P. Brantly, and Linda Whiteford. October 1993.

Guidelines for Improving Wastewater and Solid Waste Management. Technical Report No. 88. Prepared by Richard N. Andrews, William B. Lord, Laurence J. O'Toole, L. Fernando Requena, with assistance from Eugene Brantly, Philip Roark, and Fred Rosensweig. August 1993. (Available in English and Spanish.)

The Unique Challenges of Improving Peri-Urban Sanitation. Technical Report No. 86. Prepared by William Hogrewe, Steven D. Joyce, and Eduardo A. Perez. July 1993.

Constraints in Providing Water and Sanitation Services to the Urban Poor. Technical Report No. 85. Prepared by Tova María Solo, Eduardo Perez, and Steven Joyce. March 1993.

CONTENTS

TABLES

ACKNOWLEDGMENTS

We wish to thank the following people for their assistance, advice, help in obtaining data, suggestions, and recommendations: Fernando Carrión, Gonzalo Bustamante, Jeanett Vega, René Vallejo and Gonzalo Sandoval at the Municipality of Quito; Eduardo Espín and Daniel Polo at IEOS; Marco Amaya and Alicia Alvarez at INEC; Charles Crissman and Patricio Espinoza at the International Potato Center; César Poveda and Antonio Chamba at CIMAS; and Carlos Linares and Daniel Seligman at the World Resources Institute. Special thanks are due to María Carmen de Sáenz and the coordinators for the focus groups: María Lourdes García and Ruth Llanes de Legún.

This study would not have been possible without the vision of USAID staff, including Mr. Dennis Long, Mr. John Austin, and Mr. Al Bartlett, and the support of staff at the USAID Mission to Ecuador, including Mr. Ken Yamashita and Mr. Sonny Lowe. We also relied upon the cooperation of Ms. Carol Dabbs of A.I.D.'s Bureau for Latin America and the Caribbean. In addition, we acknowledge the support of Glenn Patterson of PRITECH and Ellis Turner of WASH.

All of our lives were made easier, and our efforts more effective, by the excellent administrative support provided by Mr. David Fernandes of the WASH Project. We greatly appreciate his helpfulness, efficiency, and good cheer. We also thank Joanne Tighe at Management Sciences for Health for helping to edit this report and Ken Heise at PRITECH for his administrative support.

ABOUT THE AUTHORS

Gustavo Arcia, Ph.D., is a Senior Economist with the Center for International Development, Research Triangle Institute. His work has focused on environmental policy analysis and the development of policy analysis tools, especially concerning solid waste generation, deforestation, potable water demand, and the impact of population growth on natural resource use. Dr. Arcia has worked throughout Latin America and in several African countries.

Eugene Brantly, M.S., J.D., is the WASH Project technical specialist in Environmental Policy and Management and directs the International Environment and Natural Resources Program in the Center for International Development, Research Triangle Institute. At WASH, Mr. Brantly is responsible for adapting risk assessment procedures, priority-setting processes, and other methods used in environmental management in the United States for applications in developing countries. He has worked on projects in the United States, Indonesia, Belize, and Central Asia.

Robert Hetes, M.S.P.H., is a Research Environmental Scientist with the Center for Environmental Analysis, Research Triangle Institute, where he conducts research in risk assessment and risk characterization of environmental pollutants. He has worked in the public and private sectors in the United States in environmental impact assessment, industrial hygiene, and hazardous waste management.

Barry Levy, M.D., is a Public Health physician who has worked in environmental and occupational health for over 15 years, focusing for the last 6 years on work in developing countries and Eastern Europe. Dr. Levy has co-edited 8 books, published over 60 articles, and done extensive teaching, research, consultation, and program direction. At the time of this work, Dr. Levy was Director of the Program for Environment and Health at Management Sciences for Health.

Clydette Powell, M.D., M.P.H., is currently Senior Physician Consultant for The Harvard Community Health Plan and Harvard Medical School in Boston. As a medical epidemiologist, she conducts research in clinical quality management and health services delivery. Over the last seventeen years she has lived and worked in Asia, Africa, and Latin America/Caribbean, focusing on maternal/child health, epidemiology-based planning, urban health, and quality assurance.

José Suárez-Torres, M.D., M.P.H., Ph.D., is a member of the faculty of the Medical School, Central University of Ecuador. At the present time Dr. Suarez is a Fulbright Visiting Professor at Evergreen State College in Olympia, Washington. He has been conducting several research projects on the impact of environmental changes and socio-economic conditions of the epidemiological profiles of different population groups. For many years, Dr. Suarez has been a health consultant for several Ecuadorian and international organizations.

Linda Whiteford, Ph.D., M.P.H., is currently an Associate Professor of Anthropology at the University of South Florida. She has over 15 years of experience in dealing with international health-related issues, including medical anthropology, maternal/child health, and political economy of health. Dr. Whiteford has lived and worked in several countries in Latin America and the Caribbean, including Mexico and the Dominican Republic.

ACRONYMS

A.I.D.	U.S. Agency for International Development (Washington)
EHA	Environmental Health Assessment
EPA	U.S. Environmental Protection Agency
PRITECH	Technologies for Primary Health Care
RfD	Reference Dose
R&D/H	Bureau for Research and Development, Office of Health, A.I.D.
USAID	U.S. Agency for International Development (overseas mission)
WASH	Water and Sanitation for Health Project

EXECUTIVE SUMMARY

With the initiative of the Office of Health/Bureau for Research and Development, USAID (R&D/H), and the assistance of USAID/Quito, a team of five specialists conducted Environmental Health Assessments in the city of Quito and the county of Pedro Moncayo, Pichincha Province, Ecuador, from June 8 through June 26, 1992. The study was designed to develop methods for conducting Environmental Health Assessments; to test the methodology and identify significant environmental health hazards in an urban area (Quito); to test the methodology and identify significant environmental health hazards in a rural site (Pedro Moncayo); and to provide information for setting priorities in the environmental health sector for these locations.

This assessment examined health risks attributable to a comprehensive set of environmental conditions: water supply, sanitation, wastewater, solid waste, food hygiene, vector-borne diseases, ambient and indoor air pollution, toxic and hazardous materials, occupational hazards, and non-occupational injuries. The purpose of an Environmental Health Assessment is to identify and compare risks caused by different types of environmental hazards and to determine the types of hazards that present the greatest risk to public health. Such cross-sectoral analyses are important for setting priorities and developing appropriate emphases for local or national environmental health programs. Because conditions change, such assessments should be repeated periodically.

The results of this Environmental Health Assessment for Quito as a whole revealed that (a) food contamination with microorganisms and outdoor air pollution appear to be the leading sources of environmental health risks; (b) traffic hazards, occupational hazards, exposure to contaminated drinking water and wastewater, and indoor air pollution appear to be at the next level of importance; and (c) solid waste and food contamination with pesticides present relatively lower health risks. The environmental health risks of airborne lead and non-food sources of pesticides could not be estimated because of lack of adequate data.

Data were evaluated separately for working-class neighborhoods (*asentamientos populares* *) in Quito. Results revealed that (a) food contamination with microorganisms, outdoor air pollution, occupational hazards, exposure to contaminated drinking water and wastewater, and indoor air pollution are all important sources of environmental health risks; and (b) traffic hazards, solid waste, and food contamination with pesticides appear to be of less importance.

For Pedro Moncayo the main problems appeared to be pesticide exposure, indoor air pollution, traffic hazards, and diarrheal disease due to contaminated drinking water, inadequate sanitation, and improper personal hygiene.

---

* *Asentamientos populares* are established working-class neighborhoods located throughout the Quito metropolitan area that originated as informal settlements and still have inadequate public services.

ASSESSMENT OF ENVIRONMENTAL HEALTH RISKS IN QUITO

Risk	Quito as a whole	*Asentamientos Populares*
High	Food Contamination: Microorganisms	Food Contamination: Microorganisms
	Outdoor Air Pollution	Outdoor Air Pollution
		Occupational Hazards
		Drinking Water
		Wastewater
		Indoor Air Pollution
Medium	Traffic Hazards	Traffic Hazards
	Occupational Hazards	Solid Waste
	Drinking Water	
	Wastewater	
	Indoor Air Pollution	
Low	Solid Waste	Food Contamination: Pesticides
	Food Contamination: Pesticides	
Not Estimated	Lead (air)	Lead (air)
	Toxic Substances: Pesticides (non-food sources)	Toxic Substances: Pesticides (non-food sources)

This study shows that ethnographic data are extremely useful in adapting risk assessment methodology to developing countries. Ethnographic data, which were obtained from focus groups, personal interviews, and structured observations, proved useful in defining behavioral patterns that can greatly influence exposure and in revealing hazardous environmental factors and conditions that may not have been apparent from existing (secondary) data on environmental quality and environmentally-related mortality and morbidity. The limitations of available data made it impossible to conduct a quantitative risk assessment, but secondary data and information from focus groups were sufficient to obtain a consistent picture of environmental health problems. The Environmental Health Assessment methodology used in this project could be used elsewhere, although further modifications are needed for applications in rural areas.

Chapter 1

INTRODUCTION

1.1 Background

Developing countries throughout the world are experiencing rapid urbanization and industrialization, which greatly influence the public health problems that these countries confront. The "pre-transition" infectious diseases associated with inadequate sanitation, contaminated water supplies, poor housing, and overcrowded living conditions continue to compromise the health of millions of people, especially in peri-urban settlements. At the same time, increases in industrial employment, use of hazardous materials, traffic congestion, air pollution, and cigarette smoking, among other changes, are increasing the occurrence of "post-transition" diseases such as work-related and traffic-related injuries, respiratory disease, heart disease, and cancer (Jamison, 1991).

Because of these trends, local and national governments in developing countries face health problems of increasing complexity that must compete for attention with other priorities central to achieving sustainable economic development. There is a pressing need for analytical methods that will help developing country officials set priorities and make sound policy decisions in the health and environmental sectors. This need has been recognized by international donor agencies and professionals in the environmental and health sciences. Many organizations are working to develop tools for investigating, characterizing, and prioritizing public health problems.

The Office of Health of the Bureau for Research and Development, U. S. Agency for International Development (USAID/R&D/H), is participating in this research effort by developing procedures for conducting Environmental Health Assessments. This study was implemented under two contracts managed by the Office of Health: the Water and Sanitation for Health (WASH) Project, and the Technologies for Primary Health Care (PRITECH) Project. WASH and PRITECH performed this study as a joint effort and cooperated in every aspect of the work.

1.2 Approach and Scope of Work

An Environmental Health Assessment (EHA), as defined and applied in this study, examines a broad range of environmental conditions that have adverse health consequences and seeks to determine which of the conditions present the greatest risk to public health. By identifying the most serious environmental health problems in a particular city or village, an EHA provides objective information to help municipalities, national governments, and donor agencies identify new investments, allocate existing resources, and make other decisions that will improve environmental conditions related to public health. Cross-sectoral assessments are important for setting priorities among sectors, and should be repeated periodically as conditions change. This type of assessment goes beyond "comparative health risk assessment" as it has been applied in the United States (Minard, 1993, and USEPA, 1992) and in developing countries (USAID, 1990).

The Environmental Health Assessment performed in Ecuador involved the integration of three approaches to investigating public health problems: comparative health risk assessment, health effects (outcome) assessment, and ethnographic investigation of health-related behavior. The assessments reported herein rely primarily on existing (secondary) data concerning environmental factors and the occurrence of environmentally-related diseases. These secondary data were supplemented with original (primary) ethnographic data collected by the study team.

Consistent with related programs at the World Health Organization and the World Bank, USAID has defined "environmental health" to include public health problems associated with the following (USAID, 1991):

"Pre-Transition" environmental health problems:	"Post-Transition" environmental health problems:
water supply	air pollution (ambient and indoor)
sanitation and wastewater	occupational health
solid waste	toxic and hazardous materials
food hygiene	traffic and household injuries
vector-borne diseases	

A brief description of the EHA methodology is presented in Chapter 2 of this report. A second report (Brantly, et al., 1993) describes the EHA methodology in greater detail.

1.3 Objectives of the Assessment

This study had three objectives:

To develop and refine a method for conducting Environmental Health Assessments. The principal objective of this study was to develop and test procedures for conducting an EHA. USAID/R&D/H intends to use procedures developed in this study to conduct EHAs throughout the regions in which USAID is active.

To test the EHA methodology in an urban location. The study team conducted an EHA in Quito, Ecuador, examining most of the environmental health concerns listed above. This report identifies specific environmental health hazards in Quito and describes how residents of Quito are exposed to these hazards. Special attention was devoted to assessing risks in Quito's peri-urban neighborhoods, referred to as *asentamientos populares*.* Subject to the acknowledged limitations of the methodology, this report identifies which hazards present the greatest threats to public health in Quito as a whole, and in the *asentamientos populares* separately.

---

* *Asentamientos populares* are established working-class neighborhoods located throughout the Quito metropolitan area that originated as informal settlements and still have inadequate public services.

To test the EHA methodology in a rural location. The study team also attempted to conduct an EHA in the county of Pedro Moncayo, Ecuador, focusing on problems specific to rural life (inadequate water supply and sanitation, exposure to pesticides, contamination of indoor air by cooking and heating fires, and occupational health problems). This report identifies specific environmental health hazards in Pedro Moncayo and describes how residents are exposed to these hazards. Although the assessment in Pedro Moncayo was less extensive than the assessment in Quito, this study made a preliminary attempt to determine sources of environmental health risk to residents of Pedro Moncayo.

This study was a rapid assessment, intended to make a first approximation of environmental health risks. The study team spent approximately three weeks in Quito and Pedro Moncayo. Substantial effort was invested in gathering information prior to the team's arrival. The first half of the time in Quito was spent collecting primary ethnographic data and reviewing secondary data on environmental conditions and health outcomes. The remaining time was spent interpreting the data, evaluating and rating health problems, and preparing an initial draft of this report. A more extensive study involving the careful evaluation of primary data sources and data collection methods, collection of additional primary data, and more extensive contact with Ecuadorian scientists, officials, and communities would yield more comprehensive and more authoritative results. However, the great demand for such studies, compared to the limited resources available for conducting them, requires that Environmental Health Assessments be performed as rapid assessments. Studies of broad scope and limited duration necessarily produce results that are subject to substantial uncertainty. We have attempted to fully review the uncertainties associated with the results of this study. Notwithstanding these uncertainties, we feel the conclusions derived from this study are well-founded and useful.

The results of this study should be useful to the local governments of Quito and Pedro Moncayo, and to the national government of Ecuador, in setting priorities for future new investments and for allocation of existing resources to further evaluate and control environmental health problems. The study examined problems that are now thought to pose significant risks to public health, as well as conditions that are not now considered important threats. As is often the case with such studies, the results reveal that some previously unrecognized risks are significant and others, which are significant in the public's consciousness, may not be so serious. USAID/R&D/H and the USAID Mission to Ecuador hope that these results will form a base upon which the relevant Ecuadorean authorities may begin to build a strategy for reducing environmental health risks.

1.4 Organization of this Report

The remainder of this report is organized as follows:

Chapter 2 describes the methodology for conducting an Environmental Health Assessment, as tested in this study and proposed for use in future assessments. The section also describes the known limitations of this methodology.

Chapter 3 presents results of the EHA conducted in Quito. It begins with a brief overview of environmental conditions in Quito and the main population groups considered to be at risk for environmental health problems. The chapter then presents the results of the risk assessment in detail and presents the comparative ratings of environmental health problems for Quito.

Chapter 4 presents results of the EHA conducted in Pedro Moncayo and describes the environmental health problems studied. Data were not sufficient to support a comparative rating of environmental health risks in Pedro Moncayo.

Chapter 5 summarizes the results and states the conclusions of this Environmental Health Assessment.

Chapter 2

METHODOLOGY

2.1 Overview

An Environmental Health Assessment (EHA), as developed and applied in this study, involves the integration of three approaches to investigating public health problems:

> *Comparative health risk assessment*, as developed and practiced under the sponsorship of the U.S. Environmental Protection Agency, for the study of environmentally-related health problems (USEPA, 1987 and 1993);
>
> *Health effects (outcome) assessment*, as developed and practiced by epidemiologists (Agency for Toxic Substances and Disease Registry, 1992); and
>
> *Ethnographic investigation of health-related behavior*, as developed and practiced by medical anthropologists concerned with public health problems (Scrimshaw and Hurtado, 1987).

The authors believe that the integration of these three approaches to studying health problems is critical to the success of an EHA in developing countries, for the following reasons.

Comparative health risk assessment and *health effects (outcome) assessment* techniques complement each other.

First, they have been applied to different types of public health problems, all of which must be examined in industrializing countries. Health risk assessment techniques have focused almost exclusively on cancer and other health outcomes as they relate to exposures to various chemical elements and compounds. Dose-response relationships and exposure assessment methods are only now being developed for water-borne microbes, and only for problems that still may affect populations in industrialized countries (e.g., infection with Giardia or Cryptosporidium) (Rose et al., 1991; Rose and Gerba, 1991 a and b; and Bennett et al., 1987). Epidemiological methods have long been used to assess the occurrence of and determine the causes of "traditional" public health problems and thus augment the value of health risk assessment investigations in developing countries.

Second, the data sets needed to support both types of analysis are typically incomplete. Data on environmental conditions and exposure that are needed to support quantitative health risk assessment are not available in most developing countries. Information may be available regarding the concentrations of selected pollutants in ambient, indoor, and work environments; such data are often the product of narrowly-defined investigations by government scientists, academicians, and donor agencies. Systematic monitoring programs are rare. Similarly, the clinical and public health data upon which epidemiological methods rely are generally collected and maintained in a manner that prevents, or at least impedes, efforts to associate environmental conditions with the occurrence of health outcomes in a well-defined population in a geographically-bounded area. By using risk assessment and epidemiological techniques together, one hopes to obtain two data sets that will, at least in part, complement each other.

Ethnographic investigations aid health risk assessment and health effects assessment in two ways.

First, from an operational perspective, ethnographic investigations provide information about people's behavior and activity patterns that helps identify the environmental conditions to which they are exposed. Such information is critical to health risk assessment: standard assumptions appropriate to previously studied populations (e.g., diet in the United States) can be modified to be more appropriate to the culture(s) being studied; people's practices, such as boiling water from the public water supply, are usually rational and may indicate problems that official data (such as the quality of water when it leaves the treatment plant) may not reveal. Ethnographic information is also important to health effects assessment: information about people's work conditions, home conditions, and health status can be used to augment official statistics, such as those concerning occupational exposures and disease. In short, people are probably the best source of information about the environmental conditions that affect them and the health problems that they experience. When the official data bases are incomplete and the investigatory methods being used have been developed for a culture different from that being studied, ethnographic methods must be employed as an integral part of an Environmental Health Assessment.

Second, from a more philosophical perspective, people's perceptions of the environmental health problems they face—at least the effects, if not the causes—can also contribute to the conclusions produced by health risk assessment and health effects assessment. Extensive research on risk communication has demonstrated that "perceived risk" is a personal perception of physical reality: some risks are more important—i.e., less acceptable—than others. Comparing risks and assigning priorities to various sources of risk involve subjective judgments that should be made by the people who bear those risks. The process of rating risks should be open and democratic; it should emerge from an egalitarian process of public discussion, supported and informed by conclusions from the best objective investigations that can be made with today's methodologies. Ethnographic investigations are a first step in understanding people's perceptions. They are also a necessary prerequisite to working effectively to bring about a broader process of public discussion, participatory decision-making, and sustainable change.

The remainder of this chapter describes how the team applied each approach and integrated the results. It also briefly describes the known limitations of the methodology employed.

2.2 Health Risk Assessment

In this section, we describe health risk assessment, the basic methodology on which the approach in this study was based.

Health risk assessment is the procedure by which potential adverse health effects of human exposure to toxic agents are characterized. It includes four components: hazard identification, exposure assessment, dose-response assessment, and risk characterization (see Pierson, 1992).

2.2.1 Hazard Identification

Hazard identification is a qualitative determination of whether human exposure to an agent has the potential to produce adverse effects. It involves an evaluation of all available toxicology data and other relevant biological and chemical information for the agent under consideration, including:

- Physico-chemical properties relevant to exposure
- Sources, routes, and patterns of exposure
- Structure-activity relationships
- Metabolic and pharmacokinetic properties
- Short-term in vivo and in vitro tests
- Long-term animal studies
- Human exposure studies
- Human epidemiological studies.

The most direct evidence for hazard identification comes from human studies, but in most instances the preponderance of available information on toxic effects comes from animal studies. Thus, the identification of agents hazardous to human health usually requires assumptions regarding the biological similarity of various mammalian species, as well as assumptions about the applicability of toxicity test conditions (e.g., route of exposure, frequency, and level and duration of doses) to estimated human exposure conditions. In general, unless there are human toxicity data or comparative metabolic data that refute animal toxicity data, human health effects are inferred from the results of animal studies.

Hazard identification of biological hazards is more direct and involves more human evidence because particular organisms may be pathogenic in a limited number of species. Extrapolation from animal studies is not as common as in evaluating chemical hazards. Also, biological hazard identification is different in that it focuses on actual clinical data rather than on controlled experiments. Therefore, there are typically few data on dose-response or minimum infectious dose levels.

2.2.2 Exposure Assessment

Exposure assessment involves the identification and characterization of the composition, location, and behavior of people exposed to a hazardous agent, and the quantitative or qualitative estimation of the level and duration of their exposure. Since assessing exposure may be very difficult in developing countries, appropriate methods for assessing exposure must be selected on a case-by-case basis, depending on the available data and the level of sophistication required. Under ideal conditions, exposure assessment should consist of four steps:

Determination of the concentration of disease-causing agents in the environment;

Estimation of the magnitude, frequency, and duration of human exposure to such agents;

Estimation of dose received, usually expressed as Maximum Daily Dose for acute, subchronic, or chronic exposures to non-carcinogens, or as a Lifetime Average Daily Dose for carcinogens; and

Characterization of exposed populations and individuals, in terms of their personal and exposure characteristics, and identification of subpopulations at a potentially higher risk.

2.2.3 Dose-Response Assessment

Dose-response assessment is a quantitative process that involves (1) defining the relationship between the administered or received dose of a substance and the prevalence of an adverse health effect in an exposed population, and (2) using a mathematical dose-response model to estimate the probability of occurrence of the effect based on human exposure to the substance. Although biologically plausible models are highly desirable, the mechanisms of action of many toxic substances and chemical mixtures are not well understood. In such instances, statistical models that best represent the available data are used to model dose-response relationships.

If available, dose-response estimates based on adequate human data are preferable to those derived from animal data. In the absence of appropriate human studies, data from studies of animal species that respond most like humans should be used. When several studies are available for a given agent, all biologically and statistically acceptable adequate data sets should be presented. The U.S. Environmental Protection Agency (EPA) Risk Assessment Guidelines (1987) recommend placing the greatest emphasis on data sets from long-term animal studies showing the greatest sensitivity in order to account for sensitive human subpopulations. Some analyses, however, might stress biological similarity to humans over sensitivity. All of the studies used should meet the minimum design requirements specified by the EPA Risk Assessment Guidelines (1987).

The use of animal data to estimate risks from human exposure requires at least two major extrapolations: (1) interspecies dose extrapolations to adjust for differences between human and laboratory animals in factors that may potentially affect the response to the toxic agent; and (2) extrapolation of the dose-response relationship observed at the relatively high doses used in animal experiments to the much lower doses to which humans are likely to be exposed.

Dose-response relationships are not readily available for biological contaminants because most data comes from clinical settings. At times, references can be made with regard to infectious dose, but in most cases the relationship is simply defined in terms of exposed versus nonexposed individuals.

The estimation of dose-response relationships for the citizens of Quito with respect to their exposures was not an active part of this study. Rather, dose-response relationships previously identified in epidemiological and laboratory animal studies were used in conjunction with exposure information to derive estimates of environmental health impacts. The dose-response relationships used may be derived from epidemiological evidence in other countries (e.g., ambient air pollution in the United States) or from laboratory animal studies (e.g., cancer risks of pesticides). There are no data indicating that the population of Quito differs significantly in its susceptibility or immunity compared to other populations. Therefore, it is assumed that the Quito population is sufficiently similar to these other populations so that previously established dose-response relationships can be used. Furthermore, data for Quito were usually insufficient to estimate exposure and therefore dose-response relationships could not be applied. Subjective judgment was therefore often used to estimate magnitude of exposure.

2.2.4 Risk Characterization

Having assessed the nature of the hazard, evaluated the appropriate dose-response coefficients, and estimated the level and magnitude of exposure, one can characterize the risk to human health from an agent. Depending on data quality or level of sophistication required, risk characterization can go from highly detailed accounts of dose-response relationships on a well-documented exposure level for a given population, to a qualitative description based on best guesses about exposure. Under ideal circumstances, risk characterization can produce:

- A numerical estimate of the probability that an individual will experience an adverse effect from the estimated exposure and dose-response factors;
- A numerical estimate of the number of cases of the adverse effect that will occur in the exposed population; and
- A discussion of assumptions and uncertainties in the risk estimate.

2.2.5 Limitations

If data are scant or biased, or if there is incomplete information about the hazard, the dose-response coefficient, or the level of exposure, the characterization of a risk must be performed qualitatively, as we have done in this study. In developing countries, environment and health data may be scant, of poor quality, or biased. The rankings of environmental health problems developed with scant or biased data, especially when the nature of the bias is unknown, need an external point of reference, such as ethnographic data, for comparison and for determination of whether findings are mutually consistent. (If these data sets are in agreement, one feels more confident about the findings. If they are not, one should search for explanations for discrepancies.) Such a comparison may be of extreme importance when one considers that the reference values used by USEPA in risk assessment are usually conservative and are applicable to people with prior health and social conditions that are much different than those of developing country populations.

Finally, situations in which more than one adverse environmental factor affects human health are far less common in the United States than in developing countries. Thus, the cumulative effects of poor health, and the combined effects of several adverse environmental factors acting in unison, may yield a completely different set of rankings than from a straightforward risk assessment based on secondary data.

2.3 Health Effects (Outcome) Assessment

Health effects assessment is a methodology used to identify and evaluate the adverse impacts on human health from external factors. This methodology is used to identify and describe the type and magnitude of health effects according to time, place, and person. In Environmental Health Assessment, it is used to identify and describe adverse health effects that may be related to environmental factors, to estimate the number of people affected, and to estimate what portion of these health effects are environmentally related.

Health effects assessment relies on secondary data from a variety of potential sources. These sources include birth and death certificates, from which data are generally tabulated and analyzed by the ministry of health or national office of health statistics; clinically-derived data from hospitals and outpatient health centers, clinics, and dispensaries; workers' compensation data, generally obtained by the ministry of labor; disability data, obtained by the national social security system or other government units; and data from surveys and special studies conducted by the ministry of health, university programs, and research institutes.

One must always keep in mind that data from secondary sources have been collected for other reasons, which are important to understand in order to use the data appropriately. Data may be incomplete or biased for a number of reasons. For example, data often have a bias of including only those symptomatic individuals who seek and obtain medical care. In addition, many adverse health effects may have multiple causative or contributing factors, and the environmental portion of their causation may not be appreciated. For example, occupational respiratory disease may not be correctly attributed to workplace exposures.

Interpretation of health effects data also involves an understanding of the access to medical care, the quality of medical care, and any disincentive there may be—as there often is for occupational diseases or injuries—to diagnose or report cases.

2.4 Ethnographic Methods

Ethnographic investigations use a variety of methods to collect information on people's knowledge, attitudes, and behavior. Three techniques were used to collect ethnographic information in this study: focus groups, structured observations, and in-depth interviews.

2.4.1 Focus Groups

Focus group research is a technique used for eliciting responses from a selected population about a particular subject. Focus group research is particularly useful as a technique to gather data from several people in a relatively short time, and to elicit information about people's behavior concerning a single subject.

The incorporation of ethnographic field methods into environmental health assessment provides the people being studied a voice, and provides the researchers with insight into the community. The current research achieved this by the incorporation of focus group research and the cooperation of community-based assistants. The focus group interviews provided community members an opportunity to describe their health-related behaviors, to express their opinions, and to discuss their environmental health concerns. Equally important, the discussions provided the researchers access to the terms and concepts community members used to represent the issues of significance.

Successful focus group research depends on participant selection, determination of appropriate questions and their associated probes, linguistic and community competence of assistants, and the ability of the facilitator. Selection of focus group participants should be according to criteria established by the research needs. Culturally appropriate and locally meaningful questions should reflect local language uses and community needs. Appropriate community-based assistants can provide insight into both language use and conceptually meaningful categories (within the agreed-upon research agenda) to be investigated. The role of the focus group facilitator is to create an ambience for discussion, to provide limited direction to the group, and to listen to both what is stated and what is implied. In combination, the community-based assistants, the focus group participants, and appropriate questions provide access to a variable and flexible range of human concerns too often omitted, ignored, or frozen out by other research methodologies.

Community-based focus groups also provide an opportunity to know members of the community with whom the researcher may wish to meet in order to follow up, in more depth, on issues raised during the focus groups. In such instances, the community-based assistants legitimate the researcher's presence and facilitate contact with members of the community.

For this environmental health assessment, 60 participants in six different focus groups discussed their perceptions of what constitute environmental health risks and the behaviors associated with them. Variables examined during the discussion included behaviors and beliefs surrounding water usage and disposal, sanitation, home exposure to toxic substances, occupational hazards, food hygiene, waste disposal, and air pollution. Focus groups were conducted in three peri-urban neighborhoods of Quito: Solanda, Comité del Pueblo, and Carapungo. These neighborhoods represented urban areas with limited access to urban services, and with a greater proportion of people at risk for environmental health problems than older and more established neighborhoods of higher household income. These neighborhoods are located to the north and south of the central city.

Only women participated in the focus groups in Quito because they are the family members most often responsible for food preparation, home water use, waste disposal, and child health. Moreover, the selection of lower-income women allowed for the evaluation of environmental health effects on people most at risk of water-borne diseases and diseases spread by the fecal-oral route, who are also most likely to be exposed to other environmental hazards. Although the women selected for the focus groups were of relatively homogeneous socioeconomic status, they did not know each other, thus allowing for a freer exchange of opinions.

The focus groups lasted 1½ to 2 hours. Discussions were tape recorded, while the facilitator and two assistants took notes. The tapes were reviewed immediately after the focus group ended, and were analyzed for patterns and substantive content.

2.4.2 Structured Observations

Structured observations were conducted in six households and in the general neighborhoods of Solanda, Comité del Pueblo, and Carapungo. Observations focused on personal water use patterns, location of water sources in relation to dwellings, disposal of uncollected garbage and sewage, latrine use, cooking patterns and ventilation, location of the kitchen, safety practices, and gender-specific labor patterns. In two neighborhoods (Solanda and Comité del Pueblo), garbage dumps were observed and photographed. Street vendors and market vendors were also observed and photographed. Although efforts were made to include factories in the observation process, this proved to be very difficult since access to factories is highly restricted. Informal sector labor practices, such as street vending, shoe repair, carpentry, and home preparation of food for sale, were observed following interviews, but were not considered in the rating process in this study. (This may be an area for development in the future. Evaluation of these practices could involve gathering new data beyond the scope of this study.)

2.4.3 In-depth Interviews

In-depth interviews were conducted with the Director and Deputy Director of the Department for Social Promotion, Municipality of Quito; with the Director, Deputy Director, and technical personnel of the Department of Planning, Municipality of Quito; and with municipal social workers working in the neighborhood of Inticucho, a neighborhood with potable water and no other services. They were also conducted with residents of each of the neighborhoods in which the focus groups were held. Municipal government officials were asked to list the most severe environmental health risks faced by the population of Quito. Informal interviews were also conducted with middle-class professionals in the fields of public health, dentistry, and education.

2.4.4 Integrating Ethnographic Data with Other Data

Ethnographic data generated through the focus groups, in-depth interviews, and structured observations were integrated into the analysis through a variety of techniques and sequentially throughout the duration of the project. The techniques used were oral information disseminated in team meetings, written analyses, focus group topic ranking, on-site observations, and cross-editing of work with other members of the team.

The focus group research was conducted during the initial phases of the field project, and the information generated was provided to the other members of the team in informal meetings during the first week of the field study. By the end of the second week in the field, all of the focus groups had been conducted and the data were reported according to the study categories (e.g., occupational health, air pollution). Consequent to the provision of focus group data, team members made visits to homes, workplaces, and a garbage dump in one of the communities studied, thereby providing actual on-site experience to all members of the research team and allowing firsthand knowledge of the social and physical environment.

During the third week of the field study, focus group participants' opinions on environmental health risks were rated and this information was incorporated in the team's evaluation of data and the development of an overall rating system. Also during this period, team members read each other's preliminary reports and added information where appropriate. The results of the focus group rating were returned to key informant members of the communities for their review and comment; this information, in turn, was integrated into the rating done by the team.

2.5 Rating Environmental Health Risks

Rating of risks requires a comparison of widely varied health effects that differ in occurrence and severity. Health endpoints may range from acute disease or illness that is not life-threatening to death. In addition, there may be a wide range of data available for each environmental concern. Where health data outcome data are not available, exposure data may have to be used; and where exposure data are not available, surrogates for exposure data, such as information on use of a hazardous substance, may have to be used. As a result, the confidence and type of risk estimates may also vary greatly, with some risks being characterized in quantitative terms, while others may be limited to qualitative descriptions. How to compare "apples and oranges" is often a difficult task. As a result, comparative risk assessment is often a subjective exercise relying on professional experience and judgment, including assessment of the validity of data and assessment of the certainty of conclusions drawn from various studies and data sets. Data must be analyzed and integrated before ratings can be done.

Traditional risk assessment methods use a qualitative matrix for classifying risk levels, depending on the probability of occurrence and the relative severity of an adverse health effect. In general, such methods use three risk levels (low, medium, and high) (Pierson, 1991). This study used a rating system employing five scoring levels to attempt a finer resolution with regard to severity and probability. These rankings were ultimately combined into a 3-tiered summary ranking (1-6 = high; 7-8 = medium; and 9-10 = low.)

The score for probability of effect (Table 1) is based on the percent of the total population that is likely to be exposed to a hazard and either a qualitative or quantitative estimate of those experiencing an adverse effect. For example, for every 100 people in the city, 75 (75%) may be in danger of being exposed to air pollution. However, only 50 of these 75 (66.7%) people may actually experience an effect. Hence, the *probability* of effect is 75% x 66.7% = 50% (probability of effect score = 1). When only qualitative descriptions are available, the descriptive terms "very low" to "very high" can be used.

Table 1

Scoring for Probability of Effect

Probability of Effect (probability of exposure x probability of effect *among those exposed*)	Score
0-.10 (Very Low)	5
.11-.20 (Low)	4
.21-.30 (Medium)	3
.31-.40 (High)	2
.41-1.00 (Very High)	1

The score for severity of effect (Table 2) is based on the most severe effect that may reasonably be expected to occur, based on prior laboratory, clinical, or epidemiological studies. For example, it is known that exposure to certain types of air pollution may lead to serious acute respiratory disorders. These acute respiratory disorders may range in severity from reduced ability to exercise to increased incidence of bronchitis. Air pollution may also result in respiratory dysfunction wherein a person's respiratory capacity may be significantly and permanently reduced, or in even more serious and permanent diseases, such as lung cancer. Hence, the severity score is 2.

Table 2

Scoring for Severity of Effect

Severity of Effect (seriousness of impairment x duration)	Score
Very mild	5
Mild	4
Moderate	3
Serious	2
Death	1

Using numerical scores may imply a greater degree of accuracy and certainty than is actually present in the ratings. Subjective elements are inevitably involved in assigning a score for probability of effect and severity of effect. The experienced investigator uses information drawn from experience in other countries, the uncertainty associated with dose-response coefficients for a particular variable, and the subjective judgment regarding the percentage of people expected to be exposed. In some cases, the score may be based on the upper limit percent of people likely to be exposed (e.g., ≤ 75%), while in other cases, it may be based on a lower limit (e.g., ≥ 50%). In some cases, the quantitative estimates are used as a guide and adjustments may be made when a comparison is made between environmental health problems. For example, when two environmental health concerns are evaluated separately, initially similar scores may be assigned. However, when the two are compared, adjustment may be made to one or the other if professional judgment indicates that the two risks may differ either in severity or probability of effect.

The total score assigned to the environmental risk is the sum of the scores for likelihood of effect and severity of effect. As shown in Table 3 below, items with high severity and high probability of effect will be grouped on the upper left hand corner of the matrix. These are the items posing the highest environmental health risk to the population.

Risk ratings were defined as follows, based upon the observed clustering of environmental problems evaluated:

Low Risk	9 to 10
Moderate Risk	7 to 8
High Risk	1 to 6

For example, an environmental condition presenting a high probability of effect (i.e., 1) to a toxicant that causes serious permanent damage to an organ system (severity score of 2) would have a total risk score of 3, and be considered a high-risk problem. Conversely, situations ascribing a low probability of effect to toxicants that cause minor health effects will be grouped on the lower right hand corner of the matrix, and will be deemed low-risk problems. Scores along any diagonal, lower left to upper right, would be considered equivalent. High severity-low probability effects are assumed to be equivalent in overall importance to low severity-high probability effects, and the scoring system reflects this.

Table 3

Matrix Illustrating Sum of Scores of Severity of Effect and Probability of Effect

Probability \ Severity	1	2	3	4	5
1	2	3	4	5	6
2	3	4	5	6	7
3	4	5	6	7	8
4	5	6	7	8	9
5	6	7	8	9	10

2.6 Limitations of the Study

The following is a brief summary of limitations of the process used in and results obtained from this study.

2.6.1 Scope of Work

As with any research effort, this study was designed with a finite scope of work to meet specific objectives. Readers of this report should recognize the following limitations on the use of results from this study.

First, this study evaluated health risks associated with a specific set of environmental conditions. It did not examine potential risks attributable to many other significant health problems, such as AIDS or cardiovascular disease. The results, therefore, should not be used to set priorities for environmental health investments vis-a-vis other types of health-sector issues not addressed, such as primary health care, maternal and child health, and AIDS.

Second, this study has determined which environmental health problems present significant risks in the communities examined; these problems deserve further attention. The study made no attempt to (a) identify the activities and policies that contribute to the creation of the environmental conditions presenting such risks, or (b) develop strategies or specific approaches to control the risks identified. The results, therefore, do not provide any insight regarding what actions will be needed to manage environmental health risks in Quito and Pedro Moncayo. In many cases, the most appropriate next step is additional evaluation to develop a thorough understanding of the causes and dimensions of the environmental problems presenting the greatest risk.

Third, this study made no attempt to estimate either the costs of illnesses attributable to environmental conditions or the costs of risk reduction (or risk management). The central purpose of our study was to estimate the risk of illnesses attributable to environmental conditions. For those situations in which major investments will be needed to address specific environmental health problems, the costs and benefits of such investments should be examined carefully to determine whether the investments are economically sound.

Finally, public health is only one of several perspectives from which the potential impacts of environmental degradation may be viewed: potential impacts on the ecosystem and on economic welfare were not examined. Environmental conditions that have relatively less important health impacts may nonetheless need to be addressed because of their impacts on the economy or the ecosystem.

2.6.2 Methodology

Environmental health assessment methodology uses dose-response coefficients developed for the United States. It is assumed that these coefficients capture most of the effects that environmental problems may have on people in developing countries. However, the overall health status of people at risk in developing countries is generally worse than that of people in the United States. Hence, the results shown here may underestimate the actual risk presented by environmental hazards or conditions in Quito.

The ratings reflect present risks that may change. Populations in developing countries and their cities are increasing rapidly. Urban services may improve or decline over time. Risks will vary over time for this and other reasons.

There are limits to the proper application of ethnographic information obtained from focus groups. One cannot generalize the information obtained from focus groups unless the participants are identified as a statistically valid sample. Such sampling procedures were not used in this study. The information obtained in this study, therefore, reflects the specific context within which the focus groups were held, interactions among participants, and local understandings of the questions posed.

Assessing the validity of ethnographic data is both critical and difficult. One of the great advantages of the incorporation of ethnographic data is its ability to reflect the ideas, behaviors, concepts, and concerns of the people being studied; simultaneously, that very flexibility makes it difficult to assess any single portion of the data generated. For this reason, ethnographic methodology frequently combines a variety of techniques to allow the researcher to validate the information acquired from multiple sources. The ethnographic methodology utilized in the current environmental health assessment relied on several techniques, in conjunction with information provided from secondary data sources and from consultation with other researchers. The use of information from various sources including focus groups, in-depth interviews, on-site observations, and secondary data sources provided an internal cross-check for the validity of the data.

2.6.3 Data Availability and Quality

Ideally, to conduct a thorough environmental health assessment, one would have data on environmental concentrations (or source characteristics), time-activity patterns (including cultural characteristics), and dose-response relationships for all pollutants and media of concern. Quito, like cities in most developing countries, does not have data at this level of detail or extent. There were several major gaps in data and other situations where the data were less than optimal. Environmental monitoring programs, where they do exist, may not be representative of the entire city and are often insufficient to estimate exposure for the entire population. For example, ambient air monitoring station locations may not be representative of the entire city. Microbiological testing results for food and water often were expressed in terms of whether the standard was exceeded rather than in actual measured values. As a result, exposure could not be estimated. In some cases, even if data did exist, they were not in a form from which reasonable estimates of risks could be made. For example, for many illnesses the actual cause or diagnosis may not have been listed, which makes determination of the prevalence of disease difficult. This lack of medical statistics (in useful form) made the verification of risk estimates very difficult.

Chapter 3

RESULTS OF THE ENVIRONMENTAL HEALTH ASSESSMENT: QUITO

3.1 Environmental and Socioeconomic Conditions

The environment in Quito is affected by the intensive use of land within an area of rapid urban growth. Quito's location on a narrow plateau combines with spontaneous land use by low-income dwellers to create the conditions for environmental degradation that affects human health. The city's growth, fueled by an influx of rural migrants, has overwhelmed the capacity of municipal services, resulting in large areas of the city without access to potable water, electricity, sewerage, and garbage collection. Between 1950 and 1990, the city grew 20 times in area, while it grew 6 times in terms of population (Arcia, Bustamante and Paguay, 1992). Despite this, population density remained high in specific areas. The rapid establishment of new neighborhoods on fragile land has led to problems of dust and wind-borne particles, periodic flooding, and sewer stoppage. In summary, the quick growth of the city has left a large proportion of its population at risk for a variety of environmental health problems.

3.1.1 Overview of Environmental Problems in Quito

The environmental problems of Quito are similar to those of other cities in Latin America, albeit on a relatively minor scale. They include, among other problems, air pollution from motor vehicles, water pollution, poor sanitation and food hygiene, inadequate solid waste disposal, and industrially related problems.

Air Pollution from Motor Vehicles. In 1970, there were 16,857 vehicles registered in the city—one vehicle per 30 people. At that time, the total fuel burned produced 86 kg. of contaminants per person per year. By 1989, the total number of vehicles had grown to 111,672—which produced 124 kg. of contaminants per person (Arcia, Bustamante, and Paguay, 1992). Although the city's air seems to be cleaned during the course of the day by southeasterly winds, people residing or working near public thoroughfares continuously breathe high levels of pollutants, such as lead from the burning of leaded gasoline. Quito's air receives about 2,500 metric tons of lead per year from gasoline exhaust. Blood lead levels of many children, who are especially vulnerable to the health effects of lead, were found to be above the recommended safety limits of the World Health Organization (Suárez et al., 1992).

Water Pollution. All of Quito's wastewater is discharged, without treatment, into the Machángara River. The river flows along vegetable-producing areas outside of the urban perimeter. Fecal bacteria, heavy metals, and other contaminants have been measured in vegetables sold in the city, although vegetables grown with irrigation from the Rio Machángara represent a small portion of the total diet of Quito residents (Suárez et al., 1992). Inside the city limits, potable water is contaminated by contact with water from latrines, broken sewage pipes, and illegal connections.

Poor Sanitation and Food Hygiene. The city confronts a serious problem with sanitation in the *asentamientos populares* and marginal neighborhoods. Many of the marginal neighborhoods without paved streets were not developed spontaneously, but are planned developments. Most of the *asentamientos populares* in the city are located in fragile lands with highly sloped, unpaved streets. City services are difficult to provide, especially when the population to be served is the one with the least ability to pay for these services. Poor sanitation and hygiene are prevalent in these neighborhoods, a direct consequence of the lack of access to urban services (Castro et al., 1992). Interviews conducted in some of these neighborhoods indicate that their inhabitants are very concerned with the inadequacy of sewage systems and the consequent health risks.

Inadequate Solid Waste Disposal. Quito also has a solid waste problem. According to the ethnographic data, there is garbage pick-up, but it is irregular and infrequent, so people dispose of their garbage on unoccupied land. Despite efforts from the municipal government, the waste collection service collects only about 78% of the total waste produced by households and industry (Arcia, Bustamante and Paguay, 1992; Suárez et al., 1992). The remaining 22% of the 842 tons of garbage produced daily are thrown away on empty lots within each of the neighborhoods without regular service, or thrown to the nearest creek or gully. Garbage dumped near households may attract vectors of disease.

Until 1991, the city had two large garbage dumps, Chilibulo and Zámbiza, at the edge of the city. Neither was a sanitary landfill. Chilibulo had to be closed in 1991 because it was being encroached upon by the surrounding neighborhoods. Meanwhile, at Zámbiza, leachate from toxic waste and heavy metals in the garbage contaminated the water table and the Machángara River. Now the city is in the process of creating a sanitary landfill 30 km. northeast of the city limits, in an arid zone where toxic wastes cannot seep into the water table. Zámbiza is being transformed into a receiving station for garbage transfer to large trailer-trucks. In addition, the number of collector trucks is being increased, and access to marginal neighborhoods improved in order to extend collection services as much as possible. However, large areas will remain uncovered, or with inadequate coverage, from the municipal collection service.

Industrially Related Problems. The amount and type of pollutants from factories and industrial zones are considered important for environmental health because of the locations of the factories and the toxicity of their wastes. Although factories are assumed to produce between 25% and 40% of the air pollution in the city (Jurado, 1991), the most serious environmental impacts associated with industry in Quito relate to the disposal of toxic wastes and to occupational disorders caused by exposure to toxic materials. These two industrial toxic problems seem to be especially important in the textile and metal industries, which are concentrated in Quito. Not surprisingly, data on industrial waste and on occupational health are scant and difficult to obtain, since factory owners are reluctant to recognize responsibility for any insults to the environment or to workers' health that their manufacturing processes may have produced. Focus groups also revealed that workers were exposed to high levels of dust, among other problems. The main industrial parks in the city are located in areas close to highly populated neighborhoods in the areas of San Bartolo (south) and El Inca (north).

3.1.2 Nature and Location of *Asentamientos Populares*

<u>COMBATIR ES VENCER</u>. "To fight is to win" was the slogan used to gain public services in El Comité del Pueblo. This community was initially established through an organized invasion of land; since then members of the community have acquired the titles to their land and some basic services. Women there purchase and prepare food daily, but they emphasize the significance of food preparation on Monday. "God gives more food to those who cook on Monday." Women prepared soup or rice on alternate days and had meat when they could "depende de los posibilidades de la persona."

The main underlying cause of environmental degradation in Quito, and its negative impact on health, is urban poverty. Such an ultimate cause is reflected in the quality of life found in the urban periphery, in the marginal neighborhoods of Quito known as *asentamientos populares*. These neighborhoods have grown at a yearly rate of 3% to 4%, exerting great pressure on urban land, infrastructure, and service delivery systems. The expansion of the urban area populated by low- to medium-low-income dwellers has been due to three main forces (Castro et al., 1992):

1. Urbanization of agricultural land: Initiated during the 1960s, urbanization occurred mostly during the 1970s and 1980s, with the approval of the municipal government and participation of the Banco de la Vivienda, the institution in charge of housing programs. An example of this type of neighborhood is Solanda, where some of the focus groups were conducted for this study.

2. Illegal settlements: These settlements were the result of "spontaneous" occupation of land. In most cases, the land was actually sold to the new dwellers by the previous owners through intermediaries, because the land—typically large farms—occupied areas which should not have been urbanized because of their ecological characteristics. These settlements were initiated without municipal approval, which prompted the municipality to deny urban services to the area. However, once these areas became consolidated, their access to municipal services became a political issue. The neighborhood known as Comité del Pueblo, where some of the focus groups were conducted, is an example of this type of settlement.

3. Annexed settlements: The city has incorporated into the consolidated urban area many little towns that were once on its periphery. Annexation results from the natural growth of the city into previously rural areas. In these cases, services had to be upgraded to city

standards. Improving the services took so long that some inhabitants were exposed to a variety of environmental health risks.

Each of these urbanization processes continues today, which means that a large proportion of the population still faces environmental health risks on a large scale. When the provision of infrastructure, such as piped water, effective sewers, and paved streets, cannot keep pace with population growth into previously uninhabited areas, the population is at increased risk of exposure to air- and water-borne contaminants. Most of the *asentamientos populares* are located at the north and south ends of the urban perimeter (see Table 4). In the north, the arid microclimate and unpaved roads combine to generate large quantities of dust. Participants in all focus groups believed that dust contributes to respiratory problems and that lack of water contributes to diseases related to poor sanitation. Participants believed that these problems affect women and children most frequently. In the south, proximity to industrial areas, lack of water, and lack of waste collection services also are believed to contribute to the health problems of low-income communities.

Table 4

Asentamientos Populares in Quito

	1981	1985	
Urban District	Number of Settlements	Number of Settlements	Hectares occupied
North	32	46	1815
Center North	8	10	186
Center	9	11	124
Center South	13	24	680
South	25	43	1162
Total	87	134	3967

Source: Department of Planning, Municipality of Quito

By 1992, the number of *asentamientos populares* had increased to 202. The total area covered by the settlements, however, has remained the same due to the consolidation of some neighborhoods, the legalization of others, and changes in the criteria for classification. A municipal government survey for 1990 estimates that 195,330 people, 18.3% of Quito's population, were living in illegal, spontaneous, and marginal settlements.

3.1.3 Socioeconomic Characteristics of *Asentamientos Populares*

<u>SOMOS POBRES, PERO SOMOS LIMPIOS</u>. "We are poor, but we are clean" is a phrase women used to describe themselves in Solanda. Maintaining cleanliness and hygienic conditions however, is difficult where they have garbage that is not regularly picked up, water that needs to be boiled, and sewers that back up whenever it rains. "Those who have money have garbage collection, those without have neither." Women in Solanda spoke about their children having diarrhea, and everyone having intestinal parasites, coughs, and sore throats. Remarkable among this population was the level of information about public health measures; less remarkable was the lack of concomitant behaviors.

The socioeconomic characteristics of *asentamientos populares* are distinctive from the rest of the city. Males outnumber females by 4.2%, while in the rest of the city females are more numerous by 3.2%. Approximately 54% of the population is 19 years old or younger, with close to 20% of the population being less than 12 years of age. According to a 1983 survey done by the municipal government, about 60% of the population was economically active, and about 30% of the total population were steadily employed. By 1990, the total population had increased and only 43% was economically active. (The economically active population is defined as people working or looking for work who are more than 12 years old.) Most people work as unskilled laborers in construction (38%), factories (13%), or street sales (13%). Throughout the past decade, new migrants to the city accounted for 32% of the population of illegal and spontaneous settlements. Not surprisingly, people living in *asentamientos populares* have average incomes that are only 55% of the average income of people living in other parts of the city (Castro et al., 1992).

Type of housing is another aspect of the *asentamientos populares* which is of importance for assessing risks. A 1988 survey conducted by the municipal government shows that although 67% of the people living in *asentamientos populares* live in their own houses, only about 34% have legal title to them. Dwellings average 2.14 rooms; 19.5% are one-room dwellings. Approximately 16% of the dwellings (mediaguas) barely qualify as such. About 80% of the dwellings were financed with residents' own funds. Institutional credit from the Social Security Institute and the Banco Ecuatoriano de Vivienda financed only about 4.5% of the dwellings.

Most dwellings (62%) are made of cinder blocks or bricks, and 72% of all dwellings have less than 45 square meters (450 square feet), housing about 6 people per family. Approximately 45% of the families live in dwellings of 25 square meters (250 square feet). Focus group information reveals that families often rent a room to someone outside of the nuclear family as a means of increasing income. These families may account for the 19.5% of the people who reported living in one room.

Access to urban services, a critical component in reducing environmental health risks, is scarce within the *asentamientos populares*. According to a study undertaken by the CIUDAD Research Center in 1988, only about 5% of the families in *asentamientos populares* had access to potable water in their homes. At that time, about 87% of the households in the *asentamientos populares* had to buy water from tankers, paying 5 to 8 times the price of water paid by households connected to the potable water network (Castro et al., 1992; Velasco, 1989). With the opening of the Papallacta water project in 1991, this percentage is expected to increase substantially. About 50% of the settlements have no access to sewage services. According to the 1988 municipal survey, 56% of people interviewed indicated that the supply of potable water was the need of highest priority, followed by sewage.

3.1.4 Focus Group Sites

Three sites were chosen for the focus groups:

- Solanda (in the south of Quito)
- Carapungo (in the north of Quito)
- Comité del Pueblo (in the north of Quito)

These sites were selected by the following criteria:

- location: within Quito city limits
- relation to city center: neighborhoods outside of the established center of the city
- socioeconomic status: mixed working class areas
- local contacts were available to work with the focus group facilitator in the neighborhoods.

The three neighborhoods show an excellent spread and variety in terms of location, age, and origin, while providing an acceptable degree of homogeneity among the focus group participants drawn from the communities.

Solanda appears to be the best organized of the three communities, with a strong local organization of women who campaigned for water, electricity, and a day care center. Solanda now has sewers, electricity, some telephones, and recently acquired potable water. It also has a day care center and a health clinic that were established by community organizations. Solanda is one of the oldest and largest of the neighborhoods created by a national housing campaign begun in the late 1970s with a combination of national and international funding (AID, International Development Bank, Municipio de Quito, Banco de la Vivienda, and the Junta Nacional). The result is a large planned community, construction of which began in 1984. The national Banco de la Vivienda paid for the houses to be constructed and then people bought them at subsidized prices and low interest rates from the Bank. The Bank constructed three house forms, all of which were very small. Families then modified these houses to enlarge them, enclose the small front yards, or add other floors as needed.

Of interest is that the women in the three Solanda focus groups said that most families had at least one extra person living with them from whom they received rent. This rent, they said, was a critical source of dependable revenue. Some families rented to a grandparent, while others rented to someone unrelated to them but who needed a place to live. While this arrangement provided families with a reliable, continuing source of income, it also increased the number of people living in very close quarters. This neighborhood now houses 22,361 people, according to 1990 INEC census data.

Carapungo, a neighborhood of 9,465 people located in the north of the city, is much more separated from the center of Quito than Solanda. It takes twice as long to get there, with the traffic stopping regularly to get around major road construction and obstruction of the pavement. The community itself sits in an arid bowl, within which the silt-like dirt from the unpaved streets constantly forms small dust storms, covering people and their homes with a mantle of grit. Carapungo is also a centrally planned community created through the Banco de la Vivienda in 1986. Carapungo is almost the same age as Solanda, but it has few of the infrastructural resources. It does not have piped water or day care; it has no health clinic or police force. Its markets and water suppliers are not regulated by the municipal authorities. It does not appear to have the community-based organization found in Solanda. It does have sewers and electricity, and some people have telephones. Carapungo's marginal position is reflected in its lack of infrastructural services.

Comité del Pueblo is the oldest of the three communities, begun in 1972. Its population, according to INEC census data, is 18,068. It is the only community of the three that began as an organized land invasion. By 1980-81, the community sought legalization of its land claims and families purchased the titles to their land. The houses reflect the individual character of the community and are of a variety of sizes and shapes (unlike the relatively uniform character of the homes created in Solanda by the Banco de la Vivienda). Perhaps because it is not a creation of the Bank, it has grown and expanded into another section. Comité del Pueblo has electricity and telephones, has just gotten piped water, and the city is putting in sewers. While the residents of the Comité del Pueblo were once very organized, they no longer have a strong central structure, but instead have a decentralized organization that limits their ability to work as a single community.

3.1.5 Summary

Quito's topography and ecosystem make it a fragile city, prone to environmental degradation. Thus, a key element for understanding Quito's problems of environmental health is the layout of the city. Transportation, for example, moves along an urban corridor 40 km. long and only 4 km. wide, exposing much of the population to ambient air pollution. Occasional flooding and sewer backups also reflect the influence of the city's geography on environmental health.

Another key element in understanding the negative effects of environmental degradation on human health in Quito is the identification of the population most likely to be at risk. The heavy influx of migrants to the city during the past two decades, combined with the natural growth of the city, have expanded the areas without service coverage to the point where these areas—the *asentamientos populares*—now house almost one-fifth of the total population. The lack of urban services and the low income of the population in these areas help explain the prevalence of problems associated with poor sanitation and hygiene. Furthermore, the high levels of underemployment may also help explain some of the occupational hazards to which this population may be exposed, given its need for economic survival.

3.2 Food Contamination: Microorganisms and Pesticides

3.2.1 Background

Food can become contaminated prior to its purchase, or during storage and preparation following purchase. The city of Quito conducts a food-testing program in which food purchased within the city is sampled for microbiological contamination. Food samples are purchased from markets, restaurants, and street vendors. Testing occurs on a monthly basis. Seven specific categories of food are sampled: meat, cold meats/sausage, shellfish, dairy, juices, prepared foods, and other. Several food products within each category representative of the Quito diet are sampled. Biological contamination is measured and compared to standards established by INEC. Standards have been established for total anaerobes, total coliforms, fecal coliforms, *Staphylococcus aureus*, salmonella, molds, and yeasts. Specific standards vary by food type. Total anaerobic standards range from 100,000 to 1,000,000 colonies/gm for meat products (typically around 30,000 colonies/gm). Total coliform standards range from 0 to 10 colonies/ml. for dairy products. Fecal coliforms and salmonella are typically not allowed. Mold and yeast standards range from 0 to 50,000 colonies/gm. for meat products. Individual samples are compared to relevant standards and then reported as either acceptable or unacceptable. Samples are considered unacceptable if any standard (such as coliforms, molds, or yeast) has been exceeded. Individual or average measures for each specific biological contaminant and data on compliance with standards are not available. Only the number of acceptable and unacceptable samples are reported. The data ..om the most recent reporting period, July through December 1991, are summarized in Table 5 according to food type. Data are not available according to source (such as market, restaurant, or street vendor).

Table 5

Summary of Results, Municipal Food Testing Program

Food Type	Number Sampled	Number Unacceptable	Percentage Unacceptable
Meat	434	362	83.4
Sausage (Cold Meat)	281	165	58.7
Shellfish	34	22	64.7
Dairy	189	99	52.4
Juices	225	172	76.4
Prepared Foods	288	145	50.3
Other	68	22	32.4
TOTAL	1519	987	65.0

Source: Summary of tests from July to December 1991, Laboratorio Bromatológico

Another way in which food becomes contaminated is through irrigation with contaminated water, but it is not known to what extent this contributes to food contamination. For example, water from the Rio Machángara is used for irrigation downriver of Quito, so these crops are likely to accumulate metals and organic contaminants. These crops are shipped to and consumed by residents of Quito, but they constitute less than two percent of all food consumed in Quito. Therefore, probability of effect from contaminated food irrigated with Rio Machángara water is low.

3.2.2 Methods

A survey of pesticide contamination in food conducted by the Ministry of Agriculture, CONACYT (López and Fernandes, 1987) revealed that residues are common in all food groups. The study divided the city of Quito into 56 sectors, and 20 sectors were selected for sampling. Fourteen food groups were sampled, with 10 samples in each food group. The food groups and individual food types within these groups were selected to be representative of the typical Quito diet. The food groups analyzed were: (1) milk products, (2) meat, (3) eggs, (4) fish, (5) fats, (6) cooking oils, (7) bakery products, (8) cereals and grains, (9) vegetables, (10) tubers (potatoes), (11) beans, (12) fruits, (13) sweets and condiments, and (14) water and beverages. Two analyses were carried out and results were reported for the primary and secondary analyses.

3.2.3 Exposure

Pesticide residues were found in all samples in all food types. Aldrin was the most common pesticide, observed in 90 to 100% of the samples tested for all food groups. Lindane was found in 100% of all samples for milk, bakery goods, cereals, and beans, and roughly 60% of samples in all other food groups. α-Benzene hexachloride (α-BHC) was also observed in 100% of samples of milk and potatoes, and frequencies for other food groups ranged from trace to 75% of the samples. Heptachlor, chlordane, dieldrin, diazinon, and DDT isomers were also observed, though less frequently than other pesticides. The frequency of residues was high, but rarely exceeded local pesticide residues standards. Only heptachlor (in leeks, lettuce, and potable water), chlordane (in lemons), and diazinon (in barley) were found at concentrations exceeding the maximum allowable limits established by the Codex Alimentarius FAO/OMS in 1978. Table 6 summarizes the average pesticide levels found in each food group.

Table 6

Pesticide Residues in Food (Secondary Analysis)
Average Concentration (in ppm)

Food Type	Lindane	Heptachlor	Aldrin	DDT*
Milk	0.0097	0.0038	0.0036	0.029
Meat	0.059	0.029	0.11	0.75
Eggs	0.00057	---	0.00014	0.00052
Fish	0.014	0.0036	0.022	0.078
Cooking Oils	0.0052	0.0059	0.042	---
Fat	0.0039	0.002	0.0059	---
Baked Goods	0.001	0.0039	0.0011	0.012
Grains	0.0024	0.00019	0.00042	0.00077
Vegetables	0.00039	0.00015	0.00031	0.0015
Potatoes	0.0013	0.00072	0.00024	0.0025
Beans	0.0017	0.0032	0.00019	0.0001
Fruits	0.000056	0.00016	0.036	0.13
Sauces/Condiments	0.0016	0.00093	0.00073	0.013
Water/Beverages	0.0011	0.00058	0.00015	0.000076

* Includes all DDT isomers

López and Fernandes (1987) also estimated total ingestion of pesticides based on residues and food consumption patterns. Data on the typical Ecuadorian diet, including consumption rates for each of the 14 food groups sampled, were used to estimate daily intake of pesticides (Table 7). Standards for pesticide residues in Ecuador are based on a 50-kg person, so daily intake rates were also estimated for a 50-kg person.

Table 7

Summary of Exposures to Pesticides in Food

	Daily Intake (μg/day)		Intake Rate (μg/kg/day)*	
Pesticide	Primary	Secondary	Primary	Secondary
Lindane	10.8	6.30	0.22	0.1
Heptachlor	44.3	3.78	0.89	0.1
Aldrin	11.0	26.70	0.22	0.5
Dieldrin	3.4	--	0.069	--
DDT**	296.4	84.20	5.9	1.7

* assumes weight of 50 kg.
**includes all DDT isomers

For all food types tested, more than half of the samples were found to be contaminated though the magnitude of exceedance and the specific standard (such as bacterial) was not known. Frequency of contamination ranged from 52.4% in dairy products to 83.4% for meat products tested. The rate of contamination for all foods was 65%. Given the high frequency of contaminated foods throughout the city, it is reasonable to conclude that the entire population is exposed to microbiologically contaminated foods at some time each year.

Food may also be contaminated after purchase through improper handling and storage. Neighborhoods without adequate water supply are particularly susceptible, since inadequate water supply reduces the potential for proper hygiene. In the *asentamientos populares* the cost of a refrigerator is prohibitive, and many houses have no refrigeration. However, it should be noted that the purchase of contaminated foods does not automatically result in exposure to biological contaminants. Cleaning and cooking foods properly reduces or eliminates biological contaminants. Exposure thus may be less than that indicated by just the presence of biological contaminants in raw foods, but the degree to which exposure is reduced could not be quantified. Also, according to focus group participants, the handling of food at the "ferias libres" (open air markets) makes food susceptible to contamination which would increase the potential for exposure. All things considered, exposure to biological contamination via food is considered high.

3.2.4 Health Outcomes

The major health consequences of consuming biologically contaminated food are infections with microorganisms and parasites. It is difficult to quantitatively estimate the risks associated with consumption of contaminated food, but diarrhea and parasitic infection were mentioned frequently by all focus groups. There is no consensus on quantitative methods for correlating exposure levels with incidence. Dose-response models proposed for contaminated drinking water may be used for food consumption as well, but these models require concentration, exposure, and bacterial dose data, which are not available.

The assumption of high exposure and high probability for diarrhea are supported by observed diarrheal rates and focus group reports in Quito. According to the Ministry of Health statistics, there are more than 17,000 cases of diarrhea per year in Quito severe enough to require medical consultation at Ministry health centers. This figure includes only cases treated by the Ministry. The Ministry of Health probably provides care to less than 75% of the population, so the actual incidence of severe diarrheal disease would be expected to be greater than 23,000 cases. (See also Table 13.)

With respect to pesticide residues in food, total daily consumption of aldrin (11 µg/person/day), heptachlor (44 µg/person/day), and DDT isomers (84 to 296 µg/person/day) exceeded the local acceptable total food consumption standards levels of 5, 25, and 25 µg/person/day, respectively, for a 50-kg person. Additionally, diazinon (99 µg/person/day) approached the acceptable limit of 100 µg/50 kg-person/day. Consumption of all other pesticides was below the acceptable limits.

In addition to local standards for pesticides, comparisons to USEPA standards were also made. The USEPA Reference Dose (RfD) is "an estimate of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime." Exposures below the RfD are not likely to result in adverse non-cancer health effects. Exposures above the RfD do not necessarily imply that adverse effects would occur, just that the person exposed is at risk for adverse health effects.

RfDs have been established for lindane, heptachlor, aldrin, dieldrin, and DDT. Diazinon is presently under review by the EPA. Table 8 shows the RfDs for each pesticide, the critical effect, and the estimated daily intake. The critical effect is the adverse effect that appears first as dose or exposure increases. Protecting against the critical effect would also protect against other adverse effects that may occur at higher doses or exposures. Liver toxicity is the critical effect for several of the pesticides.

Table 8

Non-Cancer Health Risks from Pesticides in Food

Pesticide	Critical Effect	Oral RfD (mg/kg/day)	Intake Rate* (mg/kg/day)	
			Primary	Secondary
Lindane	abnormal blood pigment	.002	.00022	.00013
Heptachlor	liver weight increases in males only	.0005	**.00089**	.000076
Aldrin	liver toxicity	.00003	**.00022**	**.00053**
Dieldrin	liver toxicity	.00005	**.000069**	--
DDT**	liver lesions	.0004	**.0059**	**.0017**

* daily intakes that exceed the RfD are designated in bold.
** includes all DDT isomers

Daily intake rates of heptachlor, aldrin, dieldrin, and DDT all exceed the RfD. Daily intakes were 1.4 to 18 times the RfD, with aldrin and DDT both exceeding the RfD by an order of magnitude. The incidence of health effects cannot be directly estimated, but given that RfDs are exceeded for several individual pesticides, the potential for adverse effects is likely significant.

Several of the pesticides analyzed also present risks of cancer to the exposed population. The USEPA has designated aldrin, heptachlor, dieldrin, and DDT as B2 Probable Human Carcinogens. Liver cancers have been associated with each of the pesticides in both test animals and humans. Table 9 shows that pesticide residues in food would result in estimated excess individual lifetime cancer risks from 3.4×10^{-4} (heptachlor) to 9.1×10^{-3} (aldrin). This means that for every 1 million persons exposed between 340 and 9,100 cases of cancer are predicted. By comparison, the EPA generally considers cancer risks greater than 1×10^{-6} (one in 1 million exposed) to be unacceptable.

Table 9

Cancer Health Risks from Pesticides in Food

Pesticide	Intake Rate (mg/kg/day)		Potency $(mg/kg/day)^{-1}$	Excess Cancer Risk	
	Primary	Secondary		Primary	Secondary
Heptachlor	.00089	.000076	4.50	.004	.00034
Aldrin	.00022	.00053	17.00	.0037	.0091
Dieldrin	.000069	--	16.00	.0011	--
DDT*	.0059	.0017	0.34	.002	.00057

*Includes all DDT isomers

It should be noted that these pesticides have all been banned in Ecuador and that the levels were analyzed in 1987. Therefore, present and future levels of pesticides may be somewhat lower than those reported in L6pez and Fernandes (1987).

Diarrheal diseases are caused by a variety of different pathogens. Diarrheal diseases generally have a low proportion of cases resulting in death, but they are still of great concern in the very young and the very old. The impact of diarrheal diseases is supported by Quito statistics which show that the mortality rate from intestinal infections is about 6 times higher in children under 15 years of age than the rate for the rest of the population. Therefore, for the very young and old severity of the effect can be considered medium to high, while for the remainder of the population the severity can be categorized as low to medium.

The health effects associated with pesticides are more severe, ranging from liver toxicity to cancer, but their incidence is lower than the incidence of diarrheal diseases.

3.2.5 Comments

Ideally, when estimating the risks associated with consumption of contaminated food, data would be available on the concentrations of pesticides and microorganisms in food and the distribution of food consumption patterns, on dose-response relationships between exposure and infection, and on the distribution of resistance and susceptibility within the population. When these data are not available or not sufficient, uncertainty is introduced into the risk estimate.

Microbial food contamination data for Quito are limited to standards of acceptability and not as concentrations. Also, the degree of food contamination via food preparation practices cannot be quantified, so even if data were available on concentrations, there would still be significant uncertainty about the relationship between exposure levels and the incidence of disease or infection.

The data for pesticides in food are also several years old. Many of the pesticides have been banned, and concentrations would be expected to decrease over time. Without more recent data, the anticipated trend for reduced residue concentrations could not be assessed. Likewise, the sampling protocol from the pesticide survey could not be evaluated to determine how accurately it represented the overall food supply in Quito. Furthermore, consumption patterns were not known for the different neighborhoods or socioeconomic groups. Therefore, differences could not be assessed in order to define high-risk groups. (See Section 3.6 concerning pesticides in breast milk.)

For food contamination with microorganisms, the probability score given was 1, the severity score was 4, and thus the overall score was 5. For contamination with pesticides, the probability of effects is much lower, warranting a score of 5. The severity of effects is also predominantly mild, for a score of 4, and an overall score of 9.

3.3 Water Contamination: Drinking Water and Wastewater

3.3.1 Background

The city of Quito has recognized the importance of adequate water quality and water supply. Over the years, Quito has made extensive efforts to provide water service to all inhabitants, including those in poorer neighborhoods. Table 10 summarizes 1990 census data on water service and water sources. Most of the water supply for the city is transported from the neighboring mountains and is of good quality. Of the three peri-urban settlement communities from which focus groups were drawn, only Solanda was totally supplied by piped water, and that only recently. Tankers may be official municipal operations or private operations which may collect water for distribution from any source available to them, including local public service taps, fire hydrants, or wells. Quito officials estimate that 95% of the population receives municipal water in some form.

3.3.2 Methods

There are seven water treatment plants within Quito, but three plants supply about 85% of the population: El Placer (25%), Puengasi (30%), and Bellavista (30%). The city undertakes a water quality testing program at these three treatment plants and their respective distribution systems. In addition to analyzing water as it leaves the plant, the city randomly takes 30 samples per day throughout the distribution system, within homes and other service connections. The two major criteria of concern for water quality are total bacterial colonies and

Table 10

Summary of Water Service and Water Source Data for Quito

Water Service	Percent of Population
Private in-home connections	68.9
Shared indoor connections	16.1
Outside piping	3.1
None	11.9
Water Source	**Percent of Population**
Municipal	83.3
Wells	3.6
River, aqueduct	3.0
Vended water	8.4
Other	1.7

Source: 1990 Census Data

the presence of fecal coliforms. The city is concerned when more than 10% of the samples indicate the presence of fecal coliforms. Water quality samples are deemed acceptable when total colonies are below 30,000 per liter.

3.3.3 Exposures

Table 11 summarizes the sampling results for the three plants and their respective distribution systems. The data available for review and released by the city were monthly and annual averages for all water quality criteria for 1990. For all monthly averages, for all three plants, no fecal coliforms were reported. When all samples are considered, a total of 0.4% were found to contain fecal coliforms. When the exceedances were investigated, the presence of fecal coliforms was attributed to unclean cisterns used within older buildings. All three plants showed annual and monthly averages of total colonies below the standard of 30,000 colonies per liter. The maximum reported monthly average was 8,000 colonies per liter at the Bellavista plant in May 1990. No data were available to evaluate daily or episodic measures.

The city also keeps records of every sample that exceeds water quality standards. Reports tend to indicate that exceedances or complaints are related to construction within the water distribution system (G. Sandoval, Municipal Water System Laboratory, personal communication, June 18, 1992). It should also be noted that the distribution systems are not

Table 11

Summary of Municipal Water Quality Testing Program, 1991

	Bellavista			El Placer			Puengasi		
Criteria	Ave.	Min	Max	Ave.	Min	Max	Ave.	Min	Max
Turbidity	0.94	0.4	1.9	3.42	2.4	5.1	1.3	0.85	2
Color	3.75	3	5	11.6	5	15	6	5	7
pH	7.24	6.9	7.6	6.58	6.2	6.9	6.95	6.6	7.1
Conductivity	199.3	155	250	138.8	120	170	140	125	155
Cl Residual	0.87	0.6	1.2	1.01	0.8	1.2	1	0.85	1.1
CO2	6.88	3.2	12.7	24.83	10	61.2	10.7	5.6	16.5
CO3	0	0	0	0	0	0	0	0	0
HCO3	66.32	57.3	88.9	51.12	37.8	67.1	59.7	42.7	67.1
Chlorine	40.69	10	64.1	6.08	4.5	8.5	7.8	6.8	9.1
Iron	0.06	0.05	0.09	0.31	0.2	0.55	0.08	0.05	0.17
Manganese	0	0	0	0	0	0	0	0	0
Fluorine	0.2	0.2	0.2	0.21	0.2	0.25	0.28	0.25	0.31
CaCO3	54	47	73	41.9	31	55	47	35	55
Ca++	19.2	16	24.4	10.67	8.8	12.8	12.5	11.2	13.6
Mg++	4	3.4	6	7.7	6.3	10.4	6	5.3	6.8
SO4--	20	13	26	30.7	25	34	28	25	32
Dis. solids	175	127	247	167.8	153	200	149	133	170
Total colonies	2	0	8	2	1	3	3	1	4
Total Coliform	0	0	0	0	0	0	0	0	0

Source: Summarized from monthly and annual average data from Municipio testing program
Testing Program: Random testing of homes within the distribution system, 30 samples per day, about 1/1,600 persons
Note: All samples were negative for aerobes, molds and E. Coli for all plants

necessarily discrete: due to varying water pressure within the system, a particular location may often receive water from more than one plant. Therefore, if the exceedances were related to treatment plant performance, it may be difficult to determine this strictly from the monthly average data. Fundación Natura independently conducted some water sampling within Quito. Descriptions of the sampling protocol or the sampling locations were not available. Results of the Fundación Natura sampling were limited to the number of samples exceeding certain water quality criteria, and identifying the parroquias in which the exceedances occurred (Table 12). In a total of 30 samples, standards were exceeded in 3 samples (10%) for total colonies, 5 samples (16.7%) for total coliforms, and 7 samples (23.3%) for fecal coliforms in Chillogallo and Guamani. Inadequate chlorine residues were also tested as an indicator of water without proper disinfection protection. Fifteen of 22 samples (68.2%) were found to have inadequate chlorine residues. Inadequate chlorine residues were found in Chaupicruz, Chillogallo, Puembo, Tumbaco, Quinche, Yaruci, and Pifo. The Fundación Natura sampling is small in comparison to those done by the city, but it indicates that the potential for contamination does exist.

In general, water quality in Quito is considered good, though there is some limited evidence that poor water quality can occur on occasion. The city of Quito data indicate that water quality is good. By contrast, the Fundación Natura sampling, though of limited sample size, did indicate that the potential may exist for unacceptable total colony and coliform contamination. It should also be noted that the data provided by Quito were only reported as annual averages and it is possible individual exceedances may have occurred but are not reported. The focus group interviews, however, indicated that water from the tap, on occasion, is poorer than the data indicate. People have reported that the water sometimes comes out a rusty color, with dirt and "bugs." The presence, reliability, and visual and olfactory quality of the water was a significant concern in all six focus groups, regardless of location.

Challenges for Wastewater and Excreta Management

As with water service, most of the city's population has wastewater collection: 1990 census data indicate that 69.2% of homes have exclusive toilets while 23.9% have common toilets shared with other homes. Of the 6.9% that do not have water-borne sewage collection, 4% use latrines, and the remaining 2.9% use some other unspecified means of disposal. Collection and disposal of wastewater within Quito is primarily (79.8%) by connection to the public sewer; wastewater is then released untreated into the Rio Machángara. Disposal to septic tanks accounts for 12.1% of the homes and other unspecified methods account for 4.3% of the homes. At present, 2.9% of the homes within Quito do not have any wastewater collection and disposal.

An estimated 95% of Quito's population receives municipal water in some form or another. Direct service accounts for 88.1%, while others may receive municipally-supplied water from vendors. For the 88.1% of the population that receives water directly, the water quality is generally good and exposure to biological contaminants is low. However, within this system local exceedances sometimes occur. Focus group interviews in the poorer peri-urban neighborhoods with recently installed water service have identified dirty water as an occasional problem. Water containing dirt and "bugs" has been observed in this neighborhood. Also, there is a probability that localized exceedances have occurred, though the available data do not allow one to determine the location and extent of these exceedances. In general, however, those who receive direct water service have a low probability of exposure to bacteria and parasites through drinking water. There are no data available to assess the water quality from

Table 12

Summary of Fundación Natura Funded Drinking Water Quality Study

Year	Water Quality Measure	Total	Samples Exceeding Criteria	Percent	Communities
1981	Nitrate	193	8	4.1	Ruminahai, Chillogallo, Chaupicruz
	Iron	193	3	1.6	Inaquito, la 5 de Junio
	Chlorine	170	32	18.8	La Recoleta, Ruminahai, Floresta, El Dorado, Puengasi, La Libertad
	Total Colonies	174	17	9.8	El Dorado, Ruminahai, Pugnasi, La Libertad, Cochabamba
	Total Coliforms	174	28	16.1	La Recoleta, Ruminahui, La Floresta, El Inca, El Dorado, Puenqasi, La Libertad, Inaquito, Cochabamba, La Magdelena
	Fecal Coliforms	174	8	4.6	El Placer, El Dorado, Puenqasi, La Libertad
1982	Total Colonies	4	4	100.0	Cotocollao
	Fecal Coliforms	4	3	75.0	Cotocollao
1985	Total Colonies	18	13	72.2	Chillogallo, El Recreo, VillaFlora
	Total Coliforms	18	11	61.1	Santa Priega, Pomasqui, Chillogallo, Villa Flora
	Fecal Coliforms	18	6	33.3	Santa Priisca, Pomasqui, Chillogallo, Villa Flora
1986	Iron	15	1	6.7	La Libertad
	Ammonia	15	1	6.7	La Rumibamba
	Total Colonies	22	11	50.0	La Floresta, La Libertad, San Marcos, Ruminahui, San Rogue
	Total Coliforms	22	8	36.4	La Floresta, La Libertad, San Marcos, Ruminahui
	Fecal Coliforms	22	5	22.7	La Floresta, La Libertad, San Marcos

Year	Water Quality Measure	Total	Samples Exceeding Criteria	Percent	Communities
1987	Total Colonies	5	1	20.0	Santa Anita
	Total Coliforms	5	1	20.0	Santa Anita
	Color	9	9	100.0	Quinche, Ascazuba, Guayllamba
	Turbidity	9	4	44.4	Not specified which of above
	Iron	9	6	66.7	Not specified which of above
	Ammonia	9	2	22.2	Not specified which of above
1988	Color	4	4	100.0	La Floresta, Collacoto
	Iron	4	1	25.0	
	Manganese	4	3	75.0	
1989	Color	23	6	26.1	Guamani, San Jose de Minas, Pintag
	Iron	23	6	26.1	Guamani, San Jose de Minas, Pintag
	pH	23	4	17.4	Not specified which of above
	Turbidity	23	4	17.4	Not specified which of above
	Fecal Coliform	6	2	33.3	Pintag, La Balvina
1990	pH	46	13	28.3	Aloao, Conocoto, Quinche, Yariqui, Guamaani, Guayllamba
	Color and turbidity	46	4	8.7	Conocoto, Yarqui, Checa
	Sodium	46	15	32.6	Not specified which of above
	Fluorine	46	4	8.7	Not specified which of above
	Chlorine	46	2	4.3	Not specified which of above
	Ammonia	46	1	2.2	Not specified which of above
	Total Colonies	30	3	10.0	Chillogallo, Guamani
	Total Coliforms	30	5	16.7	Chillogallo, Guamani
	Fecal Coliforms	30	7	23.3	Chillogallo, Guamani
	inadequate Cl residues	22	15	68.2	Chaupicruz, Chillogallo, Puembo, Tumbaco, Quinche, Yaruci, Pifo

Source: Estudio de la Calidad del Agua Potable en Varias Ciudades Equatorianos Estudio Preparado para la Fundación Natura, 1991 individual or community wells or from rivers and aqueducts. However, the water from these sources is likely to be of poorer quality than water from the municipal system, which comes from the highlands and is treated prior to distribution.

> LA VIDA MISMA NOS VA ENSEÑANDO. "Life teaches us" said a woman whose husband is disabled with Parkinson's disease. She and other women in el Comité del Pueblo recounted their efforts to safeguard their families from accidents, disease, and disability. Those without piped water buy used metal drums from industries, which they paint with an anti-corrosive. In these they store their drinking, cleaning, and washing water. However, storage is the least of their water problems; acquisition is more difficult. Water tankers drive through the community, and if one is fortunate and does not live too far off the main street, the tanker will come by. But the water is expensive and not necessarily uncontaminated.

Vended water from tanker trucks is more likely to be contaminated than water supplied by direct service because the vendors are not controlled. While the source of water is the same as direct water service, there is a probability that contamination occurs during transport. The quality of the tanks is not regulated or controlled, and occasionally the tankers are open to the air, allowing for possible contamination.

Another potential source of contamination is the use of cisterns. Households without regular water service, typically in the peri-urban neighborhoods, use cisterns to store water between visits by water vendors or for water collection. Focus groups described how a cistern could be any container or drum found by an individual. Many times these were empty, disposed drums that could be initially contaminated; contamination could also occur while the water is being stored. Even after neighborhoods have been connected to the municipal water system, it is common for people to continue to use cisterns. Therefore, while they may be receiving clean water, the cisterns may introduce contamination.

Those without water service who do not purchase vended water (1.7%) are likely to have a high potential for exposure. Many of these people rely on rainwater or broken water mains for their water supply. The potential for contamination in these sources is very high because collection is usually in open containers, which allow for contamination via particulate settling and provide a breeding place for insects.

Therefore, the majority of the population with direct service (88.1%) is likely to have low exposure potential, though those in the poorer *asentamientos populares* who still use cisterns and those with vended water (8.4%) are likely to have a higher potential of exposure. Those who obtain water from unspecified sources, such as rainwater, are likely to have a high exposure potential. As a result, significant exposure is likely to be limited to less than 20% of the population, and this exposure is concentrated in the *asentamientos populares*.

> CUANDO LLUEVE SON LAGUNAS. In Solanda they have a sewer system; however, the women claim that the pipes used are too narrow and the system often backs up, spilling sewage into the houses and "making lagoons in the streets." They expressed great concern over the potential contamination caused by contact with sewer water. They worried that their children would become sick from having the water splashed on them from cars passing in the street, from having to wade through it on their way to school, and having to breathe it when it dried and turned to dust.

The potential for exposure to wastewater would be high for the 6.9% of the homes and neighborhoods without water-borne sewage and for areas where wastewater elimination is inadequate due to backed up sewers. In these neighborhoods, exposure can be through direct contact with sewage either in the homes or in the streets. Likewise, dried sewage and pathogens can become wind-borne and exposure may be via inhalation or settled particulates on food or stored water. Field observations in poorer neighborhoods revealed sewage in many side streets.

Focus groups in Solanda also revealed that during rainfalls, sewer backups left raw sewage in the streets. Parents expressed concern that children had to walk through the sewage and were occasionally splashed by passing cars. The blockage of sewers and accumulation of raw sewage during rainfall represents a significant exposure pathway, but data were not available on the location and frequency of these incidents. Therefore, overall estimates of the population exposed cannot be made, but the residents of Solanda can also be included in the high exposure potential category.

The Rio Machángara presently receives untreated wastewater. The river is used for irrigation and drinking water downriver from Quito. The crops grown using river water can be expected to be biologically contaminated and some of these crops are brought to Quito. Therefore, there is the potential that people in Quito may be exposed to food contaminated by wastewater from Quito. However, this food represents a very small portion of the total food sold in Quito and therefore would not likely be of significance.

Drinking water taken from the Rio Machángara would also likely contain biological contaminants and represent a significant source of exposure. However, the use of the Rio Machángara for drinking water is downriver, beyond the city limits, and is therefore not within the boundary of this study.

3.3.4 Health Outcomes

The major health consequences associated with biologically contaminated drinking water are infections from bacteria, viruses, and parasites that result in diarrheal diseases and undernutrition and their consequences on physical and mental development and functioning. Diarrhea can be of serious health concern and actually is a leading cause of death in infants in developing countries. Table 13 summarizes the mortality and hospitalization statistics for intestinal and parasitic infections for Quito in 1990.

It is difficult to quantify the risks associated with drinking contaminated water. At present, there is no consensus on quantitative methods for correlating exposure levels with incidence of disease. Recent efforts (Rose et al., 1991, and Rose and Gerba, 1991, a and b) have focused on developing a dose-response model for many water-borne diseases based on human exposure studies; these are currently being evaluated and verified. These models require data on concentrations of microorganisms in the drinking water and can estimate the expected incidence of infection and disease. However, such data on microorganism concentrations are not available for Quito and therefore, a quantitative approach could not be used.

In general, it is thought that the probability of experiencing an infection or disease ranges from medium to high if people are exposed. Therefore, it is assumed that persons of high exposure potential (who, for example, use vended water or collect rainwater) are likely to experience diarrheal diseases. It is estimated, from interviews in *asentamientos populares* and with medical staff, that persons in the poorer neighborhoods typically experience about 5 diarrheal episodes per year. As stated in Section 3.2.4., about 23,000 cases annually are severe enough to require medical attention. The anticipated high incidence of diarrheal disease and parasites in poorer neighborhoods was supported by focus group interviews. Interviewees stated that these diseases were a part of everyday life and that children needed to be brought to the doctor every 6 months to receive treatment for parasites. In all neighborhoods where focus groups were held, the most frequent health complaints were about upper respiratory illnesses (including sore throats and coughs, and parasites).

Data from Fundación Promesa show that people rely heavily on medication purchased from pharmacies. Women in the focus groups readily discussed their reliance on home remedies ("remedios caseros").

The incidence of diarrheal and parasitic diseases can have several etiologies and may not be solely attributable to water supply. Exposure to contaminated food and/or sewage can also contribute significantly to the incidence of these diseases. The portion of these diseases attributable to the water supply could not be determined.

The risks of contracting diarrheal and parasitic diseases from drinking water can be dramatically reduced through boiling water prior to use. If water is boiled prior to use, then the probability of effect would drop to low. Focus group participants were very knowledgeable about the dangers of contaminated water and the necessity for boiling water, but this was not typically

Table 13

Summary of Mortality and Morbidity Data
for Water-Borne Illnesses, 1990

	Males		Females		Total	
	<15 yrs	≥15 yrs	<15 yrs	≥15 yrs	<15 yrs	≥15 yrs
Intestinal Infections						
No. Deaths[a]	53	16	63	25	116	41
Rate[b]	29.3	4.6	35	6.3	32.1	5.5
No. Cases	591	982	456	918	1047	1900
Rate	325.98	283.6	256	232	577.5	549.2
Intestinal Parasites						
No. Deaths	0	1	0	3	0	4
Rate	0	0.3	0	0.8	0	0.6
No. Cases	13	124	7	105	20	229.0
Rate	7.2	35.8	4	26.5	11	66.2

[a] Number of deaths or cases reported in Quito during 1990
[b] Rate is expressed per 100,000 population

Sources: INEC, Egresos Hospitalarios, 1990
INEC, Censo de Poblacion, 1990

done due to the cost of fuel required to boil water and the fact "the children did not like boiled water because of its taste." Therefore, the probability of effect given exposure remains medium to high.

Diarrheal diseases are caused by a variety of different pathogens. While the disease generally has a low proportion of cases resulting in fatality, it is still of great concern in the very young and the very old. The impact of diarrheal diseases in Quito is supported by statistics which show that the mortality rate from intestinal infections is about 6 times higher in children under 15 years of age than in the rest of the population. Therefore, for the very young and old, severity of the effect can be considered medium to high, while for the remainder of the population the severity can be categorized as low to medium.

3.3.5 Comments

Ideally, when estimating the risks associated with drinking water, data would be available on the concentration of microorganisms in potable water throughout the entire distribution system, on dose-response relationships between exposure and infection, and on the distribution of resistance and susceptibility within the population. When data are not available or not sufficient, uncertainty is introduced into the risk estimate. Water quality data for the distribution system are not very detailed, limited to monthly and annual averages with specific sampling locations not identified and specific concentrations of microorganisms not reported. Also, the degree of water contamination via tankers, continued use of cisterns, and other water sources could not be assessed. Even if concentrations of microorganisms in water were known, there is still significant uncertainty in the relationship between exposure levels and the incidence of disease or infection.

The probability of effect score given for exposure to contaminated drinking water was 4, the severity of effect score 4, and the overall score 8.

The probability score given for exposure to wastewater was 3, the severity score 4, and the overall score 7.

3.4 Solid Waste

3.4.1 Background

Solid waste can present a health hazard in one of several ways. Wastes of biological origin (e.g., human waste, animal wastes, animal scraps) may carry a wide variety of pathogens which may result in disease upon direct contact with the wastes. Solid wastes may also contain toxic or hazardous substances such as pesticides, which may impart some toxicity upon exposures. Without proper waste management, the wastes may also present a hazard indirectly by providing a breeding ground for disease-carrying vectors or rodents. Climatic conditions may also play a critical role in determining the extent of proliferation of pathogens and vectors within contaminated solid waste. Excessive moisture may contribute to beneficial growth or breeding conditions for these pathogens and/or vectors. The greater the amount of contamination of solid waste, either with biological wastes or hazardous substances, the greater the risk upon contact.

Personal behaviors may also influence the potential for health risks related to solid wastes. Scavenging or collecting solid waste, living on or near a landfill, consuming or recycling contaminated materials, and re-use of materials taken from landfills can all contribute to significant exposures to pathogens associated with solid waste. Evidence of respiratory, diarrheal, and skin disease has been detected among residents living on or near landfills. Solid waste management can significantly reduce the potential for adverse health effects. Collection of solid waste generated can greatly reduce the potential exposures of the general population. The location of disposal with respect to water sources and residences may also influence exposure. Coverage of waste upon collection and disposal would also greatly minimize human and rodent access and exposure and the potential for vector breeding grounds.

3.4.2 Methods

Quito generates an estimated 842.6 metric tons per day of solid waste, or 0.77 kg per person per day. The distribution of waste generation is as follows:

Production Source	kg/day/person
Residential	0.60
Commercial	0.12
Industrial	0.05
Total	0.77

The composition of the solid waste generated is as follows:

Type	Percentage
Organic Material	49.0
Ashes	2.5
Paper and cardboard	13.0
Plastics	8.0
Glass	6.3
Metal	3.2
Other	18.0
Total	100.0

According to municipal sources, about 75% of the streets are cleaned and about 79% of the total solid waste generated is collected. According to focus group participants, however, garbage collection is not reliable in some sections of the city: about 60% of the system receives daily pick-up, 30% receives intermittent collection (usually within a week or several times a week), while the remaining 10% of the service area is categorized as experiencing eventual pick-up (which may or may not occur on a weekly or monthly basis).

Formally collected solid waste is disposed of in two city landfills, Chilibulo and Zámbiza. These landfills are open dumps with no liners, surface water, or leachate collection systems. They are near capacity and the city is developing a new dump.

Observations and interviews suggest that uncollected waste is deposited in any vacant lot, ravine, or in the streets. This informally disposed garbage is not secured and dogs and pigs are frequently seen rummaging through and feeding on it. Garbage is frequently disposed of near streams or homes. Field observations revealed that much of the garbage in informal dumps is covered with dirt to minimize the potential for breeding and transmission of disease, but the frequency of this practice could not be assessed and observations also revealed open garbage throughout portions of the poorer neighborhoods. In addition to informal disposal, burning of these wastes in the poorer neighborhoods is also common, generating particulate emissions.

The major environmental health issues related to solid waste identified in the pre-trip phase were (1) physical and chemical exposures of scavengers and sanitation workers, and (2) surface water contamination from solid waste disposal.

<u>SUERTE O MUERTE</u>. When one of the women from Solanda used the phrase "To be lucky or to die," everyone in the focus group immediately agreed that phrase epitomized their lives. They further explained that this particular colloquialism conveyed the fear they felt that they would not be able to become pregnant, and the luck they needed to survive childbirth. The phrase had a special meaning for the woman who first used the phrase in the group. For her it offered both hope and fear. She worked recycling garbage, sorting through the pieces of plastic for those appropriate to sell to companies that make hoses. She was pregnant and she had been pregnant eight times before. Of those eight pregnancies only three resulted in live births, and only two of those had survived childhood. Now she had both fear and hope that both she and the baby would be lucky.

Specific data were not available on the specific types of wastes, air sampling near formal and informal disposal sites for chemical and biological toxicants, or leachate sampling. Therefore, risks associated with solid waste were evaluated qualitatively. There are no data on the location of informal dumps, so estimates of the population exposed could not be done.

In general, it is assumed that individuals residing in neighborhoods without, or with irregular, garbage collection (21%) would be at high direct exposure potential, and those in neighborhoods with dependable collection (79%) would have a medium exposure potential. As there are no controls on solid waste disposal in Quito, it can be assumed that chemical wastes are codisposed with other organic and inorganic materials. Therefore, exposure to both biological and chemical toxicants is likely. Those with daily and intermediate garbage collection are assumed to have low exposure potential.

3.4.3 Exposure

There are several primary routes of exposure to solid waste and related subpopulations.

Small populations of persons (estimated at 120 families) who make a living by scavenging through the raw uncovered garbage in search of recyclable materials typically use no personal protection and are exposed both through inhalation and physical contact with the garbage.

Scavengers include people in all age groups; children may accompany a scavenging parent. Exposure potential is highest for this subpopulation.

In areas where garbage collection does not occur, the garbage is frequently placed in any vacant lot which may be available. Focus groups also indicated that garbage was frequently left in front of a neighbor's house. Within these neighborhoods, informal dumps are created wherever possible, and there are likely to be persons living next to or near these informal dumps.

Individuals living in neighborhoods with informal dumps are potentially exposed via inhalation. Quito experiences strong winds, especially in the peripheral and poorer neighborhoods along the slopes surrounding the city. These wind-borne particulates may result in exposure directly through inhalation or indirectly through dust contamination on food, water, and skin. As a result, exposure to wind-borne particulates from these informal dumps is likely. In addition, wastes are frequently burned in these neighborhoods, generating particulate emissions to which residents may be exposed.

In areas where garbage collection does not occur, informal dumps act as breeding grounds for rodent- and insect-transmitted pathogens. Persons living within these areas may be exposed to these pathogens.

Leachate and surface water runoff from both informal and formal dumps may also contaminate groundwater and eventually the Rio Machángara. This water may then be used for drinking or irrigation, resulting in exposure directly via ingestion or indirectly via food consumption. Those who are exposed via drinking water from the Rio Machángara are downriver of Quito and outside the boundary of this study. The indirect exposure via food grown with irrigation water from the Rio Machángara represents a very small portion of the food consumed in Quito.

The possibility also exists that exposure may occur indirectly via contamination of groundwater or surface water. There is no control of leachate in existing landfills. A study conducted for the city of Quito concluded that percolation of leachate and subsequent contamination of the Rio Machángara was insignificant, contributing less than 10% of the total contamination in the river (GTZ, 1991). Contamination of surface water in small streams and tributaries throughout the city is highly likely. This was confirmed by field observations where informal dumps were observed at the edge of a small stream running through the Comité del Pueblo. Contamination of the Rio Machángara could occur from many sources, including leaching from solid waste landfills.

Quito, being at a high elevation, is relatively cool and dry, which reduces the populations of mosquitos and other vectors that would contribute to the risks associated with exposure to solid waste. Most exposure routes associated with solid wastes in other settings do not apply in Quito.

3.4.4 Health Outcomes

The major health consequences associated with improper solid waste disposal are increased rates of chronic respiratory and communicable diseases. Individuals who scavenge at solid waste dumps are most at risk. Studies of solid waste scavengers have reported substantial rates of respiratory, diarrheal, and skin diseases as well as diminished respiratory function; scavengers in Quito would be expected to suffer from the same illnesses. To some degree, those in neighborhoods without waste collection would also be at risk for these health problems. Children may be especially at risk for these effects. A study of environmental risks in Thailand (USAID, 1991) concluded that scavengers had increased chronic respiratory disease and diminished respiratory function due to exposure to high particulate concentrations. While there were no available data on particulate levels near formal and informal dumps in Quito, observations support the presence of high particulate levels; therefore, the probability of chronic respiratory disease and reduced respiratory function in scavengers is high, and probably somewhat lower for those in poorer neighborhoods.

Chemical wastes are likely to be co-disposed with other household wastes, so the potential exists for chemical toxicity through inhalation of volatile organics or direct contact with chemical residues. Toxic effects may include both cancer and systemic toxicity (skin diseases, and reproductive, developmental and neuro-toxicity). However, without data on the specific types of chemicals disposed of in the dumps, the probability of these outcomes cannot be fully assessed.

High concentrations of microbiological water contaminants were reported in the Thailand study, which may have contributed to the observed incidence of diarrheal disease. However, the presence of microbiological contamination in drinking water has not been substantiated near these dumps, resulting in lower probability of effect for diarrheal and infectious diseases. However, the potential for diarrheal and other infectious diseases still exists due to airborne pathogens, though likely to be less than that observed in Thailand. The potential diarrheal and other infectious diseases for those exposed is believed to be low. Health statistics in Quito do not support a widespread incidence of vector-borne diseases, even though rodents are reported in these neighborhoods.

Chronic respiratory disease and reduced respiratory function are not themselves life threatening, but they do significantly compromise a person's health and likely reduce one's life expectancy and quality of life. Increased particulate exposures have been associated with increased mortality rates. Those with chronic respiratory disease are also especially susceptible to these exposures to other air pollutants as well. Therefore, the severity of effects expected from solid waste exposures (in scavengers and those living in neighborhoods with informal disposal) is considered moderate.

3.4.5 Comments

To assess the risks associated with solid waste, data would be required for the location of formal and informal disposal sites, population estimates near these dumps, air quality monitoring data for both biological and chemical toxicants, and leachate and surface water quality testing data. Data is very limited related to solid waste disposal for the city of Quito. There are good data on the distribution of waste collection throughout the city but little data on the location of informal dumps, air quality near dumps, and leaching and surface water contamination. Estimating risk with less than optimal data introduces uncertainty into the overall risk estimate.

The probability of effect score given was 5, the severity of effect score was 4, and thus the overall score was 9.

3.5 Occupational Health

3.5.1 Background

As a city grows, the diversity of employment usually grows for its inhabitants. Diversification brings a wider range of occupational risks and hazards. Within each expanding occupation type, there may be more complex manufacturing or industrial processes. Such a situation may require a larger and more specifically trained workforce; or it may mean that the types of exposures which any one worker may experience are more numerous.

Over the last forty years, Quito has grown six times in population size and twenty times in area. The discovery and exploitation of oil in the early 1970s allowed for an extraordinary growth in the national economy. This, in turn, facilitated the diversification of industrial production, reflected particularly in cities such as Quito. The textile and metal working industries, as well as those for chemicals, wood, and minerals, grew rapidly. The gross national product (*producto interno bruto*) for the manufacturing sector alone quadrupled between 1965 and 1990.

3.5.2 Methods

Due to the narrow scope of work for this assignment and because of the diversity of industries in Quito, this environmental health assessment for occupational health focuses on only two industries in the urban area of the capital: textiles and metal-working.

To detect potential occupationally-related diseases requiring hospitalization and deaths in 1990, computerized runs were performed by Centro de Investigaciones en Medio Ambiente y Salud (CIMAS) on 1990 mortality data and hospital discharge data from the Instituto Ecuatoriano de Estadisticas y Censos (INEC). For this assessment, the international classification of diseases was used, singling out codes for likely occupation-related events. More specifically, the search was for deaths due to: (1) burns; (2) accidents involving fire, machinery, falling objects, objects that cut or punctured, explosive material, hot objects/caustic/corrosive materials and vapors or electric current; and (3) "non-specified causes of accidents not listed above." Hospital discharge data were searched for occupation-related diseases such as burns, bronchitis, asthma, emphysema, malignant tumor of the pleura, aplastic anemia, carpal tunnel syndrome, anthracosilicosis, and pneumoconiosis. For both mortality and morbidity, data on poisonings and toxic effects were studied. Toxins included corrosives and caustics, solids and liquid substances, gases and vapors.

The resulting data were arbitrarily stratified for age 15 years and above and for below 15 years old; cases in those above 15 years of age were considered to be more likely job related. Age- and gender-specific census data for 1990 relevant to urban Quito were used for denominators to calculate mortality and morbidity rates.

Several sources of data were tapped for the discussion that follows. Figures from the 1990 census form the basis of most employment statistics quoted in this text. The number of registered textile and metal working industries within Quito was obtained from a list using the CIUU (Clasificacion Internacional Industrial Uniforme) coding of the Estadisticas de Manufactura and Mineria (1990); textile industry is coded as 32 and the metal-working industry as 38. Specific processes for textile production are classified as 3200s and those for metal-working as 3800s.

Affiliated with the Central de Trabajadores, the Centro de Estudios de Salud de los Trabajadores (CEST) was expected to be a source of information for this risk assessment, but no systematization of the few existing studies had been done. Their information was generally insufficient for the purposes of this assessment. The Division de Riesgos del Trabajo (Work Risks) in IESS had been collecting data about occupational risks through a direct surveillance system, but understaffing and a reduced budget limited their coverage. Their statistics were regionally based. Extracting occupational risk data for Quito would have been both costly and time-consuming.

3.5.3 Exposure

According to the 1990 census data, Quito's urban population is over 1.1 million. Forty-eight percent of Quito's urban population is between 8 and 65 years of age. The employable population consists of those people who meet two criteria: (1) those who are age 8 to 65 years; and (2) those who are not full-time students, homemakers, retired people, pensioners, and the disabled. Using official data, according to this definition, 97% of the total employable population in Quito is employed. This officially leaves 3% of the employable population either looking for work or recently laid off.

Two considerations need to be made when examining a population at risk for occupational hazards: underemployment, and employment in the private sector. According to the 1990 census, 8% to 10% of the employable population in Quito work for less than 20 hours per week. The private sector, where monitoring for occupational hazards and adherence to safety laws may be less regulated, employs 42% of all workers.

The 1990 census broadly groups occupations. Groups at higher risk for occupational injuries (groups 6 through 9) include workers in agriculture, forestry, fishing and hunting, operators of machines and vehicles for transport, construction, and those in the manufacturing industry (small-and large-scale). It excludes those in professional and administrative jobs, as well as people in business or the service industry. Approximately 30% of Quito's urban population are employed in jobs that are at high risk for injury.

Of the high-risk groups, construction makes up 7% of urban Quito's workforce. Manufacturing industries make up 17% of urban Quito's workforce; along with other similar industries, textiles and metal-working make up 6% of all active workers in urban Quito. Fifty-two percent of those workers in manufacturing are women. Nine percent of those workers (men and women) work less than 20 hours per week.

As mentioned above, the number of registered textile and metal-working industries within Quito was obtained using the CIUU coding of the Estadisticas de Manufactura y Mineria. In Quito, there are 125 textile factories. Other surveys have indicated that each textile factory has, on average, 80 workers. Therefore, there must be about 10,000 textile workers in Quito. There are far more metal-working plants or small factories, numbering 3,429 in all of the city; the estimated number of workers is 7,000 to 8,000. The total of number of workers in textiles, metal-working, and related fields is 27,861 in urban Quito; this figure represents about 6% of all workers in urban Quito.

Exposures within the Textile Industry

The textile industry in Ecuador processes wool, cotton, and synthetics. The initial processing of cotton—opening, picking, carding, stripping and grinding—produces high concentrations of cotton dust. Subsequent processing of the raw product to the finished product entails washing, rinsing, drying, cleaning, dying, mercerizing, stamping, and printing. In the processing of textiles, workers are exposed to many detergents, solvents, soaps, acid soaks, volatile glues, blanching agents, starches, polyvinyls, sulfites and sulfates, combustibles that are burned, and dyes.

Exposures within Metal-Working Factories

Not only does metal-working generate metallic dust, the processing requires organic solvents and many acids, such as hydrochloric, boric, chromic, sulfuric, and nitric acid, with which the worker may come in contact. Cyanides, sulfates and sulfites, carbonates, nitrates, and nitrites are created during the chemical processing. Where galvanizing and electrolysis is carried out, other metals, such as nickel, zinc, tin, and copper, are also involved. In many instances, these processes require high temperatures.

EL DUEÑO NO PROTEGE AL EMPLEADO. Women who worked in factories said the "owners did not protect their employees from occupational health risks." Several women said they had stopped working in the textile factories because it was impossible not to breathe the fine dust (pelusa) from the thread, and it hurt their lungs and made them sick. Their employers did not protect them by providing masks or work rooms with ventilation. Another woman who worked sewing cloth pieces together into shirts recounted the cramped room in which 30 women worked long hours without a break. If they complained, they said, they were fired.

Behavioral Factors

Several additional factors were revealed through the focus groups. High levels of unemployment and underemployment as well as job insecurity lead people to take jobs that are potentially dangerous. National policies mandate insurance coverage by employers for workers employed more than three months. Companies are said to circumvent these policies by routinely firing workers who have been on the job three months, who are discovered to be pregnant, or who get married and risk becoming pregnant.

This selection bias against married women often forces them into the informal sector. This situation often means they work in substandard conditions, such as in poorly ventilated rooms or on busy and dusty streets as street vendors. Unsupervised children left at home during their mothers' work hours are at increased risk of injuries, such as burns or falls. If women take children with them to work, the children are then exposed to street hazards, such as accidents and air pollution.

Focus groups emphasized the occupational hazards in the formal sector as well. Workers mentioned textile dust and glass particulates, unsafe conditions in electric shops, long work shifts, toxic fumes and liquids, poorly ventilated work space, inadequate personal protective equipment (gloves, masks, uniforms), and lack of safety standards as some of the hazards they face.

3.5.4 Health Outcomes

Health Outcomes within the Textile Industry

The adverse health effects on textile workers are numerous, but byssinosis leads the list. Although the exact agent of byssinosis is not known, exposure to cotton dust plays an active role in the development of this occupational disease. Manifested by chest tightness, shortness of breath, and cough, byssinosis is often misclassified as chronic bronchitis or goes undiagnosed altogether because workers with byssinosis may not seek medical care. Smoking exacerbates the disease, but asthma is not an additional risk factor. In the United States, the prevalence of byssinosis is 20% among exposed workers. Byssinosis is more common in workers who are involved in the initial stages of cotton processing. Its prevalence increases with duration of exposure. Studies looking for byssinosis are often hampered by the fact that affected textile workers are forced into early retirement, leaving a healthy survivor population. This phenomenon leads to an underestimation of risk.

Exposure to the other agents in cotton processing may lead to respiratory tract irritation, skin disorders (allergic and contact dermatitis), burns, dehydration, hand ulcers, stomach irritation, conjunctivitis, corneal ulcers, mucous membrane ulcers, and, in some instances, neurologic and hepatic disorders. Not to be overlooked are mutagenic, carcinogenic, and teratogenic effects of chemicals used in processing.

In addition, the noise from machinery may provoke temporary or permanent hearing loss. Espin (1991, d) measured noise levels in several cities of Ecuador. Within Quito, 62 sites were examined, of which seven were industrial, although not limited to the textile industry. Although the study report did not specify whether the decibel measurements were taken inside or outside the factories, the noise often exceeded the acceptable limits by 2 to 12 decibels. In some cases, the noise levels had exceeded acceptable standards since the first measurements in 1983 and up through 1989.

Health Outcomes in the Metal-Working Industry

Procedures using high temperatures may induce burns, dehydration, and fatigue. Workers exposed to toxic and corrosive vapors may experience fever due to metallic vapors. Symptoms may range from the mild and nonspecific, such as headaches and lassitude, to more specific and severe, including pneumoconiosis and aplastic anemia. In addition, workers may suffer from conjunctivitis, corneal irritation, dermatitis, ulcers, pneumonitis, silicosis, bronchopneumonia, neurologic symptoms and signs, gastrointestinal and metabolic disturbances, cirrhosis, and nephritis. Processes using lead may also provoke hematologic and nervous system effects. As in the textile industry, noise from machinery may induce temporary or permanent deafness.

Health Outcomes within All Industries

Considering all industries, further assessment of the extent to which injuries lead to temporary or permanent disabilities has been addressed in a review (Harari, 1991) of secondary data for Quito from 1966 to 1985 for work-related accidents. The review indicated that metal-working industry contributed 10.7% of the disabling injuries (temporary or permanent) and deaths; the textile industry accounted for 6.1%.

A separate review by the same author of occupational deaths and disabilities for 1984 for all of Ecuador showed that construction work resulted in 10.3% of deaths and disabilities for that year. If only deaths are considered, then construction work resulted in 38% of all work-related deaths, while manufacturing industry contributed 14%. Analysis of Quito-specific data was not done in this part of the Harari report.

A LAS CASADAS NO NOS DAN OPORTUNIDADES. "Married women are not given job opportunities." Women from el Comité del Pueblo who had worked in industry before they were married told of how, once they were married, they were asked to leave their jobs. Industries rarely want the additional expense of pre-natal and obstetric care, so married women are asked to leave. Leaving industrial work does not reduce married women's need for income, thereby forcing women into the informal and unregulated job market. "La casada tiene necesidades." Women sell cosmetics, stockings, flowers, and food on the street. They are exposed to the constant assault of dust and wind; they are exposed to traffic if they sell on the side (or medians) of the road, and they are exposed to thieves. "La vida de mujeres es muy dura," they said. "Women's lives are very hard."

Death rates that probably reflect (non-vehicular) accidents, many of which may occur on the job, range from 5.1 per 100,000 for women 15 years or older to 24.9 for men over 15 years of age. (The mortality rate for men is thus almost five times that for women.) The overall rate for both men and women is 11.2 per 100,000. Fatal accidents started by fires are the highest for men. Non-specific causes have the highest rates for both men and women.

Morbidity rates for selected conditions in Quito that may be occupation-related in origin are shown in Table 14. Respiratory diseases are among the highest.

Table 14

Morbidity Rates That May Be Occupation Related—Quito, 1990

Diagnosis	Rate (per 100,000)
Asthma*	44.5
Burns	38.7
Chronic bronchitis*	24.0
Aplastic anemia	5.5
Carpal tunnel syndrome	4.9
Emphysema*	1.7
Mesothelioma	1.2
Pneumoconiosis	0.6

*Note: These may also be related to ambient air pollution exposure or tobacco smoke.

3.5.5 Comments

General Comments

Adequate surveillance of occupational exposures, risks, and outcomes entails many steps. Major activities include data collection, case confirmation, data analysis, workplace inspections and recommendations, education and outreach activities, interventions, and follow-back on these interventions. Each of these in turn has many components. The data collection step requires good record-keeping about employees, including specific type of job performed, duration of service, and worker's baseline health, and any changes over time in the materials or processes. The data analysis step requires awareness of the epidemiologic implications of the "healthy worker effect," which results in a "survivor" population and leads to an underestimation of risk.

Uncertainties and biases may enter at any point to cloud the picture of occupational health risk assessment. Detection and diagnostic bias, reporting bias, and misclassification must all be considered in any study of occupational health data. In addition, dose-response relationships may be complicated by uncertain assessment of degree or extent of exposure. Outcome measures must be clearly defined and recognized. Moreover, tracking cohorts of exposed workers becomes increasingly difficult over longer periods of time. When outcomes to those exposures are delayed, such as cancers after years of cumulative exposure, it may be hard to verify the cause-and-effect relationship.

Specific Comments

There are a number of limitations to interpreting the data presented above. By far the most significant limitation to the data is underreporting; no active surveillance system exists in Quito for occupational disorders. Furthermore, affected workers do not always seek medical care and when they do, the occupational nature of their problem may go unrecognized. A second limitation is that confounders, such as smoking, modify the risk of disease. Third, the deaths and illnesses in the data set likely reflect non-occupational events. For example, some severe burns, pulmonary disease, and trauma in adults do not happen on the job. Fourth, no ambulatory data have been available for analysis. The minor incidents that do occur at the workplace and that do not warrant admission to a hospital are not included in the computer runs of 1990 hospital discharge data. Such minor incidents, however, do take a toll on worker productivity and efficiency.

Another major limitation to assessment of the available occupational health data for Ecuador is that much of it is old data, from the 1970s or 1980s. Much of the occupational data are hand-written or poorly photocopied, resulting in the illegibility or incompleteness of many tables and graphs. Although more recent studies have been conducted, that raw data have not yet been analyzed by the Ecuadorian researchers; unfortunately, neither the data nor the researchers were accessible to our team.

The probability score given was 5, the severity score 2, and the overall score 7.

3.6 Toxic Substances: Pesticides (Non-food)

Toxic substances exist in many forms in an urban setting and have an influence which extends beyond that of the workplace. Toxic substances contaminate the water supply, the air, soil, food (including breast milk), and consumer products. Given the limitations of time and resources, this investigation focused on pesticides and lead. Pesticide residuals can contaminate water or food when chemical containers are re-used to store them. Pesticides can also contaminate food directly, including food purchased in markets. Pesticide contamination of food is discussed in Section 3.2.

3.6.1 Background

The effect of pesticides on human health in an urban setting may be acute or chronic. The effects may be neurologic, immunologic, neoplastic, reproductive, behavioral, or developmental. In mild cases, pesticide toxicity may be mistaken for the flu. Usually pesticide poisonings go unreported or unrecognized. In urban settings, pesticide poisoning is not common, but exposure to pesticide-contaminated food may occur. For Quito, only one study was available for evaluating a vehicle of pesticide exposure, apart from food contamination with pesticides, to humans.

3.6.2 Methods

A recent study (Bolaños, 1986) investigated pesticides in maternal milk by collecting 160 samples of maternal milk from three cities (Quito, Guayaquil, and Esmeraldas); one-half of the samples were from Quito. Lindane was the leading contaminant. For Quito samples, average levels were four times the acceptable residual allowed by the United Nations Food and Agricultural Organization. In some samples the level of Lindane was 16 times the acceptable limit.

3.6.3 Exposure

All infants of nursing mothers are potentially at risk for pesticide-contaminated breast milk. (Some pesticides are water soluble and others are fat soluble.)

3.6.4 Health Outcomes

The effect on infants of pesticides in breast milk is not entirely known; however, it may include acute effects, such as gastrointestinal upset or general irritability, and chronic effects, such as immunologic disorders.

3.6.5 Comments

The mothers' prior exposure history is unknown in this study. The study shows that some pesticides, including those that have reportedly been banned for several years, are still found in breast milk. This may represent either ongoing exposure or long half-lives of pesticides that are still part of the environment. Some questions about the accuracy of the laboratory measurements in this study have been raised.

Insufficient data were obtained to develop probability or severity scores.

3.7 Toxic Substances: Lead

> SON LOS NIÑOS QUE SUFREN. "It is the children who suffer" when the women must leave them to work. Women in Carapungo described leaving their children for the entire day while they worked as maids, laundresses, or taking care of other people's children. Married women must help their husbands provide money for the family, "Una mano lava la otra", (one hand washes the other), and often this means that the children are left alone. Sometimes 9-year-olds are responsible for 1- and 2-year-olds. "When the 9-year-old is in school, I take the babies with me when I work selling in the street. When he is out of school, he watches them."

3.7.1 Background

The principal sources of lead in the air in Quito are petroleum refining and combustion of leaded gasoline in vehicles. The organic form of lead is burned to the inorganic form and appears in vehicular emissions. Other potential sources are lead paint dust, batteries, lead leached from painted ceramics, lead solder used in manufacturing and in the repair of automobile and truck radiators, and lead used for waterproofing. These sources of lead exposure affect workers, mothers and their children, street vendors, and bystanders.

3.7.2 Methods

The information on lead came from one study of blood lead levels in street vendors, mothers, and children (Oviedo 1991). Otherwise, very little is available about lead poisoning in the Ecuadorian population.

A 1992 study of lead in the air in Quito examined 300 samples in 30 different sites within the city. The average lead levels in the air were 0.67 $\mu g/m^3$, 1.5 $\mu g/m^3$ being the maximum allowable level; however, in some places the maximum was as high as 7.58 $\mu g/m^3$ The south district, including the tunnels, produced the highest average values (above 1.0 $\mu g/m^3$), but the center of the city produced the levels above 7.0 $\mu g/m^3$. About 9% of all the average values of the 300 samples exceeded the norms; however, the average value for all of Quito was well within the acceptable range. (Study done by Facultad de Geología y Minas, Central University and IEOS, 1992.)

3.7.3 Exposure

All the people of Quito are exposed to lead in the air; however, some population subsets may have higher exposures because of occupation or residence. The probability of effect is high for those at greatest exposure, such as street vendors and those who live near major roads. Sources other than the air must also be considered as potential sources of lead exposure.

A study of blood lead levels in 83 pregnant (term) women, 15 pre-eclamptic ones, and 31 newborns of those mothers from three different parts of Quito was conducted in 1991. Blood lead levels ranged from 15 to 23 micrograms per deciliter (µg/dl) but did not differ for the three areas of the city. The authors assumed the lead was due to gasoline lead in the air; other sources of lead (diet, lead paint dust, batteries, leachings from ceramics, lead-containing cosmetics, and folk remedies used in Latin American cultures) were not thought to contribute significantly.

Another component of the same study conducted in 1991 examined the blood of street vendors (17 men and 59 women) in the historic center of Quito. On average, these men and women had worked 15 years in this area for 9 to 10 hours per day. Blood levels were reported to range from 26 to 30 µg/dl. In some people blood lead levels appear to be a cause for concern.

3.7.4 Health Outcomes

Lead is a potent central nervous system poison. In addition, it can adversely affect the peripheral nervous system, the hematopoietic system (bone marrow), the reproductive system, the gastrointestinal system, and the kidneys. Lead poisoning may be manifested subtly as changes in intelligence or as a learning disability or more obviously as an anemia or peripheral neuropathy. Health effects include hypertension, interference with heme metabolism, and reduced intelligence (IQ) in exposed children.

3.7.5 Comments

The blood lead level for which further investigation is indicated is not standardized and the authors did not state what standards or laboratory methodology were used. The U.S. Centers for Disease Control (CDC) screening criteria are 10 μg/dl in children; OSHA workplace exposure to lead in adults uses 40 μg/dl as its criterion for further study. Some uncertainty about the validity of the data from this study is generated by the speculative nature of the sources of lead in the study subjects' environment and the contribution to the overall burden of lead in the blood. Moreover, the narrow range of results (26 to 30 μg/dl) also raises some questions of validity.

The probability and severity were not estimated because of the paucity of data and the questionable validity of existing data.

3.8 Ambient Air Pollution

3.8.1 Background

A discussion of air pollution must include both outdoor and indoor contamination. Vehicles, industry, and even smoking all contribute to this increasing environmental problem. While the population of Quito has doubled in the last 20 years, the number of automobiles has increased six times. Vehicles contribute to a large portion of the air pollution in Quito. Although industrial discharges into the air may account for up to 40% of the particulate and chemical contaminants, it may in fact be difficult to quantify the actual contribution by industry to Quito's air pollution.

3.8.2 Methods

Three monitoring stations within Quito collect data on ambient air. Although they are roughly distributed as central, north, and south stations, their placement may not be ideal for monitoring. They monitor suspended particulates and anhydrous sulfur; the Quito-corrected standards are 185 μg/dl and 300 μg/dl, respectively.

Collection of samples follows standard protocols. For sedimentary particulates, a continuous 30-day sample is collected. For suspended particulates, a 24-hour sample is collected every three days; a similar procedure is followed for sulfur dioxide (SO_2).

Gravimetric and colorometric methods are used. The official register for Ecuador as a whole states that the concentration of sedimentable particulates should not exceed 1 mg/cm^2 over a 30-day sampling period. The geometric mean of suspended particulates should not exceed 80 $\mu g/m^3$, and the maximum concentration of a 24-hour sample of 250 $\mu g/m^3$ should not be exceeded more than once a year. SO_2 standards are an arithmetic mean not exceeding 80 $\mu g/m^3$, with a once yearly 24-hour sample maximum of 400 $\mu g/m^3$; for a 3-hour sample, it should not exceed 1500 $\mu g/m^3$. As for lead, it should not exceed 1.5 $\mu g/m^3$ as a 24-hour sample within a three-month period.

Suspended particulate matter samples show that since 1979, the corrected norms for Quito (185 $\mu g/m^3$) have been exceeded at two of the three monitoring stations throughout the city. In 1991, the norms (as average readings) were exceeded once, but on seven occasions the norm was exceeded by a maximum reading. For suspended particles, three out of four maximums were exceeded for the south station but never for the north station.

For the central monitoring station, the 1991 air quality data show that the allowable concentration for sedimentable particulates was exceeded 7 months out of 12, with an average of 1.48 mg/cm^2. For the north station, sedimentable particulates exceeded norms four times; for the south station, only once.

One study (Jurado, 1991) found that 44% of the SO_2 discharged into Quito's air comes from the textile and leather working factories and that the food and beverage industry adds 37% more to that figure. As for oxides of nitrogen (NO_x), 40% of the NO_x is from the textile and leather-working factories and 35% is from the food and beverage industries. This study found that SO_2 exceeds the norms by 6%; the other measures are below acceptable norms. Some have expressed doubts that the industrial contribution to air pollutants is actually this high, since these industries are generally not regarded as major polluters of the air. As for anhydrous sulfur, there have been no measurements exceeding the norms (300 $\mu g/dl$, corrected for Quito) since 1979; in general measurements have been far below the maximum allowable levels.

3.8.3 Exposure

The entire population of Quito is exposed, since outdoor air pollutants are ubiquitous. Most of the vehicular traffic, especially mass transit, occurs on a few major transportation arteries. Therefore, vehicle emissions are highest in these areas and pollutant concentrations are expected to be higher near these arteries than the levels indicated by the air quality monitoring station. However, 25% of the population (285,752) lives within 100 meters of the major transportation arteries. Given their proximity to traffic, it is likely that the exposure of these people to vehicle emissions would be significantly higher than monitoring stations indicate. Besides those who live near major arteries, street vendors are at higher risk for health effects from air pollution. It is estimated that 13% (25,350) of the people in the *asentamientos populares* are street vendors.

Outdoor air particulate concentrations also tend to be higher in the *asentamientos populares* than in the city as a whole due to wind-borne particulates from unpaved roads, informal dumps, and trash burning, although the concentrations of pollutants have not been measured or estimated. Incidence of upper respiratory infection and pulmonary dysfunction may be as much as 60% higher in the *asentamientos populares*.

Behavioral Factors

In a qualitative sense, focus groups contributed further to understanding the probability of the health effects of air pollution. Many participants stated that the major health problem is upper respiratory infection. A dusty outdoor environment, largely because of heavy vehicular traffic on unpaved streets and little surrounding vegetation, probably plays a major role.

3.8.4 Health Outcomes

Air pollution, especially particulate matter, is likely to have an effect on respiratory function in the general population. Particles smaller than 10 microns are not cleared by the nasal mucosa and therefore lodge in the lower respiratory tree. Exposure to suspended particulates is associated with upper respiratory infection and reduced respiratory function. Epidemiological studies in several countries have consistently shown that increased particulate levels can result in lost working days, reduced activity levels, and death, especially in those whose respiratory systems are already compromised. The single most frequent health complaint mentioned in all focus groups was upper respiratory problems.

Most people with normal respiratory function, when exposed to air pollution, will have minor symptoms, such as runny nose or mild cough. Prolonged exposure, however, leads to irritation of the mucous membranes, which in turn leads to a greater susceptibility to viral or bacterial superinfections.

Air pollution can exacerbate underlying respiratory disease. In the asthmatic, this may be manifested by more frequent and severe episodes of wheezing, sometimes warranting hospital admission. In the person with emphysema or chronic bronchitis, similar reactions may be seen. In all cases, some worsening of pulmonary function will occur, even if the patient is relatively asymptomatic.

There is evidence to suggest that particulate matter contributes to respiratory symptoms. Increased rates of cough, bronchitis, and lower respiratory disease in school-age children in six U.S. cities were significantly associated with annual total suspended particulate (TSP) levels, between 60 and 150 mg/m^3 (Ware et al., 1986). However, significant associations were not observed within individual cities, only for pooled data. Therefore, while this evidence has its limitations, it does suggest that there is an association between particulates and respiratory symptoms. The TSP levels within Quito exceed this range and may significantly contribute to the high prevalence of respiratory symptoms.

Estimated correlations have been developed for increased TSP levels and morbidity, days of work lost (Ostro, 1983a), days of reduced activity (Ostro, 1983b), and increased mortality (Oskaynak et al., 1986). These correlations have been used previously to estimate risks associated with particulate levels (e.g., USAID 1990). The morbidity relationships are based on data obtained from the Health Interview Survey conducted by the National Center for Health Statistics in the United States. Data on health outcomes were compared with air pollution data for the city in which respondents lived. Data controlled for the following potential confounding variables: age, sex, chronic health conditions, race, marital status, income, annual temperature and precipitation, population density, occupational status, and smoking. After controlling for confounding variables, significant relationships were found between health and particulate levels. The proposed relationship between particulates and work days lost is:

WDL = 0.00145 X 26 X (δTSP X P), where

WDL = excess work days lost in exposed population
δTSP = change in TSP levels
P = exposed population

The relationship for estimating restricted activity days is:

RAD = 0.00282 X 26 X (δTSP X P), where

RAD = restricted activity days in exposed population
δTSP = change in TSP levels
P = exposed population

The mortality relationship was estimated from cross-sectional mortality data using multiple regression, controlling for age, race, education, population density, and economic status. Data indicate that the relationship between particulates and mortality is essentially linear, with no indication of a threshold. The equation used is:

MORT = (0.2/100,000) X (δTSP X P), where

MORT = estimated excess mortality in exposed population
δTSP = change in TSP levels
P = exposed population

Each of the above equations is based on changes in TSP levels. Some suspended particulate matter occurs naturally in the absence of human activities. Therefore, analysis of risks from particulates must use some benchmark from which increased levels can be assessed. For the purposes of this analysis, the U.S. standard for annual average TSP concentrations, 75 mg/m^3, will be used.

Particulate levels have been measured at three monitoring stations within the city. Geometric averages at the stations were 123.3 mg/m^3 at the central monitoring station, 58.8 mg/m^3 at the north monitoring station, and 149.9 mg/m^3 at the south monitoring station. Assuming equal distribution of population among these three monitoring stations, it was estimated that an additional 78 deaths annually would be expected at existing particulate levels, above those allowed in the United States. Existing particulate levels would also result in an estimated 1.5 million days of work lost throughout the city annually, and 2.9 million days of reduced activity. In addition, increased incidence of upper respiratory infections is possible. Given the magnitude of work days lost and reduced activity days, it is assumed that roughly 30% to 40% of city residents would experience some health effect.

3.8.5 Comments

It is known that air pollution compromises respiratory function. In some instances effects may be asymptomatic, only manifested by reduced force ventilatory output or vital capacity. Where underlying respiratory disease, such as asthma or emphysema, already exists, symptoms and signs are more likely to be observed by the patient or the physician. Studies have been done in other countries showing increases in incidence of pulmonary disorders during inversions over cities when air quality worsens. At best, a prospective study in Quito could demonstrate the relationship between air quality and increased incidence of pulmonary disorders or worsening of already-existing asthma, bronchitis, or emphysema.

The probability score given was 2, the severity score 3, and the overall score 5.

3.9 Indoor Air Pollution

3.9.1 Background

Of the many things that contaminate indoor air, cigarette smoking and certain cooking fuels lead the list. When coupled with poor ventilation and crowding, the effect by these contaminants on respiratory health can be noticeable. Allergens such as dust, mold, and animal dander can also contribute to the airborne particulates within a house.

3.9.2 Methods

Data on frequency of smoking and statistics on crowding and cooking fuels are used in this assessment. Studies by other investigators measuring indoor air contaminants were not completed at the time our team was on-site.

Studies throughout United States and Europe have shown that indoor NO_2 levels would average about 30 $\mu g/m^3$ if gas cooking fuel is used and peak 1-hour levels may reach more than 400 $\mu g/m^3$. Whether levels in Ecuadorian homes are similar is not known. Windows in Ecuadorian homes are probably not as well-insulated as those in U.S. or European homes. In the poorer neighborhoods of Quito, homes have fewer windows and poorer kitchen ventilation. In many cases, the home is a single large room, where living and cooking areas are in close proximity to one another. For the purposes of this study, it is assumed that fewer windows and smaller dwellings would offset less insulation. Therefore, indoor concentrations are assumed to be similar to those measured in the United States and Europe.

3.9.3 Exposure

All inhabitants of Quito are exposed to indoor air pollution; however, some groups are at greater risk tnan others. These are occupants of homes in which smoking, poor ventilation, and heavy use of cooking fuels contribute contaminants to the air. Young children are particularly susceptible to the effects of indoor air pollution.

Statistics indicate that propane and gas are used as cooking fuels by almost all of Quito's 262,709 living quarters (94%); only 2% of the population, those in the *asentamientos populares*, use wood. Gas stoves are major contributors to indoor pollution and subsequent health effects. Emissions of indoor pollutants generally increase with reduced appliance efficiency, more common in poorer homes.

Formal studies (Aguilar, 1992) demonstrate that the prevalence of cigarette smoking is 60% in Quito and slightly lower for rural areas. This suggests that the quality of indoor air may not meet acceptable standards for respiratory health. As a result, there are two categories of populations at risk: the 40% exposed to cooking fuels alone and the 60% exposed at higher levels to both fuels and smoking. There are no data on indoor air concentrations, so they are qualitatively inferred from other countries' experience.

Behavioral Factors

Focus groups contribute further to the understanding of indoor air pollution. Many participants state that the major health problem is upper respiratory infection. This is likely due to a combination of factors, especially (1) a dusty outdoor environment, largely because of heavy vehicular traffic on unpaved streets and little surrounding vegetation; and (2) heavy indoor smoking by men. (Many women also smoke.) Three-quarters of the husbands of the women interviewed smoked inside the house. Frequency of smoking and the degree of ventilation influence the incidence of health outcomes, such as increased upper respiratory infections and asthma. It is likely that upper respiratory disease is provoked by indoor air contaminants. As mentioned, allergens such as dust, mold, and animal dander can also contribute to the particulates within a house.

Monitoring and epidemiological studies conducted in the United States and throughout Europe have shown that the use of gas for cooking fuels and resultant indoor concentrations of NO_2 of 30 $\mu g/m^3$ increase the incidence of respiratory infections in children by 16% (EPA, 1991a, EPA, 1991b). Peak concentrations of greater than 400 $\mu g/m^3$ have been shown to result in complications of asthma and chronic obstructive pulmonary disease.

3.9.4 Health Outcomes

Most outcomes of indoor air pollution are likely to be minor upper respiratory disorders. It is known, however, that passive exposure to cigarette smoke can exacerbate allergies and, as NO_2 can, increase the incidence of respiratory infections in children and adults. Chronic passive exposure to cigarette smoke is thought to adversely affect the anatomical development of the sinuses and the lungs in young children. Passive exposure to cigarette smoke is known to increase the risk for lung cancer and cardiovascular disease in adults.

3.9.5 Comments

No completed studies were available regarding the quality of air inside private homes, business offices, or factories; however, air quality deteriorates with cigarette smoking, cooking fuels used inside homes, and crowding by occupants. Data derived from on-site observations and through focus group interviews suggest that the vast majority of homes in the *asentamientos populares* depend on butane gas for cooking and have little ventilation. The data for potential health risks of nitrogen dioxide are based on U.S. and European data using natural gas as a cooking fuel. There may be significant differences in the emissions and resulting indoor concentrations due to differences in cooking fuel, natural ventilation in homes, size and volume of rooms, cooking practices, and relative time spent indoors and outdoors.

The probability score given was 3, the severity score 4, and the overall score 7.

3.10 Traffic Hazards

3.10.1 Background

The environmental impact of vehicles in urban Quito has been exponential. The population of Quito has grown from 515,206 in 1979 to more than 1.1 million at the time of this study, more than doubling in less than 20 years. In contrast, the number of automobiles has risen by more than six times. In 1970, there was one automobile for every 30 people in Quito; in 1989, one in 10 people in Quito had an automobile. Apart from the health effects of air pollution, traffic accidents take a major toll on Quito's population in disability and death.

3.10.2 Methods

Acquisition of data required tapping into three sources of information regarding motor vehicle accidents: (1) INEC data tapes for mortality statistics; (2) the Comandancia General de Policia (Police Headquarters); and (3) the 77 Regimiento de Quito. INEC organizes accident data provided by the Comandancia General de Policia. The information provided at national and provincial levels is tallied by type of accident, main cause, and type and severity of injury. It is not possible to disaggregate the information for smaller geographical units (for example, Quito) or to reorganize data for cross-tabulation.

This limitation led to investigation at the next lower level of data storage, the Comandancia de Policia. The Comandancia has collected information on the type of accident, general location, cause, and type of people involved—at the provincial level, and in Quito. For Quito, even the specific location of accidents is available; however, data on age and gender of victims are not available.

Four categories of accidents were examined for 1990 mortality data for urban Quito: (1) accidents involving only vehicles; (2) accidents involving vehicles and pedestrians; (3) vehicular accidents without collision; and (4) "accidents not specified." Accident statistics from the Comandancia de Policia were classified in the data set according to type of accident, cause, and whether an injury or death occurred. Types of causes include excess velocity, drunkenness, and poor judgment on the part of the driver or the pedestrian. Information on gender and age could only be obtained through review of individual accident report forms, an an activity which was beyond the scope of this assignment.

Further information on accidents involving pedestrians would have been helpful, since the very young and the very old are likely to be victims. These data were not available since obtaining it would have required setting up a database and individually reviewing accident report forms. These forms, which are stored at the Regimiento de Quito, have no structure, but consist of rambling text by a reporting police officer.

3.10.3 Exposure

The population at risk is the entire urban population of Quito, although one might argue that those living near major streets and avenues could be at greater risk for some accidents.

Concomitant with traffic and crowding in urban Quito is an increase in the probability of an accident, whether as a driver, a passenger, or as a pedestrian on Quito's streets and avenues. To some extent, the probability may be age-specific, since very young and very old pedestrians may lack judgment, mobility, or agility. The probability of injury or death is higher for street vendors, who may be pushing carts or carrying heavy loads. Moreover, the children who accompany the street vendors are also at greater risk. Among drivers, the less skilled or more impulsive may be greater risk-takers. Alcohol-impaired judgment also increases the probability of an accident. Poor road quality, lack of traffic safety aids (such as speed limits, traffic police, street signs and directions, and traffic lights at intersections), malfunctioning vehicles, poor weather conditions, or even animals in streets may also contribute to vehicular accidents. Especially critical are monitoring and enforcement of city traffic ordinances; it has been said that because some traffic fines in Quito are very small, they do not deter speeding or other violations on the road.

3.10.4 Health Outcomes

When mortality rates for 1990 are calculated for vehicular accidents in Quito as a whole, the age-specific death rate for males under 15 years of age is 17.7 per 100,000; for males 15 years of age and over, the rate triples to 64.4. For females, this rate doubles from 10.7 to 22.2. Overall, the rate for males is 2.5 times greater than that for females. About 20% of accidents result in injuries. The case-fatality rate for traffic accidents in Quito in 1990 was

12%. Using 1990 population census data, the accident victim rate for Quito is 102 per 100,000.

When one considers the type of accident, the data for 1990 are revealing. As might be expected, 60% of motor vehicular accidents in Quito are collisions, but 13% involve pedestrians. Disaggregating the data for pedestrian deaths by age, one notes that the death rate is 13.2 per 100,000 for Quito males under 15 and 26.3 for males 15 years of age and older.

According to data obtained from the Comandancia de Policia, of the 13% of accidents in Quito in 1990 involving pedestrians, 33% were due to misjudgment by the pedestrian and 12% to driver misconduct. Seven percent of accidents were due to drunkenness. For all of Ecuador, only 5% of the accidents are attributed to pedestrian misjudgment and 14% to drunkenness.

More deaths occurred on the Pan American Highway (in 1990) in Quito than on any other road, possibly due to high speeds.

3.10.5 Comments

Mortality statistics, available through computer runs of 1990 vital statistics, were considered to be reliable. Morbidity data (in the form of hospital discharge data), however, are coded for primary cause, such as femoral fracture, and not for underlying cause, such as a vehicular accident. A search for fractures would have resulted in numbers containing non-vehicular accident data, such as injuries from falls. No ambulatory data were available for this analysis because the health information system for Quito does not provide aggregated information. (Ambulatory data are only kept in the health units, and only basic summaries of number of cases treated, by age or sex are routinely reported to the central system: Jefatura Provincial de Salud.)

It would have been instructive to determine the age of pedestrians involved in accidents, but this was not possible given the lack of data organization at the Regimiento level. By casual observation of traffic patterns, pedestrian behavior, and lack of protective seat belts and infant car seats, one would expect a high number of children involved in car accidents. Such a study could have a significant impact on safety.

The probability score was 5, the severity score was 2, and thus the overall score was 7.

3.11 Ratings for Environmental Health Problems: Quito

3.11.1 Introduction

Table 15 summarizes the relevant data used in developing the environmental health assessment ratings. For each environmental problem, the population at risk, exposure levels (concentration), type of health outcome expected, and an estimate of probability are provided. A semi-qualitative scoring system was developed for both probability and severity of health outcome. Separate ratings were developed for Quito as a whole and for the *asentamientos populares*, in which environmental exposures are significantly higher. These scores are somewhat judgmental and imply a relative frequency ranking between the different problems. (The scoring system has been described in Section 2.) The frequencies reported are based on judgments made after reviewing the available data, making field observations, and conducting focus groups. These scores can be used to compare the risks between environmental problems.

3.11.2 Risk Ratings for the Municipality of Quito

High Rating (Overall score 1 to 6):

Food Contamination: Microorganisms (Overall score 5)

About 65% of all food sold in Quito is biologically contaminated. As a result, it is likely that the entire population will be exposed to contaminated food some time during the year. The likelihood of an effect (diarrhea or parasitic infection) from exposure is very high. Assuming all those exposed experience an effect, then the overall incidence for the city would be around 100%, and thus is scored very high: 1. The main health consequences of consumption of biologically contaminated food are bacterial, viral, and parasitic infections. In general, these would be considered mild health effects. However, diarrhea does contribute significantly to mortality in the very young and old, and therefore the severity is adjusted upward to 4.

Outdoor Air Pollution (Overall score 5)

The entire population is exposed, since outdoor air pollutants are ubiquitous, but a subpopulation is at much higher risk due to vehicle emissions. About 25% of the population lives within 100 meters of the major transportation arteries. Given their proximity to vehicle emissions, it is likely that their exposure would be significantly higher than the monitoring stations indicate. Suspended particulates are the major pollutant of concern. Based on monitoring data, an estimated 78 deaths, 1.5 million workdays lost, and 2.9 million days of reduced activity would be expected annually. In addition, increased incidence of upper respiratory infections is possible. With about 30% to 40% of the population affected, the probability score is 2. With outcomes classified as moderate, the severity score is 3.

-10-

Table 15

Summary of Environmental Health Assessment for Quito

Type of Exposure	Estimated % of Population Exposed	Overall Estimated Probability of Health Effect	Probability Score		Outcome(s)	Severity Score	Overall Score	
			Quito as a whole	*Asentamientos Populares*			Quito as a whole	*Asentamientos Populares*
Food Contamination: Microorganisms Pesticides	 100% 100%	 100% <10%	 1 5	 1 5	Parasites, GI tract infection, diarrhea (microorganisms); liver, kidney, bone marrow toxicity, cancer, other non-cancerous effects (pesticides)	 4 4	 5 9	 5 9
Occupational Hazards	30%	<10%	5	4	Injuries, illnesses, permanent disability, death	2	7	6
Traffic Hazards	100%	<10%	5	5	Bodily injury, death	2	7	7
Drinking Water	10%	12%	4	1	Parasites, GI tract infection, diarrhea	4	8	5
Wastewater	24% moderate 8% high	30%	3	1	Parasites, GI tract infection, diarrhea	4	7	5
Pesticides (non-food)	NE*	NE	NE	NE	Neurological effects, systemic poisoning, death	NE	NE	NE
Solid Waste	30%	<10%	5	3	Parasites, GI tract infection, diarrhea	4	9	7
Lead (air)	NE	NE	NE	NE	Neurological effects, hypertension	NE	NE	NE
Air Pollution:					Increased URI, reduced respiratory capacity, asthma			
Indoor	40% cooking gas only; 60% cooking gas and smoking	25%	3	2		4	7	6
Outdoor	75% moderate 25% high	31 - 40%	2	1		3	5	4

* NE: Not estimated

Moderate Ratings:

Traffic Hazards (Overall score 7)

For motor vehicle accidents, all residents of Quito are at risk as drivers or pedestrians. The outcomes of concern range from temporary bodily injury (broken bones) to physical disability or death. Based on actual data from motor vehicle accidents, the likelihood of injury from accidents is less than 1% of the population per year (102/100,000) and thus receives a very low likelihood score of 5. However, the severity of health outcome is very high, with one-third of reported cases resulting in death. Given that effects would range from moderately serious (3) to death (1), a severity score of 2 was assigned.

Occupational Hazards (Overall score 7)

The working population in Quito at risk of occupational hazards is estimated at 30%. The incidence of occupational injuries among workers is assumed to be 10% to 20%. The incidence, using the whole population as the denominator, is less than 10% (probability score of 5). Occupational injuries can be severe, ranging from broken bones or disability to death; therefore, this risk receives a severity score of 2.

Water Contamination (Overall scores: Drinking water 8, Wastewater 7)

Publicly supplied drinking water is of good quality with little observed biological contamination, so those who receive public water would not be at risk of exposure. The 11.9% of the households that do not have water service would be at risk of drinking contaminated water. The exposure potential is twofold: where the water source is contaminated, or where water handling and storage practices may lead to contamination. The likelihood of an effect (diarrhea or parasites) from exposure is very high. Assuming all those exposed experience an effect, the overall incidence for the city would be around 12%, and thus the likelihood score is 4. The main health consequences of drinking contaminated water are diarrheal disease and parasites. In general, these would be considered mild health effects, but diarrhea does contribute significantly to mortality in the very young and old, and therefore the severity is adjusted upward to 4.

Those at risk for exposure to wastewater are the 32% of city residents who do not have household connections to the public sewer. This group can be further divided into two groups: those who share common bathrooms with other households (24%), who have a medium risk of exposure; and those who use latrines or have no sanitation service (8%), who would have an extremely high exposure potential. The likelihood of an effect (diarrhea or parasites) from exposure is very high. Assuming all those exposed experience an effect, then the overall incidence for the city would be around 30%; it thus has a medium probability score of 3. The main health consequences of contact with wastewater are diarrheal disease and parasitic infection. In general, these would be considered mild health effects, but diarrhea does contribute significantly to mortality in the very young and old and therefore, the severity is adjusted upward to 4.

Indoor Air Pollution

For indoor air, statistics indicate that propane and gas are used by all of Quito for cooking fuels, except the 2% of the population who use wood. Gas stoves have been shown to be major contributors to indoor pollution and its health consequences. Therefore, the entire population is at risk of exposure to this source. Additionally, statistics show that 60% of the population smokes, representing another significant indoor pollutant. Therefore, the population is divided into two categories, 40% exposed to cooking fuels alone and 60% exposed at higher levels to both fuels and smoking. There are no data on indoor air concentrations, so they are qualitatively inferred from other countries' experiences.

Epidemiological data have shown that the use of gas for cooking fuels equates to an increased incidence of 16% of respiratory infections in children and complications of asthma and chronic obstructive pulmonary disease during peak use. Focus groups indicated that the prevalence of respiratory disease was high; therefore, any incremental increase is significant. The presence of smoking would increase the incidence of health outcomes, even further increasing upper respiratory infections and episodes of asthma. A qualitative estimate of incidence for the entire population is that roughly about 25% of the population would experience some effect. It thus receives a likelihood score of 3. The severity score is based on the severity of upper respiratory infections, which are generally mild; thus, the severity score of 4.

Low Rating:

Food Contamination: Pesticides (Overall score 9)

All residents of Quito are also exposed to pesticides in their food. A survey of foods indicated that all samples contained some residues of pesticides, though concentrations were typically below allowed levels. However, three banned pesticides were shown to exceed acceptable levels for total consumption, indicating potential risks. The likelihood of experiencing an effect is less than 10% in those exposed, so it receives a low likelihood score of 5. The effects associated with low levels of pesticide exposure typical of food ingestion range from cancer to mild non-cancerous effects. Because the predominant effects are mild, a severity score of 4 is given.

Solid Waste

The areas of the city that do not receive frequent solid waste collection and those individuals who make a living scavenging through garbage for recyclable materials would be at risk. About 30% of the population does not have solid waste collection; this group can be divided further into those in neighborhoods with eventual collection and medium risk of exposure and those in neighborhoods without any waste collection who would have high exposure potential. All solid waste is not pathogenic and therefore contact with waste does not necessarily result in an effect. Incidence of effect (diarrhea and parasites) would likely be less than 20% of those exposed, which equates to less than 10% for the city as a whole and a very low likelihood score of 5. The main health consequences of contact with solid waste are diarrheal disease and parasites. In general, these would be considered mild health effects. However, diarrhea does contribute significantly to mortality in the very young and old, and therefore the severity is adjusted somewhat upward to 4.

Not Rated:

Toxic Substances: Lead

The population at risk for lead may be equivalent to that for outdoor air pollution, since vehicle exhaust is assumed to be a major contributor and those living near major roads would be expected to have higher levels of exposure. Air monitoring data indicate that air lead levels (at 0.6 $\mu g/m^3$) are fairly low in comparison with other problem cities. On average, these air lead levels would be expected to increase blood lead levels by 1.2 $\mu g/dl$ in adults and 1.8 to 3.0 $\mu g/dl$ in children. This represents a minimal contribution to overall blood lead levels. Blood lead levels in a small sample of pregnant women were 15 to 23 $\mu g/dl$ and a study of highly exposed street vendors showed levels in the range of 26 to 30 $\mu g/dl$. These are considered to be an upper bound estimate of blood lead levels for the population as a whole. The contribution of airborne lead to overall blood lead levels and incremental health effects is relatively insignificant. Therefore, lead in the air is likely to result in small likelihood of outcome. However, it should be noted that the contribution of lead in the air does not account for the blood lead levels that have been observed. Therefore, there are likely to be other environmental sources that have not been identified and that cannot be quantified. The effects most associated with lead include IQ decrements in children and hypertension in adult males. IQ decrements are often significant, while hypertension is usually mild. Insufficient data were available to develop probability and severity scores.

Toxic Substances: Pesticides (Non-food sources)

Agricultural use of pesticides within the city of Quito is very small, exposing less than 0.5% of the total population. Elevated levels of pesticides have been found in breast milk of women in Quito, but the probability and severity of health effects could not be determined.

3.11.3 Ratings for *Asentamientos Populares*

The *asentamientos populares* in Quito are home to the poorer population (20% of the total population), which is exposed to significantly different and worse environmental conditions than the city as a whole. Therefore, this group is at greater risk than the remaining city population. As a result, a separate rating was made for the environmental risks for the *asentamientos populares*. The severity ratings for effects related to each environmental problem remain the same, since it is assumed that the same effects would result. However, exposure potential and incidence may be altered due to worsened environmental conditions, and therefore alternative frequency scores were established for some of the environmental problems.

Indoor Air Pollution

Homes using wood for cooking fuel are all located in the *asentamientos populares*. While people in these homes make up only 2% of the city population, they constitute 10% of the peri-urban settlement population. Also, cooking appliance efficiency is likely to be less than in the more affluent sections of the city. Emissions of indoor pollutants generally increase with reduced appliance efficiency. As a result, incidence of health effects would tend to be higher in the *asentamientos populares* than for the city as a whole, and the probability score is thus changed to 2.

Outdoor Air Pollution

Outdoor air pollution tends to be worse in the *asentamientos populares*. Particulate concentrations in the *asentamientos populares* are significantly higher than for the city as a whole, due to wind-borne particulates from unpaved roads, informal garbage dumps, and trash burning. Therefore, incidence of upper respiratory infection and reduced pulmonary function in the *asentamientos populares* is higher than for the city as a whole. The probability score is revised to 1.

Occupational Hazards

Those working in high-risk occupations, such as construction, and workers in factories or shops with low safety standards tend to make up a higher percentage of the population of the *asentamientos populares* than for the city as a whole. Therefore, the incidence of injury or death tends to be higher in the *asentamientos populares*. The probability score is adjusted to 4.

Water Contamination: Drinking Water and Wastewater

For all water-related environmental issues, nearly the entire population within the *asentamientos populares* is at risk due to its minimal water and wastewater infrastructures. For drinking water, the 10% of the city's population at risk is entirely within the *asentamientos populares* and represents about half of that population. Given that the incidence of diarrheal episodes is high, and given exposure, the incidence of episodes is about 50% and thus the likelihood score is changed to 1. For wastewater, where the entire population is at risk, and most use latrines for sewage disposal, incidence of episodes of diarrhea is probably around 70% to 80%, so the probability score is changed to a 1.

Solid Waste

It is assumed that the entire population of the *asentamientos populares* is at risk of exposure to improperly disposed solid waste. Additionally, the families who make a living as scavengers are located in these neighborhoods. The incidence of effects, although not certain given exposure, tends to be higher than in the city as a whole, and therefore the probability score was changed to a medium score of 3.

Other Exposures: Unchanged Overall Scores

For traffic hazards and food contamination, it was assumed that environmental conditions did r 't differ significantly enough between the *asentamientos populares* and the city as a whole to warrant alternative scores.

Chapter 4

RESULTS OF THE ENVIRONMENTAL HEALTH ASSESSMENT: PEDRO MONCAYO

4.1 Background

Pedro Moncayo is a county located in the northern part of Pichincha Province, on the Mojanda Mountain, no more than 40 miles north of Quito. Pedro Moncayo has 15,718 inhabitants, living in five parroquias, Tabacundo (the county seat, 37.5%), Malchingui (19.1%), Tocachi (9.2%), La Esperanza (13.5%) and Tupigachi (20.5%). Most of the population live in the rural areas (81.2%). The educational level is low; since 19.5% of the population 10 years of age or older is illiterate. Of the population 6 years of age or older, only 1.5% has completed high school, and 11.5% has completed elementary school.

Of the population 8 years of age or older, 46.2% is considered economically active. The main economic activity is agriculture, which involves 58% of the economically active population. Other economic activities are of less importance: services (19.6%), construction (11.3%), industry (7.2%). People in rural areas and women are generally worse off economically than others.

Pedro Moncayo is considered one of the poorest counties in the province as well as in the country, with little development in agriculture, industry, and other economic activities. Its natural resources have severely deteriorated due to erosion and deforestation. It is the only county in the province that shows a negative population growth, due to significant outmigration.

4.1.1 Potential Environmental Health Problems

Preliminary evidence from Suárez (1992) and Crissman and Espinoza (1992) indicate that rural areas have environmental health problems that are different in type and severity from urban areas. For Pedro Moncayo, it is estimated that the following environmental health problems are the most important:

1. Occupational health problems due to pesticide exposure of agricultural workers and the general population
2. Exposure to high indoor levels of particulates and toxic fumes from cooking and heating fires
3. Traffic hazards

4. Diarrheal disease attributable to contaminated drinking water, poor sanitation, and poor personal hygiene.

4.2 Occupational Health

4.2.1 Background

As stated above, more than half of the economically active people work in agriculture, although agriculture is not well developed. Others work in services, construction, industry, and other sectors.

4.2.2 Methods

The same procedure used for Quito was followed for Pedro Moncayo. To detect potentially occupation-related deaths and diseases requiring hospitalization in 1990, computer analyses were performed by Centro de Investigaciones en Medio Ambiente y Salud (CIMAS) on 1990 mortality data and hospital discharge data from the Instituto Ecuatoriano de Estadisticas y Censos (INEC). For this assessment, the international classification of diseases was used, singling out those codes for likely occupation-related events. More specifically, the search was for deaths due to (1) burns; (2) accidents involving fire, machinery, falling objects, objects that cut or punctured, explosive material, hot objects, caustic/corrosive materials and vapors, and electric current; and (3) non-specified causes of accidents not listed above. Hospital discharge data were searched for occupation-related diseases such as: burns, bronchitis, asthma, emphysema, malignant tumor of the pleura, aplastic anemia, carpal tunnel syndrome, anthracosilicosis, and other pneumoconioses. For both deaths and non-fatal illnesses, data on poisonings and toxic effects were studied. These included corrosives and caustics, solid and liquid substances, and gases and vapors.

The resulting data were arbitrarily stratified for age 15 years and above and for below 15 years of age; those cases above 15 years of age were considered more likely to be job related. Age- and gender-specific census data for 1990 relevant to urban Quito were used for denominators to calculate mortality and morbidity rates.

4.2.3 Exposure

According to the 1990 census, Pedro Moncayo has 15,718 residents. Only 36% of the county population is between 8 and 65 years of age. The employable population consists of those people who are: (1) between age 8 and 65 years; and (2) not full-time students, homemakers, retired people, pensioners, and the disabled. By this definition, 97% of the total employable population in Pedro Moncayo is actively employed. This leaves 3% of the employable population either looking for work or recently laid off.

In contrast to Quito, Pedro Moncayo is largely agricultural. Although exact figures are not available for the number of farms or agriculturally-oriented industries in this rural county, agriculture makes up 58% of Pedro Moncayo's formal and informal workforce. Three-quarters of this workforce consists of men; 10% work part-time.

Two considerations need to be made when examining population-at-risk data: underemployment and employment in the private sector. According to the 1990 census, 8% to 10% of the employable population in Pedro Moncayo works less than 20 hours per week. The private sector, where both monitoring for occupational hazards and adherence to safety laws may be less regulated, employs 42% of all workers in Pedro Moncayo.

The 1990 census broadly groups occupations. Groups at higher risk for occupational injuries (groups 6 through 9) include workers in agriculture, forestry, fishing and hunting, construction, operators of machines and vehicles for transport, and those in the manufacturing industry (small and large scale). It excludes those in professional and administrative jobs, as well as people in business or the service industry. Examination of these categories shows that approximately 74% of workers in Pedro Moncayo are employed in jobs that are at high risk for injury.

4.2.4 Health Outcomes

The 1990 morbidity and mortality data for Pedro Moncayo are sparse; only two accidents (falling objects) in men over 15 years age were reported. There were five potentially occupation-related accidents of non-specific cause, yielding a rate of 44.5 reported accidents per 100,000 for the overall working population. There were no accidents reported for women. Morbidity for selected causes that may be occupation-related in 1990 were as follows:

Morbidity for Pedro Moncayo
(per 100,000)

Asthma	32.2
Burns	10.7
Chronic bronchitis	10.7
Aplastic anemia*	
Carpal tunnel syndrome*	
Emphysema*	
Mesothelioma*	
Pneumoconiosis*	

*No cases reported.

4.2.5 Comments

The same uncertainties exist for the Pedro Moncayo assessment as for the one in Quito. The lack of an active surveillance system for occupational hazards in a rural area hampers an evaluation of the types and extent of job-related injuries and deaths. The same factors are at work even in the passive surveillance system: misclassification, underreporting and reporting bias, and diagnostic bias. The more migratory nature of rural workers further complicates the tracking of cohorts with exposures whose outcomes may be delayed and therefore not readily linked to an exposure in the workplace. Not to be overlooked is hesitation on the part of workers to report an injury or illness for fear of job or wage loss.

There are a number of limitations to interpreting the data presented above. Besides underreporting in Pedro Moncayo for occupation-related disorders, there are confounders, such as smoking, that modify risk of disease. In addition, the deaths and non-fatal illnesses and injuries in the data set are likely to include non-occupational events. For example, some incidences of severe burns, pulmonary disease, and trauma in adults do not happen on the job. Also, no ambulatory data have been available for analysis. The minor incidents that do occur at the workplace and that do not warrant admission to a hospital are not included in the computer analyses of 1990 hospital discharge data. Such minor incidents, however, take a toll on worker productivity and efficiency.

Another major limitation to assessment of occupational health data for Ecuador is that most of the data obtained are from the 1970s or 1980. Much occupational data are hand-written or poorly photocopied, resulting in the illegibility or incompleteness of many tables and graphs. Although more recent studies have been conducted, those raw data have not yet been analyzed by the Ecuadorian researchers; unfortunately, neither the data nor the researchers were accessible to our field team.

4.3 Toxic Substances: Pesticides

4.3.1 Background

Potato pesticide poisonings in humans are of interest because ten times as much pesticide is applied to the potato as to wheat. Moreover, the potato plant receives about nine pesticide sprayings over its six-month growth period. Potatoes are grown year-round in Ecuador. The fungicides are wettable powders, usually prepared in 50-gallon vats by the women, and the insecticides come as liquids. The pesticides most commonly applied by farmers and studied by the Centro Internacional de la Papa (CIP, International Potato Center) are carbofuran (Furandan) and methamidophos (Monitor) among the phosphate-based insecticides, and dithiocarbamates (Maneb, Mancozeb) and carbamates (carbofuran) among the fungicides. Chlorinated pesticides are no longer used by farmers in Carchi province, but residues are still found in potatoes.

4.3.2 Methods

The information about the effects of pesticides was obtained through papers and information from the CIP, which has been conducting research in Carchi Province, north of Quito. Although the risk assessment team did not have access to any data on pesticide practices in Pedro Moncayo, it is thought that practices in Pedro Moncayo are likely to be similar to those in Carchi.

4.3.3 Exposure

It is reported that although the male back-pack sprayers are often soaked with pesticide liquid while spraying, they do not use personal protective equipment (PPE) while working. A 1989 survey showed that 71% of workers thought that PPE was unnecessary. The cost of PPE, custom, or discomfort often contribute to its infrequent use.

Evidence also suggests that there is essentially no health education for agricultural workers about pesticides. A recent study showed that 87% of workers with pesticides have no information, education, or communication about the adverse effects of pesticides. In addition, the vendors and distributors either do not know the toxic effects of pesticides or limit the information provided to the purchaser, further contributing to ignorance about the harmful effects of the pesticides. A survey in 1989 demonstrated that 44% of agricultural workers do not know the symptoms of pesticide poisoning.

KAP studies show that many farms and agricultural sites have no separate areas for washing, eating, and working. In addition, because sprayers do not have uniforms, they take their work clothing home with them for periodic washing, thereby also exposing their families to the pesticides.

Passive surveillance by the government has detected about 21 cases of pesticide poisonings in a population of about 100,000 over one year. A new active surveillance system run by the CIP has detected an average of 4 cases per month for a population of about 9,000, or 533 per 100,000 per year. These statistics indicate the substantial underreporting of pesticide poisonings in Ecuador—by a factor of 25!

4.3.4 Health Outcomes

A survey conducted in 1985 revealed that 39% of workers studied had mild symptoms of pesticide poisoning and that 37% of those went on to have severe symptoms, warranting health care. A 1989 study (Harari) showed that there were 29 cases of chronic organophosphate poisoning in 346 agricultural workers (8% incidence rate). Poisonings may be manifest as mild gastrointestinal upset or more severely as frank neurological syndromes which include seizures, autonomic dysfunction, respiratory failure, and occasionally death. It should be noted that pesticides have been used for suicide and homicide.

Pesticide poisonings are classified under the code of "toxic effects of other non-medicinal substances." For Pichincha Province, there were 71 and 44 pesticide poisonings reported for 1987 and 1988, respectively. It can be assumed that these occurred rurally, of which the county of Pedro Moncayo is just one part. The 1990 data show that the rate of toxic effects of non-medicinal substances was 10.4 per 100,000 (absolute number of 42) for the urban Quito population 15 years of age and over. (This does not include suicides or homicides; there were 266 deaths in Ecuador for 1990 that were attributed to poisonings using solid and liquid substances, of which pesticides were a contributor.) Only toxic effects were reported for Pedro Moncayo for 1990, at a rate of 10.7 per 100,000.

4.3.5 Comments

A major limitation to detecting poisonings is the reporting system itself. Few reports come through the Instituto Ecuatoriano de Seguridad Social (IESS) because the insured population among the farming community is small. The IESS does not cover small independent farmers and their families, except in small proportion through the Seguro Social Campesino. The Ministry of Labor has a Health and Safety Department with legal powers, but it is said to be ineffective for monitoring pesticide safety.

The need for further studies has been apparent. In June 1992, the CIP began a prospective study of about 100 pesticide sprayers. They are being monitored by a battery of neurologic tests as well as chemical tests of blood and urine of these workers.

4.4 Traffic Hazards

4.4.1 Background

Motor vehicle accidents may be smaller in absolute number in a rural area, largely because there are fewer private automobiles. Nevertheless, farm vehicles and machinery on the road, stray animals, and pedestrians who are less accustomed to traffic may still provoke accidents. In addition, speeding violations may occur more frequently because an area may be less policed. Geography may also influence driving behavior; mountain roads, unpaved roads, hidden accesses and exits, and poor or absent lighting on rural roads create hazards as well. Alcoholism is more frequent in rural areas and may lead to misjudgment by both drivers and pedestrians. Lastly, the lack of readily accessible emergency medical care contributes to higher morbidity and mortality rates.

4.4.2 Methods

Mortality data for 1990 was obtained through the vital statistics registry in the same fashion as that for Quito. Limited data about traffic accidents (type and location) was obtained through the Comandancia de Policia.

Four categories of accidents were examined for 1990 mortality data for Pedro Moncayo: (1) accidents involving only vehicles; (2) accidents involving a vehicles and pedestrians; (3) vehicular accidents without collision; and (4) accidents not specified.

4.4.3 Exposure

The population-at-risk is the entire population in the county (15,718). Different factors are at work in a rural area than in an urban one. Because there may be fewer private vehicles, the population uses public transportation more often. In addition, slow moving farm equipment on the roads, stray and grazing animals, and unlicensed drivers are more common. Lack of speed limits, traffic lights, or police to monitor and enforce traffic safety also contribute to higher rates of motor vehicle accidents. The mountainous terrain of Pedro Moncayo presents greater driving hazards. Public transportation on these roads runs a greater risk of accidents with a larger number of victims.

4.4.4 Health Outcomes

For Pedro Moncayo, data are not disaggregated for type and cause of accident as they are for Quito. The 1990 data are incomplete; however, 6 deaths and 14 injuries resulted from 9 accidents. The pedestrian death rate is 62.8 per 100,000 for males under 15 years of age and 112 per 100,000 for males 15 years of age and older. In contrast to urban Quito, these rural rates are almost five times higher for males under 15 and over four times higher for males 15 years and over.

When the county of Pedro Moncayo is compared to Quito, the statistics are compelling, even though absolute numbers are smaller and number of registered automobiles per population is presumably lower in a rural setting of lower socioeconomic level. Males 15 years of age and older experience mortality rates of 224 per 100,000, while no females of the same age group died in 1990. Young males under 15 years of age have mortality rates of 94, less than half of those 15 years of age and older. For the whole population of Pedro Moncayo, the death rates were 107 per 100,000 for those 15 years of age and older, and 46.9 for those under 15.

Based on 1990 population census data, the rate for victims in accidents for Pedro Moncayo is 127 per 100,000. As one might expect, in both urban and rural locations, mortality rates are higher for males 15 years of age and over. Mortality rates are notably four to five times higher in Pedro Moncayo than in Quito, possibly due to less access to emergency medical care.

4.4.5 Comments

Mortality statistics, available through computer analyses of 1990 vital statistics, are considered to be reliable. Morbidity data (hospital discharges), however, are coded for primary cause, such as femoral fracture, and not for underlying cause, such as a vehicular accident. Were one to have searched for fractures, the numbers would have contained non-vehicular accident data, such as injuries from falls. No ambulatory data have been used in this analysis because the health information system is presently incomplete in terms of reporting units.

Of the accidents involving pedestrians, it would have been instructive to determine age distribution. This determination was not possible given the lack of organization of the data at the regimiento level. It would have also been helpful to have data for public transportation accidents, since public transportation may be more commonly used than private transport in rural areas compared to Quito.

4.5 Indoor Air Pollution

4.5.1 Background

Of the many things that contaminate indoor air, cigarette smoking and certain cooking fuels lead the list. When coupled with poor ventilation and crowding, the effect by these contaminants on respiratory health can be noticeable. Allergens such as dust, mold, and animal dander can also contribute to the airborne particulates within a house.

4.5.2 Methods

Estimates of indoor air contaminants for Pedro Moncayo have not been done; however, data on number of rooms and occupants within one dwelling are obtained from the 1990 census. Much helpful information for further studies could be obtained from focus groups and on-site observations.

4.5.3 Exposure

The same factors considered for Quito are also applicable to Pedro Moncayo: crowding, smoking, cooking fuels, and airborne particulates. The degree of crowding is reflected by the number of rooms and the number of inhabitants. The average home in Pedro Moncayo has 4.35 people and 2.6 rooms; in fact, 28% of the homes in Pedro Moncayo have only one room. This would be a significant factor for indoor air pollution, since cooking and smoking would be done in one room, exposing all the inhabitants. It is estimated that slightly less than 60% of inhabitants in Pedro Moncayo are smokers. About 62% of inhabitants of Pedro Moncayo use wood as a cooking fuel. In the poorer rural areas, homes have fewer windows and poorer kitchen ventilation. In many cases, the home is a single large room where living and cooking areas are in close proximity to one another. Young children are particularly susceptible to the effects of indoor air pollution.

4.5.4 Health Outcomes

It might be predicted that many residents of Pedro Moncayo also suffer from upper respiratory symptoms like their counterparts in the *astentamientos populares* of Quito. This is likely encouraged by a combination of factors, especially (1) a dusty outdoor environment, largely because of heavy vehicular traffic on unpaved streets, and little surrounding vegetation; and (2) heavy indoor smoking by men. Three-quarters of the husbands of the women interviewed were smokers who smoked inside the home. Formal studies (Aguilar, 1992) demonstrate that the prevalence of cigarette smoking is 60% in Quito and slightly lower for rural areas. This suggests that the quality of indoor air may not meet acceptable standards for respiratory health. Frequency of smoking and the degree of ventilation influence the incidence of health outcomes, such as increased upper respiratory infections and asthma. It is known that upper respiratory disease may be provoked by indoor air contaminants. Allergens such as dust, mold, and animal dander can also contribute to the particulates within a home.

Most outcomes of indoor air pollution are likely to be minor upper respiratory disorders. It is known, however, that exposure to passive smoke can exacerbate allergies and provoke respiratory problems in children and adults alike. Chronic exposure to passive smoke is thought to adversely affect the anatomical development of the sinuses and the lungs in young children. It also increases the likelihood of lung cancer and cardiovascular disease.

Epidemiological studies conducted in the United States and throughout Europe have shown that the use of gas for cooking fuels—and subsequent indoor concentrations of nitrogen dioxide of 30 ug/m^3—increases the incidence of respiratory infections in children by 16%. Peak concentrations of greater than 400 ug/m^3 have been shown to result in complications of asthma and chronic obstructive pulmonary disease.

4.5.5 Comments

No completed studies in Ecuador were available regarding the quality of air inside private homes, business offices, or factories; however, air quality deteriorates with work place air contaminants, smoking, cooking fuels used inside homes, and crowding by occupants.

4.6 Diarrheal and Other Infectious Diseases Related to Contaminated Water Supply, Inadequate Sanitation, and Personal Hygiene

4.6.1 Methods

The same procedure used for Quito was followed for Pedro Moncayo. The population census and hospitalization statistics were reviewed. Data were summarized with respect to water and wastewater service in Pedro Moncayo and are summarized in Table 16.

4.6.2 Exposure

In general, water service is similar to Quito with about 84% of the population having some service connection and with about 82% receiving water from public service. However, unlike Quito, there were no data available on the water quality, so whether this water presents potential health risks could not be assessed. Wastewater service was found to be more limited than that found in Quito. More than half of the population does not have formal wastewater and sewage collection (54%) or waste treatment (58%) (Table 16). However, no data were available on the location of waste disposal with respect to residences or water supplies. Therefore, the potential for exposure in Pedro Moncayo could not be quantified, although it is clearly greater than in Quito.

Table 16

Demographics Related to Water and Wastewater in Pedro Moncayo

Type of Service	Population	Percentage
Water Service		
In-house connection	1033	29.8
Common indoor connect	1561	45.0
Outside piping	319	9.2
No piping	554	16.0
Total	**3467**	**100.0**
Water Source		
Public Service	2841	81.9
Well	143	4.1
River, aqueduct	291	8.4
Vendora	19	0.5
Other	173	5.0
Total	**3467**	**100.0**
Toilet		
Exclusive	731	21.1
Common	222	6.4
Latrine	627	18.1
Other	1887	54.4
Total	**3467**	**100.0**
Wastewater		
Connect public sewer	904	26.1
Septic Tank	282	8.1
Other	274	7.9
None	2007	57.9
Total	**3467**	**100.0**

Source: Census Data, 1990

4.6.3 Health Outcomes

The 1990 mortality and morbidity data for Pedro Moncayo were sparse. However, data that were obtained for intestinal illnesses and other potential water-borne illnesses have been summarized in Table 17. As suggested by the increased exposure potential, Pedro Moncayo did have greater rates of illnesses than the city of Quito. However, given the lack of data, the exact source of illness could not be determined.

Table 17

Mortality and Morbidity for Waterborne Illness, Pedro Moncayo

	Males		Females		Total	
	<15 yrs	≥15 yrs	<15 yrs	≥15 yrs	<15 yrs	≥15 yrs
Intestinal Infections						
Deaths	9	1	9	3	18	4
Rate	282.6	22.5	280	61.6	281.3	44.4
Cases	9	3	3	5	12	8
Rate	282.6	67.4	93	102.7	187.5	88.8
Hepatitis						
Deaths	0	0	0	0	0	0
Rate	0	0	0	0	0	0
Cases	1	0	0	1	1	1
Rate	31.4	0	0	20.5	15.6	11.1
Intestinal Parasites						
Deaths	0	0	0	0	0	0
Rate	0	0	0	0	0	0
Cases	0	0	0	0	0	0
Rate	0	0	0	0	0	0

Source: INEC, Egresos Hospitalarios, 1990
INEC, Censo de Poblacion, 1990

4.6.4 Comments

The same uncertainties exist for Pedro Moncayo as for Quito. However, there are greater uncertainties in that the quality of the water provided could not be assessed and there were no data or information on the disposition and fate of wastewater and excreta.

Chapter 5

CONCLUSIONS

Quito has less severe environmental problems than most large cities in Latin America. However, its ecology and population are in a process of interaction which, if uncontrolled, may result in the rapid degradation of the environment, with consequent negative results for the health of its citizens. Thus, Quito is at a threshold where it needs to invest in a risk management strategy that would prevent current environmental health problems from becoming worse.

Our assessment of Quito's environmental health risks is summarized in Table 18.

Table 18

Assessment of Environmental Health Risks in Quito

Risk (score)	Quito as a whole	*Asentamientos Populares*
High (1 [illegible]	Food Contamination: Microorganisms	Food Contamination: Microorganisms
	Outdoor Air Pollution	Outdoor Air Pollution
		Occupational Hazards
		Drinking Water
		Wastewater
		Indoor Air Pollution
Medium (7-8)	Traffic Hazards	Traffic Hazards
	Occupational Hazards	Solid Waste
	Drinking Water	
	Wastewater	
	Indoor Air Pollution	
Low (9-10)	Solid Waste	Food Contamination: Pesticides
	Food Contamination: Pesticides	
Not Estimated	Lead (air)	Lead (air)
	Toxic Substances: Pesticides (non-food sources)	Toxic Substances: Pesticides (non-food sources)

Environmental conditions in Quito have different human impacts in *asentamientos populares* than in the rest of the city. For Quito as a whole, food contamination with microorganisms appears to be the most prevalent environmental health risk. The data collected indicate that gastrointestinal problems are the most common category of ailments among city dwellers, and the most prevalent cause of death. Since water quality seems to be adequate, and since 65% of all foods are contaminated, it appears that food contamination may be the principal source of gastrointestinal illnesses.

The second highest risk source is particulate matter in outdoor air. Analogous to food contamination, air pollution potentially affects everyone. Its average severity, however, is low when compared to other hazards, such as car accidents. Still, the evidence, both in terms of morbidity and mortality, indicates that it is a significant risk to human health. This risk is particularly high for those people—about 25 % of the population—who live and work along the transportation corridors running from North to South throughout the city.

For *asentamientos populares*, the data show that contaminated food and polluted outdoor air are also the largest sources of risk. However, outdoor air quality problems in these areas are caused, at least in part, by dust from unpaved streets. Although respiratory ailments may come from several sources besides dust in the air, the site visits performed by the study team indicate that dust is such an overwhelming problem in these neighborhoods that trying to associate respiratory problems with other sources may be difficult.

In addition to food and air, people living in the *asentamientos populares* are more exposed to risks from indoor air contamination and occupational hazards than people living in other areas of the city. Cooking stoves along with textile and metal industries are important risk sources. Although the anecdotal evidence also points toward the construction industry, data were not available to document its potential risks to human health.

The results also show two surprises: the relatively low risks associated with solid waste and with drinking water. The former is less a source of pathogens than originally believed because of the cool weather and because of the relatively low contact between people and garbage. Even though there are many informal dumps around the city, the data show that almost 80% of the solid waste is disposed of properly. Moreover, direct observation and in-depth interviews indicate that the uncollected waste does not seem to account for much environmental health risk.

Water quality also seems to pose low risks to the general population in Quito. The data collected by the water company on a regular basis clearly show that network water is of good quality. Contamination seems to occur at the connection points in houses with septic tank problems, or among households with poor hygiene, which are primarily in the *asentamientos populares*.

Overall, the results show that there are significant differential health consequences related to access to infrastructure, such as paved roads and potable water. Hence, residents of *asentamientos populares* are more at risk of environmental health consequences than are those living in more middle-class neighborhoods. Most striking is the health risk people are exposed to through food contamination and outdoor air pollution, and contact with waste water.

Finally, the experience gained from this study shows that qualitative data need to be integrated into risk assessment studies conducted in developing countries. Without such data, quantitative data on environmental quality and health will be substantially less useful.

Although this study has its limitations, the evidence from secondary data—and the corroboration provided by qualitative data from focus groups—indicate that the findings from this study are fairly unambiguous. The results of this study should be useful to the local governments of Quito and Pedro Moncayo, and to the national government of Ecuador, in setting priorities for new investments and allocating existing resources for environmental health programs. This study addressed environmental health risks in only two locations, both in Ecuador's highlands. Additional studies should be considered for evaluating conditions in Ecuador's coastal zone, where the relative risks attributable to various environmental problems are likely to be quite different. Such studies are needed in order to identify appropriate emphases for environmental health programs in individual coastal cities, and for setting national priorities in a manner that reflects the relative severity of problems in the highlands and the coastal zone.

In the ideal risk assessment study, all risk estimates are derived from quantitative estimates of people's exposure to environmental hazards. Ideal conditions—in this case, complete data—never exist, of course. As in all risk assessment studies, this study had to contend with substantial gaps in the available data. Qualitative data collected through focus groups, interviews, and observations were essential in filling some of these gaps and interpreting available data. Risk estimates could still be made more accurate and reliable, however, if additional quantitative data were developed. The following paragraphs summarize the most important needs for additional data.

Food contamination. A widespread food testing program provided good data on the extent of food contamination in Quito's markets and restaurants. Food contamination alone, however, does not determine whether people will become ill. Improved data on food preparation practices and diarrhea incidence would greatly improve the quality of the risk estimate. Initial testing also indicates that pesticides in food present a low risk. More information on pesticide levels in food would be useful.

Ambient air pollution. Risk ratings were based on air quality monitoring data and field observations by the study team. While the ambient monitoring data indicated potential problems, field observations played a crucial role because the monitoring locations are probably not representative of conditions throughout the city. A detailed study of the locations of monitoring stations is warranted. More importantly, monitoring of air pollutant concentrations at street level -- or, even better, personal sampling -- would provide important insights into the magnitude of exposures for the majority of the population.

Indoor air pollution. There was virtually no data available on indoor levels of air pollutants. Since this is a large source of risk in other countries where the problem has been studied, better data would likely demonstrate that indoor air pollution also presents significant health risks in Quito.

Occupational Health. Very little data was available with which to estimate the potential magnitude of occupational health problems. A greatly expanded program on health and environmental monitoring in occupational environments, including accident and illness registries and routine medical examinations, is needed to understand the magnitude of occupational health problems in Quito.

Wastewater. Limited data were available on wastewater service and potential exposures. Improved data collection is recommended, especially for the *astimientos barrios* where service is less reliable or nonexistent. Environmental sampling (e.g., surface waters, soil) in areas without service connections would confirm the presence of pathogens and help determine the nature and magnitude of health risks. Better data would also be useful on system upsets in areas with sewer service.

Drinking water. Data on drinking water quality appeared adequate. Improved recordkeeping on system upsets and documentation of complaints and investigations would improve the understanding of the degree to which drinking water might be a source of health risks.

Solid Waste. In general, solid waste does not appear to be a significant source of health risk. Better data would be useful, however, primarily information on the locations of informal waste dumps and a characterization of the types of waste disposed of in these dumps.

REFERENCES

Agency for Toxic Substances and Disease Registry. 1992. Public Health Assessment Guidance Manual. Atlanta: U.S. Department of Health and Human Services, Public Health Service.

Aguilar, E. 1992. La Farmacodependencia en el Ecuador: Factores de Riesgo. Quito, Ecuador: Division de Salud Mental, Ministerio de Salud Publica.

Arcia, G., G. Bustamante, and J. Paguay. 1992. Poblacion y Medio Ambiente. Quite, Ecuador: Direccion de Planificacion. I. Municipio de Quito.

Bennett, J.V., S.D. Holmberg, M.F. Rogers, and S.L. Soloman. 1987. Infectious and Parasitic Diseases. American Journal of Preventive Medicine 3: 102-114.

Bolanos, M. and Santacruz, X. 1986. Determinacion de residuos de pesticidas clorados en leche materna. Quito, Ecuador: Ministerio de Agricultura/CONACYT.

Bradley, D., S. Cairncross, T. Harpham, and C. Stephens. 1991. A Review of Environmental Health Impacts in Developing Country Cities. World Bank, Environment Division, Urban Management Program Discussion Paper Series No. 6.

Brantly, E., R. Hetes, B. Levy, C. Powell, and L. Whiteford. 1993. Environmental Health Assessment: An Integrated Methodology for Rating Environmental Health Problems. WASH Field Report No. 436; PRITECH Report No. HSS-133IR. Arlington, Va., WASH Project and PRITECH.

Castro, A. et al. 1992. Asentamientos Populares. Department of Planning, I. Municipio de Quito, Quito, Ecuador.

Crissman, C.C. and P. Espinoza. 1992. Agricultural Chemical Use and Sustainability of Andean Potato Production: Project Design and Pesticide Use in Potato Production in Ecuador. International Potato Center, Quito, Ecuador. 27p.

Espin, E. 1991. Estudio de la contaminacion causada por ruido en varias ciudades Ecuatorianas. Quito, Ecuador: Proyecto Medio Ambiente y Salud, Fundación Natura.

GTZ. 1991. Saneamiento del Rio Manchagara: Estudio de Desechos Solidos.

Harari, R. 1991. La Salud Ocupacional en el Ecuador: Informacion existente y tentativa de interpretacion. Quito, Ecuador: Fundación Natura.

INEC. 1990a. Anuario de Estadisticas Hospitalarias. Quito, Ecuador.

Jamison, D.T. and W.H. Mosley. 1991. Disease Control Priorities in Developing Countries. American Journal of Public Health 81(1): 15.

Jurado, J. 1991. Diagnostico Preliminar Estimative de la Contaminacion Industrial en Cuatro Ciudades del Ecuador. Quito, Ecuador: Proyecto Medio Ambiente y Salud, Fundación Natura.

Lopez, E. and B. Femandes. Estudio de la Contaminacion de Plaguicidas en los Alimentos en Quito e Besicos Constituyentes de la Dieta Media Ecuatoriano. (Study of pesticide contamination in food in Quito: basic constituents of the average Ecuadorian diet). Prepared for CONACYT.

Minard, R., K. Jones, a::d C. Paterson. 1993. State Comparative Risk Projects: A Force for Change. Northeast Center for Comparative Risk.

Ostro, B. 1983a. Urban Air Pollution and Morbidity: A Retrospective Approach. Urban Studies 20: 343-351.

Ostro, B. 1983b. The Effects of Air Pollution on Work Loss and Morbidity. Journal of Environmental Economics and Management 10: 371-382.

Oskaynak, H. 1985. Health Effects of Airbome Particles. Health Effects Office, Energy and Environmental Policy Center, John F. Kennedy School of Govemment, Harvard University.

Oviedo, J. et al. 1991. Correlación neurológica, neurofisiológica y psicológica con los niveles de plomo en sangre de habitantes en la ciudad de Quito. Proyecto Medio Ambient y Salud, Fundación Natura, Quito.

Pierson, T. 1991. The Role and Methodology of Environmental Risk Assessment: A Framework for Developing Countries. Staff Working Paper, Center for Intemational Development, Research Triangle Institute. Research Triangle Park, North Carolina.

Rose, J.B. and C.P. Gerba. 1991a. Assessing Potential Health Risks from Viruses and Parasites in Reclaimed Water in Arizona and Florida, USA. Water Science & Technology 23: 2091-2098.

Rose, J.B. and C.P. Gerba. 1991b. Use of Risk Assessment for Development of Microbial Standards. Water Science & Technology 24: 29-34.

Rose, J.B., C.N. Haas, and S. Regli. 1991. Risk Assessment and Control of Waterbome Giardiasis. American Journal of Public Health 8: 709-713.

Scrimshaw, S. and E. Hurtado. 1987. Rapid Assessment Procedures for Nutrition and Primary Health Care. Los Angeles: UCLA Latin America Center for Publications.

Suarez, J. et al. 1992. Medio Ambiente y Salud en el Ecuador. Quito, Ecuador: Fundación Natura.

U.S. Agency for Intemational Development. 1990. Ranking Environmental Risks in Bangkok, Thailand. Office of Housing and Urban Programs Working Paper.

U.S. Agency for International Development. 1991. Towards a Healthier Environment: A Strategy for Environmental Health in LDCs. Office of Health.

U.S. Environmental Protection Agency. 1991a. Air Criteria for Oxides of Nitrogen, 1991. Office of Research and Development, Washington, D.C.

U.S. Environmental Protection Agency. 1991b. Health and Environmental Effects Document for Nitrogen Dioxide. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Cincinnati, OH.

U.S. Environmental Protection Agency. In press for 1993. Facing the Future: Comparing Risks and Setting Priorities (The comparative risk "road map.")

U.S. Environmental Protection Agency. 1992. Tribes at Risk: The Wisconsin Tribes Comparative Risk Project. EPA Region 5. EPA 230-R-92-017.

Ware, J. H., B.G. Ferris, Jr., D.W. Dockery, J.D. Spengler, D.O. Stram, and F.R. Speizer. 1986. Effects of Ambient Sulfur Oxides and Suspended Particulates on Respiratory Health of Preadolescent Children. American Review of Respiratory Diseases 113: 834-842.

OTHER SOURCES OF INFORMATION

Albornoz, C. et al. 1990. Centro Historico de Quito: Sociedad y Espacio Urbano. Quito, Ecuador: Direccion de Planificacion. I. Municipio de Quito.

Aguilar, E., Narváez, A. and Samaniego, N. 1990. Informe de la Inestigacion Nacional sobre Uso indebido de Alcohol, Tabaco y Drogas. Quito, Ecuador: Division de Salud Mental, Ministerio de Salud Publica.

Bossano, F and C. L. Valoracion neurologica y neuro fisiologica en Escolares. Quite, Ecuador: Proyecto Medio Ambiene y Salud, Fundación Natura.

Carpio, F., N. Leon, M. Velasco, V. Bravo, S. Demera, and D. Cole. 1991. Proyecto Efectos en la Salud del Uso de Pesticidas en la Produccion de Papa en el Ecuador. International Potato Center/Fundación Nuestra, Quito, Ecuador. 43p.

Castelnuovo, A., C. Castelnuovo, and M. Castelnuovo. 1991. Conocimientos y Prácticas en el Manejo de Alimentos Frescos y Desechos Alimenticios en Tres Barrios de Interés de la Ciudad de Quito. CONSULTRIEB: Quito, Ecuador.

Cole, D.C. (In progress). The Ecuador Study. Assessing Health Impacts of Pesticide Use in the Potato Farming Region of Carchi. International Potato Center, Quito, Ecuador. 35p.

Carrion, F. et al. 1990. Centro Historico de Quito: Problemas y Perspectivas. Quito, Ecuador: Direccion de Planification. I. Municipio de Quito.

Ducrot, C.E.H., R. J. Wagenet and J.L. Hutson. 1992. Estimation of Pesticide Impacts on Water Quality in El Carchi. International Potato Center, Quito, Ecuador. 17p.

Durango, P. 1992. Projecto de Fomento Y Localizacion Industrial. Quito, Ecuador: I. Municipio de Quito.

Espin, E. 1991. Evaluacion con la normas de Calidad del Aire: Quito. Quito, Ecuador: Proyecto Medio Ambiente y Salud, Fundación Natura.

Espin, E. 1991. Estudio de la contaminacion causada por los Desechos Solidos en Varias Ciudades Ecuatorianas. Quite, Ecuador: Proyecto Medio Ambiente y Salud, Fundación Natura.

Espin, E. 1991. Estudio de la Calidad del Agua Potable en Varias Ciudades Ecuatorianas. Quito, Ecuador: Proyecto Medio Ambiene y Salud, Fundación Natura.

Fundación Natura, 1991. Potencial Impacto Ambiental de las Industrias en el Ecuador. Quito, Ecuador.

I. Municipalidad de Quito, Direccion de Higiene. 1989. Inentario Industrial, Canton Quito: Priorizacion por Fases. Quito, Ecuador.

Immink, Maarten D.C. 1983. Food and Health Expenditure Patterns in Urban and Rural Ecuador: Analysis of Household Budget Survey Data. U.S. Agency for International Development, Quito, Ecuador. 111p.

INEC. 1990b. Anuario de Estadisticas Vitales, Nacimientos & Defunciones. Quito, Ecuador: Direccion de Planificacion. I. Municipio de Quito.

INEC. 1990c. V. Censo de Poblacion; Provincia de Pichincha. Quito, Ecuador.

INEC. 1990d. IV Censo de Vivienda; Provincia de Pichincha. Quito, Ecuador.

Instituto Ecuatoriano de Normalizacion (INEN). 1992. Informe del Estudio de Contaminacion de Alimentos. Quito, Ecuador.

Ministerio de Salud Publica, Direccion Nacional del Medio Ambiente del Instituto Ecuatoriano de Obras Sanitarias (IEOS) and Universidad Central del Ecuador. 1992.

Proyecto Medicion de Niveles de Plomo en el Aire de la Ciudad de Quito: Informe Final. Quito, Ecuador.

Rosenstock, L.A. 1992. Conceptual and Methodological Aspects of Assessing the Health Impact of Pesticides. Occupational and Environmental Medicine Program, University of Washington, Seattle, Wa. 18p.

U.S. Environmental Protection Agency. 1987. Risk Assessment Guidelines of 1986. Office of Health and Environmental Assessment. EPA 600-8-87/045. Washington, D.C.

Velasco, Julián & Asociados. 1989. Plan de Asistencia Técnica para los Sectores de Agua Potable y Alcantarillado: Encuesta Socioeconomica y Análisis de Capacidad de Page. USAID: Quito, Ecuador

Wagenet, R.J. 1992. Conceptual and Methodological Aspects of Assessing the Environmental Impact of Pesticides. International Potato Center, Quito, Ecuador. 11p.

Winthuysen, B. et al. 1991. Arquitectura Paisajista, Quito: Conceptos y Disenos. Quito, Ecuador: Division de Salud Mental, Ministerio de Salud Publica.