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A.I.D. Environmental Health Workshop

Final Workshop Report

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A sincere thanks must go to the fourteen presenters, nine of whom prepared valuable background papers on very short notice. The other participants, from A.I.D. and other organizations, while not asked to prepare papers, nonetheless worked very hard over the intensive two-day period of the Workshop. Their efforts made a large contribution to this effort.

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Executive Summary

The A.I.D. Office of Health (S&T/H) is developing an environmental health initiative which includes the formulation of an environmental health strategy. This report summarizes the process used in, and results of, a Workshop conducted to assemble information as input to that strategy development. The Workshop was organized and conducted by the Research Triangle Institute (RTI).

The term "environmental health" encompasses those diseases and health conditions that are environmentally determined and are increased or exacerbated through environmental degradation. The problem was approached by examining nine categories of environmental health problems, including:

- Air Pollution
- Solid Waste Management
- Wastewater Management
- Toxic, Hazardous & Radiological Wastes
- Water Supply and Sanitation
- Vector-Borne Disease Control
- Housing and Shelter
- Food Hygiene
- Occupational Health & Injury Control.

The Workshop was held February 14-15, 1991 in Washington DC. There were 30 participants, including RTI technical staff, "experts" from other organizations, and staff from a number of A.I.D. Offices. The Workshop consisted of a mix of technical presentations, small work group sessions and plenary discussion sessions. The technical presentations were based on prepared background papers addressing the nine topics above. Additional presentations on "over-arching" technical and policy issues, and the activities of selected other organizations were also offered. The small-group work sessions also focused on the nine topics, identifying associated diseases and other health conditions, characteristics of the health risks, and possible interventions to assess, reduce and manage the risks. The synthesis sessions examined which problems should be addressed in an environmental health strategy, considered whether the strategy should be focused narrowly or offer a broad menu, assembled information on the priority interventions for each risk area, and identified important issues not addressed in the Workshop.

After the Workshop, all participant input was tabulated and assessed, and compared to information submitted by A.I.D. Missions in response to a cable sent out before the Workshop. In general terms, Missions placed the highest emphasis on traditional areas of AID intervention, while the Workshop participants recommended a broad-based approach including attention to newer, "emerging" issues. The participants suggested that a broad-based strategic approach will be required to understand and deal with environmental health problems because many of the areas are inter-related, and because different countries and regions have different needs. A synthesis of A.I.D. Mission priorities as well as those elaborated by the Workshop participants has led to three options for A.I.D.'s consideration:

Options for A.I.D.'s Environmental Health Strategy			
	Give Increased Effort in Traditional Areas	**Develop a New Focus on Selected Emerging Areas**	**Offer a Broad-Based Menu**
Sustained Effort In:	- Water Supply and Sanitation - Vector-Borne Disease Control	- Water Supply and Sanitation - Vector-Borne Disease Control	- Water Supply and Sanitation - Vector-Borne Disease Control
Increased Effort In:	- Solid Waste - Wastewater Management - Housing & Shelter	- Solid Waste - Wastewater Management - Housing & Shelter	- Solid Waste - Wastewater Management - Housing & Shelter
Add New Effort In:		- Air Pollution - Toxic, Hazardous & Radiological Wastes	- Air Pollution - Toxic, Hazardous & Radiological Wastes - Occupational Health - Injury Control

While the broad-based approach offers the advantage of being comprehensive, it requires the most resources to implement. A.I.D. may wish to concentrate its efforts on specific countries or regions, or start out with a broad focus and then narrow the scope with time and experience.

It was also noted that, in terms of priority interventions, the emerging areas such as air pollution and hazardous wastes require more emphasis on risk assessment, while the more traditional areas require more emphasis on risk reduction, because these areas are better understood, in the majority of developing countries.

The Workshop concluded that environmental health problems have a very large effect on human health. A number of the environmental conditions affect literally billions of people in the developing world, with the greatest effect on children, the poor, and women. The problems are magnified in rapidly growing urban areas, and will be exacerbated by continued economic development and population growth. A concentrated, yet broad-based effort by A.I.D. to assess the risks and assist governments and other local organizations to reduce and manage these risks will be required. Such efforts will best be conducted in collaboration with groups operating in many sectors, and in coordination with other donors and international agencies. While the Workshop has assembled extensive information and focused attention on the issue, considerably more data need to be collected and assessed, key strategic options evaluated, and responses planned. Environmental health is a growing concern, and A.I.D. has a good opportunity to be a focal point for broad efforts and to "lead the way" to a healthier environment.

1. Introduction and Background

1.1 Background & Objectives

The A.I.D. Office of Health is developing an environmental health initiative which includes the development of an environmental health strategy. This report summarizes the process used in, and results of, a Workshop conducted to assemble information as input to that strategy development. The Workshop was organized and conducted by the Research Triangle Institute (RTI), under a Task Order within its Indefinite Quantity Contract with the A.I.D./S&T/Office of Health (Contract No. PDC-5929-I-00-0108-00 Task 3). Appendix A provides the Scope of Work for the Task. During early planning of the Task, some revisions to the technical approach were proposed by RTI and agreed upon by the Office of Health. Those modifications are described in several places in this report.

It is important to recognize that the objective of this Task was not to develop a strategy, but to collect information and elaborate options for A.I.D. to use in its strategy development process. The Office of Health will have to assess these options and make the key decisions that will create the specific focus of the strategy. A number of tactical issues were not addressed at the Workshop and will have to be examined by A.I.D. as it defines the strategy. Similarly, this Workshop Report does not make recommendations on the necessity of, and conceptual framework for, any possible follow-on A.I.D. environmental health project.

The objectives of the Task, the Workshop and this report were to:

Task:	Examine priorities & create options for an A.I.D. environmental health strategy;
Workshop:	Generate ideas on priorities and options for the strategy; and
Report:	Describe the priorities & options, and document the proceedings of the Workshop.

To define more precisely the objectives of the Workshop, an initial planning meeting was held to elaborate key questions, which appear in the box below:

What is A Successful Workshop?

Generate Ideas on Five Topics:

1. What environmental problems have the greatest effects on mortality and morbidity in A.I.D.-assisted countries?
2. What interventions would best alleviate these environmental problems or their effects?
3. What are the most important information gaps regarding problems and interventions?
4. What are other organizations doing and how should A.I.D. relate to their efforts?
5. What unique capabilities exist in the US that should be used in an A.I.D. environmental health strategy?

The Workshop and the Background Papers placed the greatest priority on the first two of these topics, with lesser emphasis on the other three.

1.2 Task Activities

As outlined in the Scope of Work (Appendix A) the Task involved a number of activities:

1) ***Workshop Participant Recruitment:*** RTI assembled a team of "expert" Workshop presenters to address the various technical topics to be reviewed.
2) ***Team Planning Meeting:*** A meeting was held January 31, 1991, involving A.I.D. and RTI staff to review the Scope of Work, finalize the Workshop design, and discuss logistical matters. This meeting proved highly useful in synchronizing the efforts of all parties.
3) ***Workshop Preparation:*** From February 1-13, 1991, Workshop presenters prepared background papers, addressing the 5 questions on the previous page (see outline in Appendix B).
4) ***Execution of the Workshop:*** The Workshop was held February 14-15, 1991 at a hotel in Washington, DC. Appendix C contains the agenda, and Appendix D lists the participants, including "experts" from various organizations, and staff from a number of A.I.D. Offices.
5) ***Briefings:*** Two briefings were held for A.I.D. to report on preliminary results of the Workshop. The first was made on March 4, 1991, for A.I.D./S&T/H staff, and the second on March 7, 1991, for the A.I.D. Health Sector Council.
6) ***Draft Workshop Report:*** A Draft Workshop Report was prepared, outlining the approach, proceedings and conclusions from the Workshop. It was sent to all Workshop participants on March 15, 1991.
7) ***Review Period:*** Workshop participants reviewed the Draft Report and provided comments up until March 29, 1991.
8) ***Final Report:*** Comments of the reviewers were incorporated into this Final Workshop Report, and it was submitted to A.I.D. on April 5, 1991.

1.3 Definitions and Scope of Coverage

The Workshop utilized a definition and scope for environmental health, elaborated by A.I.D./S&T/H, which is summarized in the box below. It is important to recognize that the Office of Health's concern is diseases and other health conditions caused by environmental problems, and not on the environmental problems themselves. In other words, the concern of the Office is focused on health, not the degradation of the global ecology *per se*. Alternative definitions of environmental health were touched on in the Workshop, but no modifications to the selected definition were discussed.

The approach to examining the risks from environmental health problems was based on a categorization of the overall problem, mostly by topic areas related to environmental media, as shown in the box. Some brief comments on the nine topics are useful. The first five of the topics, from air pollution to water supply & sanitation, are traditionally thought of as "environmental" problems which may impact health. The other four topics were included in the Workshop because each is clearly linked to environmental issues in general, is linked to the other

five topics above, is considered "environmental health" by other international agencies (or some developing countries), or is linked to the environment and are not addressed by A.I.D. in any other initiative.

Environmental Health

Definition: "Environmental Health" encompasses those diseases and health conditions that are environmentally determined and/or are increased or exacerbated through environmental degradation.

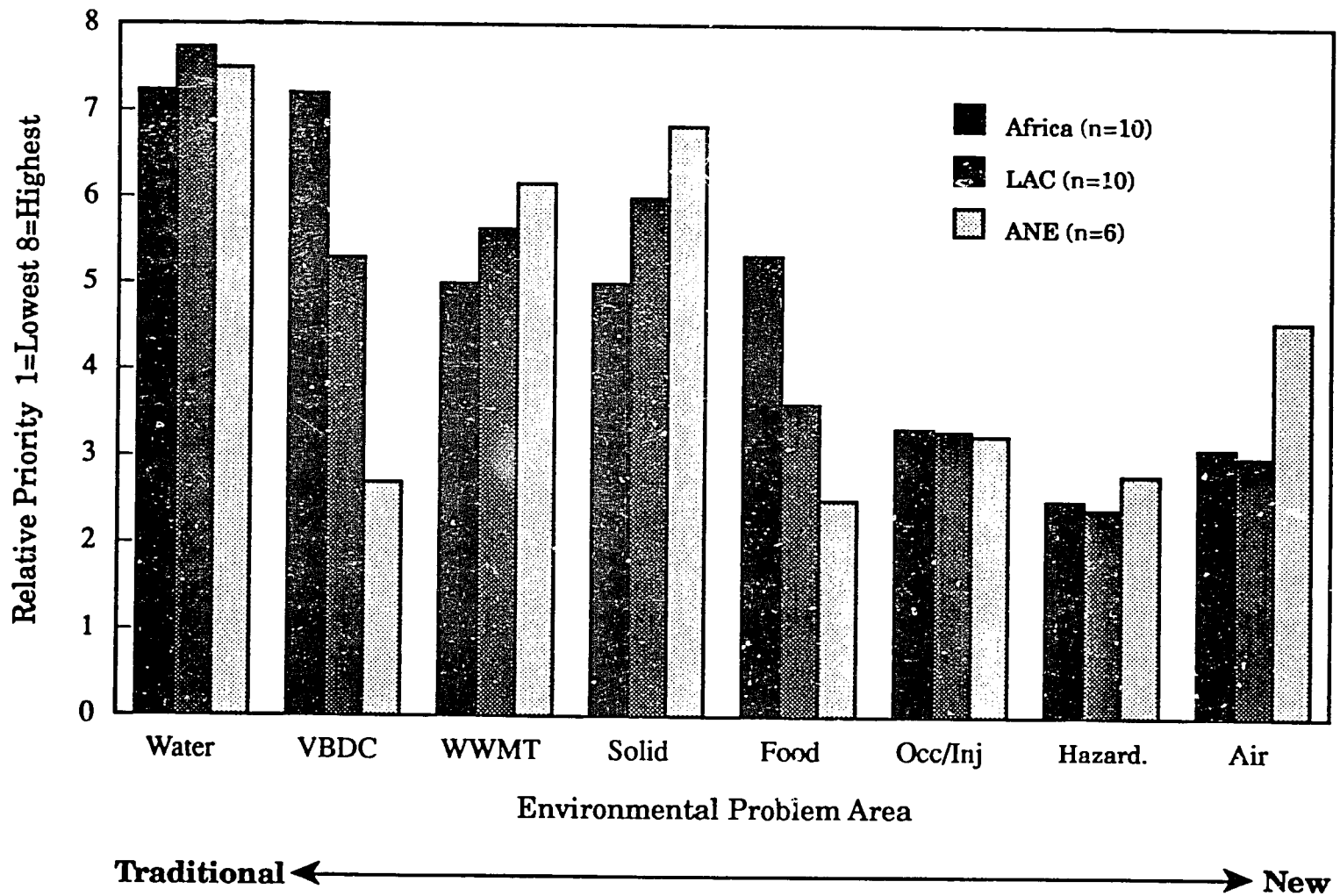
Categories:
1. Air Pollution
2. Solid Waste Management
3. Wastewater Management
4. Toxic, Hazardous & Radiological Wastes
5. Water Supply and Sanitation
6. Vector-Borne Disease Control (VBDC)
7. Housing and Shelter
8. Food Hygiene
9. Occupational Health and Injury Control

1.4 Other Inputs to the Strategy

In addition to conducting this Workshop, the A.I.D. Office of Health also solicited other input to its environmental health strategy. In January 1991, the Office of Health sent a cable to all A.I.D. field Missions, announcing the environmental health initiative, and soliciting input. Missions were asked to prepare a priority ranking of the environmental problem areas, as categorized above. (Housing & Shelter was, at that time, not one of the categories, so it was not included in the cable or Mission responses.) The response rate was large - 36 missions responded, which is a high rate given that many Missions were mostly shut down due to the Persian Gulf crisis. 26 Missions provided a relative priority ranking of the problem areas and other comments, and 10 provided just general comments.

The results of the Mission responses are summarized in Figure 1. The graph is arranged with the traditional areas of A.I.D. intervention on the left, and newer emerging areas in which A.I.D. has not worked on the right. For each area, relative priority rankings are shown for three A.I.D. geographic regions: Africa (sub-Saharan), Latin America and the Caribbean, and Asia/Near East (combining the current ENE and APRE countries). Two major trends can be seen in the responses. First, the priority rankings generally decline from left to right indicating that Missions rank areas of current involvement higher, and newer areas, with which they may not be familiar, lower. This ranking is somewhat understandable. It represents an important trend to compare to Workshop participant priorities, which will be discussed later. Second, there are strong regional differences for some topics, such as VBDC, food hygiene, and air pollution, but near consensus on others such as water and sanitation, wastewater, solid waste, and the others.

Figure 1. AID Mission Priorities in Environmental Health



2. Workshop Design

2.1 Basic Structure

The agenda for the Workshop is in Appendix C. The first day consisted of introductory sessions, two technical sessions involving presentation of background papers, and two work sessions for the small groups of participants to examine the topics covered in the technical sessions. The second day included a session on the activities of other organizations, a third technical session, a third set of work sessions, a special session to synthesize the results of the Workshop, and a final session for Workshop evaluation.

2.2 Technical Sessions and Small-Group Work Sessions

Background papers were presented at each of the three technical sessions. Each paper covered one of the nine environmental problem areas. Participants were divided into three small groups (A,B,C) and each considered one of the technical topics which had just been presented. This interplay between plenary technical sessions and small-group work sessions allowed all participants to hear all nine presentations, and to examine 3 topics in detail. The small-groups included a facilitator, the technical "experts" for the 3 areas discussed, other participants with knowledge of the three topics, a participant from S&T/H, and a cross-section of other A.I.D. participants. Given a total of 30 participants, each small working group consisted of 10 people.

	Small Groups		
Sequence of Technical Presentations	A	B	C
1) Water Supply & Sanitation	X		
2) Wastewater Management		X	
3) Air Pollution			X
4) Food Hygiene	X		
5) Solid Waste		X	
6) Vector Borne Disease Control			X
7) Housing/Shelter	X		
8) Toxic, Radiological & Hazardous Waste		X	
9) Occupational Health & Injury Control			X

Prior to the technical sessions, an introductory session was held to cover three topics which related to all the technical topics which were to follow. Two topics - Policy & Regulatory Options and Risk Assessment - covered general themes on the potential interventions for all nine areas. The other undergirding background topic was population growth, a factor which adversely impacts upon all environmental health problem areas.

This report will not summarize the material reviewed in the background papers. The papers are included in Appendix I, the last of the appendices. A two-page summary of some of the data on the impact of environmental health problems was prepared for the briefings for A.I.D. after the Workshop, and is included in Appendix E.

2.3 The Content of the Work Sessions

The work sessions:

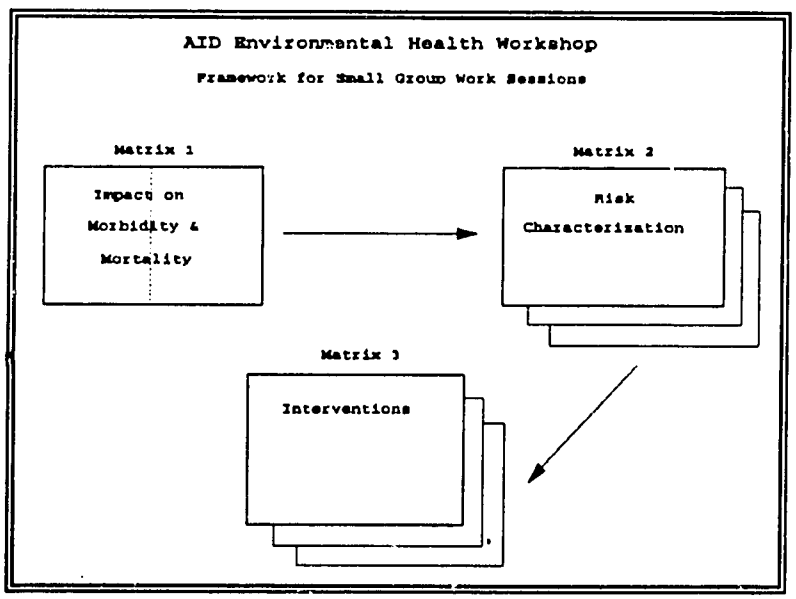
1) Identified key associations between environmental problem areas and disease or other health conditions;

2) Characterized the environmental health risks in terms of:

   - Sources of problem
   - Routes by which it affects health
   - Personal behaviors that increase risk
   - Extrinsic factors that increase risk
   - Highly susceptible groups; and

3) Identified and prioritized interventions in the following categories:

   - Risk assessment and other information needs
   - Risk reduction/management
     - Changing personal behavior
     - Developing policy and infrastructure
   - Prioritized interventions according to three general criteria:
     - General feasibility
     - Cost-effectiveness
     - Required time for impact.



A set of 3 matrices was developed to guides the sessions (see Appendix F). Matrix 1 addressed the impact of each environmental problem area by identifying links between the area and the major causes of morbidity & mortality in developing countries. Some participants objected to its use, because they felt that was a very limited way of understanding the impact of these problems on health in general. After discussion, Matrix 1 was dropped. Instead, a simple listing of the associated diseases or other health conditions and the environmental problem area was outlined in Matrix 2. In addition, the groups generally found they did not have sufficient time to prioritize interventions, although some prioritization was done in the final synthesis session. Section 3 provides a narrative description of the discussion in the small group work sessions.

2.4 Synthesis Session

The synthesis session first involved time for participants to examine working group output from the other small groups which they did not participate in. Next, the plenary discussions considered:

- What problems should be addressed in an environmental health strategy?
- Whether the strategy should be focused narrowly or offer a broad menu?
- Which are the priority interventions for each risk area?
- What important issues were not addressed in the Workshop?

2.5 Workshop Evaluation

During the final session of the Workshop the participants completed an evaluation form. A blank form, as well as a tabulation of the results, appears in Appendix G.

3. Work Session Outputs: Environmental Health Risks and Interventions.

Note: The paragraphs below document and summarize the small-group work sessions on each of the nine environmental health problem areas. These summaries, which came directly from the small-group facilitator's reports, vary somewhat in depth, style, structure and format, according to the characteristics of the groups and the topic. It should be noted that these are not polished or comprehensive analyses; they are notes of discussions about 1 hour long, following a 20 minute presentation on the subject. The reader is also referred to the Background Papers in Appendix I for more information. The topics are presented here in the same order in which the topics were presented.

3.1 Water Supply & Sanitation (WS&S)

3.1.1 Associations with Human Health

The following diseases were noted to be primarily associated with the lack of WS and/or S:

- Diarrhea
- Schistosomiasis
- Ascariasis
- Hepatitis A
- Trachoma
- Guinea Worm
- Typhoid

In addition, noninfectious diseases caused by water pollutants (minerals, metals, organic contaminants) were noted to be a probable "big problem", though the extent of the problem is unknown. In the above list, ascariasis was relegated to the "second tier" because it is considered a less severe disease than others on the list.

3.1.2 Characterization of Risks and Interventions

The components of the problem were defined to be water quality, water quantity (or availability), and sanitation.

Poor water quality causes ill health by the ingestion of infectious or noninfectious substances. Insufficient water quantity contributes to ill health by discouraging sound hygienic practices. Inadequate sanitation contributes to poor health by fecal contamination of the environment, including contamination of water and poor water quality.

Noninfectious causes of poor water quality were noted to have different sources and, by implication, different solutions from the other components of the problem. This category is comprised primarily of industrial and agricultural (e.g., pesticide) pollutants. Interventions that may address this problem include modified agricultural practices and the development and enforcement of policies which promote the private sector to avoid practices increasing the risk of drinking water pollution. While there are indications that pesticide contamination of water supplies is a large problem in some areas, there is generally insufficient information about water pollution in developing countries and more information needs to be gathered through the identification of existing hazards, such as industries and agricultural practices, as well as monitoring of appropriate water quality indicators.

Other water quality, water quantity, and sanitation environmental health problems are related to the lack of basic services, inadequate maintenance of services that exist, and poor hygiene practices that do not maximize the health effects of existing services. A wide variety of personal behaviors, including personal hygiene, domestic hygiene, water handling and storage behaviors, weaning practices, and others affect the risk of WS&S related diseases. Issues that affect availability of services include the lack of effective demand, the lack of culturally appropriate sanitary facilities, and inadequate funding for operations and maintenance of facilities that have been constructed. Interventions to address these problems include increased education and literacy to both improve hygiene behaviors and increase effective demand, and specific interventions to improve personal, domestic, and school hygiene practices. Policy issues include the overall level of public expenditure as well as allocation levels within the sector (e.g., urban vs. rural allocation of funds), cost recovery policies, and private sector involvement. More information is necessary for monitoring water quality indicators, time and energy expenditure and potential savings associated with improved services.

Finally, Sanitation and Water Supply (SAWS) was discussed as an alternative to WS&S because it stresses the primacy of sanitation in terms of health effects from improved services and because of the need to increase attention to increasing sanitation coverage, which lags far behind water supply.

3.2 Wastewater Management

3.2.1 Associations with Human Health

The working group emphasized the importance of reviewing the findings or comments pertaining to any of the three areas designated for discussion, i.e., wastewater management; solid waste; and toxic, radiological and hazardous wastes, in the context of several general points.

The group questioned the wisdom of spending valuable and limited discussion time to define the specific links between a given environmental problem and one or more conditions of ill health. It was noted that each of the environmental problems under review had a direct, adverse impact on one or more physiological systems, e.g., circulatory, pulmonary, etc., and was directly linked with specific disease conditions, e.g., acute respiratory infection. Rather than spending time discussing the linkages between environmental conditions and specific disease conditions, the group decided to emphasize the material requested in Matrix 2 (Characteristics of Environmental Health Risks) and Matrix 3 (Environmental Health Interventions).

3.2.2 Characterization of Risks and Interventions

While distinguishing among three types of wastewater - industrial, nonindustrial, and agricultural - the group only analyzed the industrial wastewater situation in countries of the developing world, due to time constraints. The group suggested that industrial wastewater is becoming an increasingly important environmental problem in the developing world. Most industrial wastewater is found in the urban areas of the more industrialized countries and at sites where extractive industries are in operation, i.e., mines.

Ill health results when heavy metals, toxic organics (e.g., pesticides), and organic and inorganic compounds and metals are deposited or leach into water supplies and are directly or indirectly (via the food chain) ingested by humans. Industrial workers, peri-urban residents, pregnant women, and downstream residents are the primary high-risk groups.

Personal behaviors which increase the health risks were identified as:

- migration to and residence in peri-urban industrial sites or mining sites
- poor personal hygiene and dietary practices, e.g., eating fish from polluted rivers or streams, and
- use of polluted sources for drinking water and bathing.

The following were identified as other factors which increase the health risks to humans:

- the degree to which industries are concentrated in a given country and the types of industries present,
- the absence or nonenforcement of standards and practices, and
- the lack of land use planning, pretreatment practices, pollution prevention information, hygiene education, and protected water supplies.

To obtain more precise information on the link between the risk of exposure and mortality & morbidity, the group suggested that A.I.D. encourage developing countries to identify and monitor primary sources of wastewater pollution. In addition, it was proposed that a study be implemented in one or more of the more developed countries to estimate the savings realized in health care by introducing pollution control practices and standards in those industries that are primary polluters.

Beyond emphasizing the importance of providing effective hygiene education programs, the group was unable to recommend interventions that might lead to changes in personal behavior and improved health outcomes. The group had numerous suggestions on what A.I.D. might or should do to encourage the adoption of policies and/or programs that can reduce the health risks associated with exposure to industrial wastewater. The following are among the measures proposed:

- provide incentives to developing country industries to reduce toxic discharges,
- help to establish a stable and effective regulatory environment,
- develop and enforce an adequate and effective land use plan,
- draft legislation that prevents the U.S. from purchasing products from polluters,
- re-examine U.S. policy on exporting hazardous materials,
- encourage U.S. firms to transfer environmental protection practices to developing country private sector firms,
- facilitate the development of local, private sector consulting firms capable of introducing and disseminating pollution control technologies,
- foster the development of an indigenous research capacity (perhaps through links with U.S. universities) that can monitor local wastewater situations.

3.3 Air Pollution

3.3.1 Associations with Human Health

The discussion group identified a long list of sources of morbidity and mortality (without differentiating between them) associated with air pollution. This list included both specific illnesses, categories of illness, and organ systems which are affected by air pollution. The list comprised:

- Respiratory: acute irritative; infectious upper respiratory disease; acute lower respiratory infection (ALRI); chronic respiratory disease
- Neoplasms
- Neurological and behavioral disorders
- Reproductive and developmental disorders, low birth weight
- Circulatory and cardiovascular disorders
- Skin and eye diseases
- Renal and urinary diseases
- Systemic toxicity and poisoning, acute and chronic.

Since respiratory disease dominates all others associated with air pollution, the group concentrated on that area exclusively, and still did not cover all aspects.

3.3.2 Indoor Air Pollution: Characterization and Interventions

The discussion concentrated on domestic pollution. A variety of factors affect air quality in the home: geographically, this risk is likely to be a more significant in climates in which fires are required for heating, as well as cooking. It is also a rural problem, since rural areas are less likely than urban to have access to public services. The transmission route, in common with other categories of air pollution, is primarily inhalation, and to a lesser extent also ingestion of materials deposited on food, and dermal exposure.

Direct and indirect causes include indoor fires used for cooking, lighting, and heating, particularly when these use a low-quality fuel source; tobacco smoke; and other volatile compounds stored in the home. The level of indoor air pollution will be exacerbated by poor ventilation, smoky stoves or heating devices, and crowding in the home.

Risk is increased by personal behavior: exposure to pollutants will be associated with the amount of time spent in the home. The choice to smoke cigarettes exposes the smoker and others in the same space to greater risk. And certain occupations outside the home, such as mining, will make a person more vulnerable to additional exposure inside the home. Some personal choices will have a strong cultural basis: choice of house design, or the decision to separate cooking area from other parts of the house, will affect ventilation. A cultural preference for particular cooking styles - long-cooking or grilling - will increase exposure to cooking fumes. Factors beyond individual control which increase risk will include availability of alternative fuels for cooking or heat.

Particularly at risk are the people who spend most of their time in the home (women, preschool children, and the elderly), and those who are vulnerable for physiological reasons (pregnant women, the infirm, children).

The scale of the health risk associated with domestic air pollution exposure has not been adequately documented, and research on high-risk groups, such as children and women of reproductive age, would be helpful. However, the group stressed that <u>enough</u> is known to justify taking action. Along with epidemiological surveys, risk assessment can be "active"; information gathering should take the form of pilot projects and rapid assessments of the impacts. Looking ahead, it may be worth mapping radon exposure: this may emerge as a source of "replacement" morbidity once other sources of exposure are reduced.

A recurrent theme in the discussions was the need to consider synergisms and trade-offs. For example, improved cooking and heating technology will reduce indoor air pollution <u>and</u> reduce the incidence of household injuries. On the other hand, indoor pesticide use may control vector-borne disease, but increase inhalation of toxic materials.

In the home, many interventions are possible at a personal level: modification of house design, changes in smoking habits, or changes in cooking styles. Many personal changes are only possible

with institutional support: the siting of houses, or the purchase of improved stoves, and heating devices and cleaner fuel. Government policy, including subsidies and import policies, will have a powerful effect on individual behavior regarding fuel choice and consumption, or tobacco use. Finally, government can establish construction standards, or encourage the development of appropriate technologies, such as stoves and heating devices.

Only briefly discussed, air pollution in the workplace was recognized as sharing some but not all characteristics of domestic indoor air pollution. Particularly important differences include the composition of the pollutants, and the degree of individual control over exposure, which will be less in the workplace. Interventions may have to be of an institutional or regulatory nature.

3.3.3 Outdoor Air Pollution: Characterization and Interventions

While domestic air pollution is more of a rural than an urban problem, outdoor air pollution is a largely urban phenomenon. Meteorological conditions can compound the problem, as can local topography (such as that of Mexico City) which slows dispersal of pollutants. In addition, the need (and demand) for heating or cooling will increase energy use, generating more air pollution.

Transmission routes, as above, are inhalation, ingestion, and dermal exposure. Direct and indirect causes, however, are very different, and include: transport systems, industrial sources, energy generation sources, incineration, waste treatment, and the release of domestic (point source) pollution into the ambient environment. In addition to human sources, there are also natural causes, such as fires, and sand.

Personal behavior can increase risk, through occupational choice, cigarette smoking, mode of transportation, or housing location, but the individual has far less control over exposure than in the domestic environment. Other factors, such as proximity to industry, smelters, roads, electricity generators, and other sources will endanger individual health, but are not under the individual's influence.

Vulnerable groups will be any city dwellers, but particularly those prone to lung disease, asthmatics, growing children, and individuals who are frail for other reasons, such as the elderly.

There was more agreement than in the previous topic on the utility of collecting data on ambient air pollution as a tool for identifying and refining interventions. Major areas included:

- epidemiological information on respiratory disease, and an assessment of how much is attributable to air pollution;
- emissions inventory of pollutants (GEMS database?) for the area;
- industrial profile of the area, identifying likely sources of pollutants;
- monitoring of toxic chemical import and movement;
- records of fuel consumption and mix; and
- use of biological markers.

Interventions at the personal level are few, but include training workers in the use of controlled technologies, and encouraging the choice of less polluting transportation. Education which

emphasizes the worker's or the community's "right to know" about ambient pollutants can be a powerful source of grassroots pressure for policy change.

Changes at the policy level include:

- standards: for air quality; issuing of air pollution alerts
- regulation: use of scrubbers; lead-free gasoline; environmental impact statements; the responsibilities of multinational corporations; assurance of the importation of spare parts necessary to maintain clean technology
- education of policymakers
- provision of services, particularly affordable public transport options
- analysis: establishment of cost/benefit analysis which reflects true environmental costs
- subsidization, taxation, or removal of subsidies: as a form of demand management
- collaboration among sectors, particularly energy, transport, industry, imports, foreign investment
- planning for control technology at the beginning of any project.

3.4 Food Hygiene

3.4.1 Associations with Human Health

The following diseases were noted to be strongly associated with food hygiene:

- Diarrhea
- Respiratory Diseases
- Typhoid
- Hepatitis A.

Respiratory diseases may be caused during the preparation and handling of foods and constitute a problem that is different from the other three diseases that are caused by contamination of foodstuffs. In addition other food contaminants were noted which may cause illness:

- Biotoxins, including aflatoxins
- Pesticides
- Metals.

3.4.2 Characterization of Risks and Interventions

While the background presentation focused on domestic food hygiene, food hygiene problems may arise at the agricultural, industrial, and commercial levels as well. Similarly, problems associated with food hygiene may arise during the handling, storage, preparation, and disposal of food.

Domestic food hygiene is related to ill health through the ingestion of contaminated food. Contaminants include fecal contamination, pesticides in foods, and parasites that may be present in meats. Personal behaviors play a large role in the prevention or amelioration of illnesses related to food hygiene. Specific behaviors include those related to food storage practices, food handling, food preparation (particularly cooking time and duration), food disposal practices, and choice of foods. Other factors that affect food hygiene include the availability of electricity, refrigerators, and types/quantities of fuel available. Interventions to improve domestic food hygiene include school education in hygiene practice, baby feeding programs, primary health care clinics and community-based education, and monitoring and surveillance systems to ensure food quality. More information is needed to define the extent of the problem and to further define the cultural and household food hygiene practices most associated with ill health.

Commercial food hygiene includes cooked foods sold by vendors (primarily, though not exclusively, an urban issue), restaurants, and food retailers. Ill health may be related to contamination of foods, air pollution, and solid waste produced by commerce in foodstuffs. Interventions to improve food hygiene in the commercial sector include improving personal behaviors, as mentioned above, as well as educating consumers and food handlers, developing and enforcing commercial regulations (including expiration dates), hiring enforcement inspectors (HACCP was mentioned), and improving facilities for the testing of food quality and contamination. Again, more information is needed to define the extent of the problem in the developing world and to define critical points for intervention and controls in the commercial food sector.

Industrial food hygiene was discussed briefly. This area relates to ill health primarily through air pollution and solid waste production. Interventions that will improve industrial food hygiene include regulation and enforcement of the industry; improvement of available technologies, especially irradiation; and identification of practices that contaminate the food supply, particularly during packaging and distribution. Food policy and import/export issues are likely to play a large role in this area.

3.5 Solid Waste

3.5.1 Associations with Human Health

The working group identified respiratory and gastrointestinal ailments as most closely linked with the disposal (i.e., housing or industrial site), collection (i.e., formal or informal), and storage/destruction/reuse (i.e., landfill) of solid wastes.

3.5.2 Characterization of Risks and Interventions

The group noted that solid waste consists largely of organic materials in most developing countries, although hazardous wastes are becoming an increasing important portion of the material. In addition, solid wastes were noted to be a particularly important health risk in large,

rapidly growing urban centers (e.g., Manila and Mexico City) and in tropical (wet) developing countries.

Human populations most at risk are primarily the poor who live near uncollected waste or scavenge in the landfills where solid wastes are deposited. These groups are bitten by the rodents and pests who infest the sites, and are subject to fumes from burning organic materials, chemicals, and other hazardous materials found in the dumps, as well as to injuries (e.g., cuts) associated with scavenging or, as in Mexico City, working the sites.

Personal behaviors that jeopardize human health were identified as:

- scavenging or collecting solid waste and living at or near the landfills,
- consuming or recycling contaminated material, and
- improperly storing, disposing, or reusing materials taken from the landfill.

Other factors that the working group identified as constituting risks to human health were:

- the degree of available land and the location of disposal sites or transfer stations,
- the collection and coverage practices of the agency responsible for solid waste; i.e., does it maintain its vehicles properly and collect materials in the poor neighborhoods as well as in those that are better off,
- the absence of policies, standards, and practices on siting and operating landfills, and
- the rainfall and temperature conditions in the developing country.

Before initiating a discussion on the data or studies needed to define the extent of the problem or considering interventions that might be taken to reduce the health risks with exposure to solid wastes, the working group noted that solid waste collection and disposal is often a sensitive political issue. Quite frequently national and municipal officials place political supporters seeking jobs in the solid waste collection and disposal authority. Examples of this practice are found in the U.S. as well as in the developing world. Given this well-entrenched practice, the working group felt it would be difficult to change conditions rapidly and dramatically.

After noting this obstacle to change, the group suggested that it would be important to undertake the five studies or analyses listed below. All are designed to "get a handle on the problem." These include:

- a "quick and dirty" study of the composition of solid wastes in selected developing countries - what does it consist of and are the contents changing (especially toxic or other high health risk materials),
- serious attention to separability of the hazardous waste fraction,
- a multi-national study of the cost of solid waste collection and disposal,
- a study of the health risks associated with "unlicensed" dumping, and
- a study of the health risks and costs to the health system of solid waste scavenging to workers and those residing close to dump sites and landfills.

The working group suggested that households close to landfills and dump sites should be given instruction on the proper disposal and use of materials found at the sites. Those who work at or

scavenge in the sites should be retrained for other jobs - admittedly difficult to do - or given special training and the equipment necessary to conduct "safe scavenging practices."

The working group also proposed that A.I.D. consider encouraging governments to:

- develop programs to train professional solid waste managers, and promote the development of private sector solid waste management systems;
- define and implement standards, regulations, and enforcement practices regarding the storage, collection, and disposal of solid waste;
- introduce waste reduction strategies for industries that are keyed to specific toxic substances, e.g., pesticides;
- develop facility operating standards to upgrade existing landfills and to open and operate new sites; and
- support the initiation of highly visible, properly run landfill "demonstration sites" in one or two developing countries (e.g., Haiti and Egypt).

3.6 Vector-Borne Disease Control

3.6.1 Associations with Human Health

The burden of vector-borne disease on human health may be the most thoroughly quantified of any area of environmental health. Malaria leads the list, and was chosen for discussion because of the scale of the problem and its seeming intractability. For contrast, the group also discussed Chagas' disease, which affects fewer people, but may be more manageable. Other diseases of widespread importance include arthropod-borne viruses, schistosomiasis, onchocercosis, and Guinea worm disease.

3.6.2 Malaria

Of particular concern is the cerebral form of malaria caused by *Plasmodium falciparum*, which is more often fatal than *P. vivax*. Most of the following discussion, however, is relevant to both forms. The geographical spread of malaria is both rural and urban, sometimes varying with season, sometimes dependent on climate, such as a rainy and dry season.

Malaria is transmitted by mosquito bite, and anything which makes exposure to infected mosquitos more likely increases risk: nearby rice cultivation, or other activities which increase standing water and, hence, breeding sites; siting of houses near breeding sites; inadequate housing and sleeping arrangements (no screens or bednets). Risk is also increased by resistance to pesticides of both the host (mosquito) and the parasite (plasmodium); by development projects such as water impoundments or forest clearing (Nepal); and by global climate change which may extend the range of infected mosquitos into areas where human immunity is rare.

High risk groups include children, victims of anemia, tourists, and workers who migrate to endemic areas, but do not have immunity.

Research is needed into how to make existing interventions work, such as determining vector sensitivity to specific agents. Since resistance is a problem, specific information about the local population of both host and parasite will result in more effective control programs.

Interventions at the personal level include the promotion of housing and sleeping arrangements which minimize biting. At the policy and infrastructure level, environmental management of breeding sites can reduce the source, and programs of surveillance can promote efficient use of control techniques.

3.6.3. Chagas' Disease

Chagas' disease is limited to Latin America, and is transmitted through the feces of the triatomine ("kissing") bug, which feeds on human blood. While biting, it defecates on a person's skin; scratching the site of the bite allows entry of the feces, and infection by the parasite. The disease can also be spread by transfusions of infected blood.

Chagas' disease is associated with substandard housing, where the insect can live in the walls. So poverty, which leads to poor housing, is a principal risk factor. Other risk factors include blood transfusions and lack of housing standards. Children and young adults are particularly at risk, although the infection may not cause serious health consequences for many years. The disease can be treated if it is spotted early, but there is a need for a cure for the late stage.

Risk reduction is largely beyond personal control, if poverty is the cause of the poor housing conditions which promote the disease. Nevertheless, housing improvement will reduce risk. Education which links the insect's bite to the risk of infection will be of limited help, since it is very difficult to prevent a victim from scratching the site of the bite.

At the policy level, screening and treating the blood supply will block one route of transmission, although this is less likely to reach the poor, who are the principal victims. Likewise, housing codes will help, but only if they are applied. Creative schemes for financing home improvement may have the greatest chance of reaching those at greatest risk.

3.6.4 General Points Common to Many Vector-Borne Diseases

Standing water is implicated in many diseases as a breeding ground for the vector, and as a principal means of contact with human victims. This area also offers an opportunity for local control efforts.

Children seem to be both more vulnerable to vector-borne diseases, and more efficient at transmitting them. Therefore, children need special protection for themselves and for others: child labor presents a risk to adult laborers.

The movement of labor presents an additional risk, as groups travel through endemic zones, picking up diseases to which they have no immunity, and carrying them to their home

communities. Screening of migrant workers can be effective, and monitoring the illnesses of migrants can be a useful surveillance method.

Projects should be evaluated in advance for their effect on vector-borne disease, as is already done in A.I.D.

In light of the resistance of vectors and hosts to various chemical controls, the danger of the chemicals themselves to people and their environment, and the difficulty in treating many of the vector-borne diseases, blanket use of any control technique is a mistake. Stratification - the process of choosing a specific target group of people to protect, or a narrow control strategy to employ - is much more effective.

3.7 Housing/Shelter

3.7.1 Associations with Human Health

Categories of diseases were discussed here, primarily grouped by common causes:

- Vector-Borne Diseases
- Respiratory Diseases
- Infectious Diseases
- Mental Health
- Injuries/Accidents
- Toxicities
- Exposure Related Disorders
- Security (from robbery, etc)

3.7.2 Characterization of Risks and Interventions

The components of Housing and Shelter related to ill health were defined to be:

- House Location
- Size of House
- Availability of Services (electricity, heating, WS&S)
- Ownership
- Housing Construction
- Community Density

The issues vary by geographic focus: urban, peri-urban, and rural.

Housing location is related to ill health when housing is located in areas prone to natural disasters, such as on a floodplain. In addition, housing may be located near the breeding and/or feeding sites of insects that are the vectors for some diseases. Finally, housing may be located far from the location of employment, commonly the case for peri-urban populations. Issues that

relate to housing location, and from which interventions follow, include personal choice in site selection, land tenure policies, land use planning and enforcement, financing mechanisms, and public education.

Housing size is related to ill health through issues of crowding, hygiene, and indoor air pollution. Respiratory-transmitted and hygiene related diseases are those primarily related to small house size and crowding. Personal behaviors that play a role here include traditional cooking and ventilation practices, fuel choice, stove type, food preferences, and livestock habits. Availability of construction materials and land tenure issues also play a role.

Many of the health effects of the availability of services have been discussed elsewhere. Availability of WS&S is central and discussed under that topic. Availability of electricity and refrigeration is related to food storage and food hygiene. In addition, the availability of electricity is related to global issues of education, opportunities for cottage industries, and quality of life.

Land ownership affects health through the stability of the physical house and household and is manifested in housing construction, size, and services.

Housing construction relates to ill health through respiratory diseases and exposure-related disorders. Respiratory diseases related to cooking and indoor air pollution are discussed above. Exposure related disorders are those related to inadequate protection from the elements and include freezing, frostbite, etc. Housing construction also relates to vector-borne diseases by inadequate protection from insects, or, as in the case of Chagas' disease, providing an environment for vector breeding.

Community density relates to ill health through WS&S and hygiene-related diseases and through exposure to security risks, such as theft.

The interrelated nature of housing and shelter issues indicated a group of interventions that would be crosscutting in effects on housing. Some of these have already been mentioned; the list discussed included:

- increasing community participation in housing;
- increasing participation in the political system;
- improving education in home maintenance, hygiene, and animal raising;
- establishing minimal standards and costs for housing and associated services (including land tenure policies);
- planning and enforcing land use regulations;
- ensuring equity issues;
- providing adequate infrastructure;
- providing insurance (property, title, etc);
- improving financing mechanisms; and
- ensuring pluralism.

Information needs include a better definition of the extent of the problem, more information on the risks associated with specific traditional practices, and a better determination of the true costs of interventions.

3.8 Toxic, Hazardous & Radiological Wastes

3.8.1 Associations with Human Health

The group did not spend limited discussion time to define the specific links between this environmental problem and one or more conditions of ill health. It was noted that this area has a direct, adverse impact on one or more physiological systems, e.g., circulatory, pulmonary, etc., and was directly linked with specific disease conditions, e.g., acute respiratory infection.

3.8.2 Characterization of Risks and Interventions

The working group noted that pesticides, herbicides, fertilizers, heavy metals, and solvents constitute the most significant materials in this category; radiological waste is currently only a very small percentage of the waste in this category. Medical waste, the group stated, should be included in hazardous waste. The group also noted that a better approach would be to look at this area as hazardous materials and wastes, as this encompasses the notion that these substances are of concern while in use, and when they become a waste. This report continues to use the term as it was defined at the outset of the Workshop, however the revised term would be better for future use.

When addressing this environmental problem, the working group emphasized the importance of taking action at the point where the waste is generated (point of generation) rather than "downstream." This perspective would facilitate increased feasibility of separation of the hazardous elements from all waste streams, which may be the most severe problem. This conclusion was illustrated through a discussion of the flow cycle of hazardous materials which clearly illustrated that health risks to human populations, through ingestion, dermal contact, and inhalation, increase as materials move from the point of generation through use to post-disposal. Those at highest risk reside closest to the sites where hazardous materials are generated or released, or reside downstream and are "victims of dumping," either intentional or unintentional.

Factors which increase the risks to human health include:

- acute accidents, spills, leaks;
- intentional, improper disposal of hazardous wastes, i.e., dumping;
- routine use of hazardous materials; and/or
- the improper handling or transport of hazardous material.

The working group suggested that a 2 by 2 matrix could be used to diagnose the hazardous waste problem in a given developing country. The suggested matrix appears in the accompanying box.

Since the risk associated with hazardous materials is directly linked to the dose to which human populations are exposed, the working group proposed that total exposure studies (TES) be undertaken in selected developing countries. These could be used to determine how much hazardous waste is being generated, and where and how it is being dispersed. It was noted that the methodological approaches used in these studies would have to be modified to accommodate

developing country conditions. Two additional studies were suggested. The first would analyze the costs and risks of substituting other less hazardous materials and alternative disposal methods for the hazardous materials and disposal methods currently employed. The second study would estimate the economic consequences of exposing resident populations to hazardous materials.

Assessing Hazardous Waste

	Intentional	Unintentional
Acute		
Chronic		

Beyond promoting the need to develop educational programs to teach industrial workers and the general population about the dangers of hazardous materials, the working group suggested that A.I.D. consider supporting the following interventions:

- development of standardized classification systems that rank materials as more or less hazardous;
- development of policies on generating, handling, transporting, and disposing of hazardous materials;
- definition of policies on labeling and handling procedures;
- introduction of toxic use reduction/substitution programs, and incentives and/or penalties for reducing or using hazardous materials;
- introduction of appropriate treatment and control methods;
- introduction of hazardous waste separation programs, and specialized programs for managing hazardous waste; and
- establishment of technology transfer linkages between U.S. and developing country institutions, e.g., private sector groups and universities.

3.9 Occupational Health and Injury Control

These two topics, though overlapping, are dealt with separately because 1) they tend to fall under different administrative jurisdictions and thus are regulated by different authorities, and 2) they have different (overlapping) constituencies - "workers" and "citizens" - so pressure for change is organized in different ways.

3.9.1 Occupational Health

This category includes the recognition, treatment, and prevention of all non-intentional injuries and diseases that occur as a result of work exposures or working conditions: in the formal or informal sector, in small industry, or in agriculture and fisheries, all of which present different dangers. Although the problem definition reveals different types of risks, types of interventions for different problems are similar, and are discussed together.

Injury. These are non-intentional events caused by machinery, burns, falls (of workers or of objects onto workers), and vehicles used at work. Unsafe machinery, or once-safe machinery

which has deteriorated for want of maintenance or spare parts, is a major cause. Untrained laborers, excessive hours worked, or conditions which stress speed over safety contribute to injuries.

Respiratory Disease. Acute or chronic exposure to inhaled substances in the workplace can lead to a wide variety of respiratory illnesses.

Systemic Poisoning. The geographic focus includes agricultural and industrial sectors. Transmission routes primarily are inhalation and skin absorption. For pesticides, agricultural workers and their families are vulnerable. Personal behaviors which increase risk include reuse of contaminated containers and field entry too soon after pesticide spraying. However, institutional behaviors, such as the import of highly toxic pesticides, also increase risk.

Cumulative Trauma Disorders. Inappropriate design of job tasks, equipment, or work stations can lead to chronic disabling musculoskeletal disorders.

Interventions. Risks can be reduced at the personal level through worker training in the use of machinery and of toxic materials. Workers are rarely able to protect themselves, and may be discouraged from doing so if the employer does not see occupational safety to be in his or her best interest. Economic incentives, government laws and regulations, union pressure, and the mass media are among the means by which employers are compelled to take action for the health of their employees.

Additional interventions include: screening workers to assess health effects; using environmental measurements and appropriate biological markers to gauge exposure; using personal protective equipment; and, at the policy level, restricting the importation, labeling, use, sale and transport of hazardous substances.

3.9.2 Injury Control/Prevention

The group deliberately avoided use of the word "accident," and used "non-intentional injury," in the belief that these incidents are not random, and their number can be reduced: they are not really accidental. Two categories of injury were chosen: motor vehicle injuries and burns. In the case of the former, one could adapt, in part, the U.S. road safety model, whereas for the latter, which arises from situations which are more typical of developing countries, we have no transferable model.

Motor vehicle injuries. Geographically, the focus is on more industrialized countries and more urban areas, but not exclusively so (for example, overloaded vans for rural transport are a source of many injuries). The transmission route is, of course, trucks, cars, vans and buses, motorcycles, and bicycles. The direct cause is often termed "human error", but is often due to physical factors (vehicle, road, or weather) interacting with personal behavior (alcohol, speeding, poor vehicle maintenance, no use of restraints, or poor driving skills). Other factors which increase risk include:

- poor road design
- poor vehicle design

- overcrowding of buses and other public transport
- inadequacies in driver and vehicle registration
- inadequate emergency transport and emergency medical services
- cultural attitudes towards driving
- inadequate vehicle maintenance
- hazardous vehicle mix: e.g., large trucks and donkey carts sharing the same road.

Groups at risk include drivers and passengers, pedestrians, and bicyclists.

Information-gathering in the area of motor safety includes descriptive epidemiology which can help pinpoint areas of intervention and risk factors. Steps to reduce and manage risk could draw heavily on the U.S. model. At the personal level, educational efforts should stress driving skills, alcohol use, road "sophistication", use of restraints (seat belts), and the dangers of overloading vehicles. Infrastructure investment is necessary to improve the physical condition of roads, and to promote the use of safe mass transit. Regulations are needed to require that drivers and vehicles be licensed, and that sanctions against dangerous drivers are effective. This means that financial penalties are levied against those who drive dangerously, and the records of driving offenses are shared with insurance companies who can penalize the driver further.

The group emphasized the importance of involving host country NGOs in mobilizing support for motor safety; the U.S. example cited was the success of Mothers Against Drunk Drivers. Host country technical personnel should also be involved in collection and analysis of data.

Burns. Here, the prevalence of open fires in the home environment means that U.S. experience is less transferable. Many burns occur in the home (and at work). The transmission route is a fireplace, open fire, hot object, oil spatter, or house fire. Direct and indirect causes include:

- the use of open flames for cooking, lighting, or heating
- unstable stoves
- loose clothing which can catch fire
- fuel explosions
- stored flammable substances.

Personal behavior which increases risk includes: cooking; crowding; children sleeping, sitting, or playing around the fire; and inadequate child supervision, such as occurs when a young child is put in charge of a baby. Risk is also increased by hazardous fuel type, flammable housing and clothing material, and inadequate first aid treatment and emergency medical care.

Collection of basic data for risk assessment is difficult because these incidents often occur in the home; however, the lack of hard data should not prevent action being taken, as this is clearly a major source of morbidity and mortality. Many countries are tempted to repeat studies done elsewhere. Instead, existing data can often be generalized. Interventions which focus on personal behavior include changing cooking techniques and teaching first-aid. Where crowding contributes to burns, the kitchen can sometimes be separated from the rest of the house, although doing so can be costly, and may not be practical where the cooking fire doubles as a heat source. At the policy and infrastructure level, improved stove designs can be promoted, safety standards can be set for clothing, and safer fuels can be promoted.

4. Activities of Other Organizations

4.1 Urban Environmental Activities of the World Bank, *by Carl Bartone*

Dr. Bartone presented a description of the activities of Urban Management and the Environment Component of the Urban Management Program, being conducted by the Urban Development Division of the World Bank (INURD) and UNCHS (Habitat), with support from UNDP. Appendix I includes papers on the Urban Management and the Environment Component of the Urban Management Program.

The project is conducting a number of activities, including:

1. ***Development of Strategic Options Framework.*** An outline for the framework is included in Appendix I, and a draft strategic options paper has been prepared. The other activities outlined below will provide additional input to the strategy.

2. ***Research Papers*** are being prepared on: the relative health impacts of environmental conditions in developing cities; economic spillover effects of urban environmental problems; a framework for urban environmental data collection; and the application of remote sensing and geographic information systems to urban environmental planning.

3. ***Background Studies*** are being prepared on: priorities for urban waste management and pollution control; regulatory and economic instruments for pollution control; local management of wastes from small-scale and cottage industries; energy-environment linkages in the urban sector; urban environment - degradation of land, ecosystems and cultural property; and options for planning and managing the urban environment.

4. ***Case studies*** are being conducted in six particular urban areas, including preparation of urban environmental profiles, identification and analysis of priority environmental concerns, analysis of institutional and jurisdictional arrangements for environmental management, and a detailed examination of one priority concern. These studies will be prepared by local consultant teams. Each of the cities tentatively selected is a candidate for World Bank future lending operations.

4.2 Activities of the WHO Environmental Health Commission, *by Dr. Bernard Goldstein, Environmental & Occupational Health Sciences Institute, and Head of the Industrial Panel of the WHO Environmental Health Commission.*

Dr. Goldstein provided an overview of the activities of the WHO Environmental Health Commission. The WHO has set up this high-level Commission of 23 members, under the direction of Simone Weil of France. The task of the Commission is to make an inventory of the present knowledge of the impacts of environmental change on human health, indicate areas where further research is needed, and lay the basis for WHO to develop strategies to tackle the problems of health and the environment in the future. The Commission has appointed four panels, covering Industry, Food & Agriculture, Energy, and Urbanization. Dr. Goldstein serves as the Head of the Industry Panel.

Dr. Goldstein next reviewed several issues facing the Commission:

1. ***Approaches to Environmental Health.*** There are several ways to organize the study of environmental health problems: by medium (air, water, etc), by disease, by type of toxin (solvents, particulates), or by "driving forces" (industry, food & agriculture, energy and urbanization). The Commission considered these options and decided to structure its analyses around "driving forces", and appointed a Panel for each. While population growth was also seen as a driving force, it was not separately addressed, but is being considered by all four of the Panels. The Panels have been preparing reports, which were to be completed in draft form in mid-March, in time for a meeting of the Commission in Geneva. The Panels are developing a strategy on how WHO should move forward in each area.

2. ***Assessment of Health Impacts.*** The determination of health impacts from environmental problems is difficult. Generally there is a lack of data to attribute incidence of particular disease to environmental causes as opposed to other causes. Yet the experience of the Commission has revealed some clear linkages, but showed that careful studies are needed. Dr. Goldstein presented the example of Katowice in Poland, where there are four metal smelters - two old and two new. Examination of municipal hospital records showed lead and cadmium blood levels exceeding CDC limits. Careful study showed that the new smelters, with newer technology, but with staff with a lax attitude to safety, posed a greater risk to workers and nearby residents than the older smelters where more precautions were taken. Intensive study is needed to fully understand the impacts of environmental health problems.

4.3 Discussion

An open discussion considered how A.I.D. could collaborate with other organizations in an environmental health initiative. After a brief review of the new A.I.D. Mission statement and mandate, discussion focused on several themes, including links to the World Bank, WHO and the UN system in general, links to other US Government agencies such as EPA or NIOSH, and links to and collaboration with the private sector. Key points include:

1. The mandate and financial resources of ***A.I.D. and the World Bank are complementary.*** A.I.D. focuses mostly on the poor has modest grant resources, while the Bank takes a broader view, and has large loan programs. This complementarity should lead to jointly planned programs.

2. There is no organization taking a ***lead role*** with developing country governments and environmental health, as WHO does for AIDS. WHO or another group should fill this role.

3. Increased ***involvement of the private sector*** is desirable. Policy and regulatory changes may be needed to facilitate such involvement. Without a stable regulatory environment, the private sector will stay out. There is a need to examine different regulatory paradigms.

The group noted that EPA has strong technical expertise, but limited funds to use in developing country work. Also noted was the observation that, in many countries, NGOs and PVOs may be the best collaborators for A.I.D.

5. Synthesis Session Output

5.1 Setting Priorities for an A.I.D. Environmental Health Strategy

Workshop participants were asked to review the output of the small-group work sessions and answer the following question:

"For each environmental health category, do you feel that A.I.D., for:

Traditional Areas:
(1) Must do more,
(2) Should do more, or
(3) Need not do more (status quo OK), and for

New Areas:
(1) Must be addressed in an A.I.D. environmental health strategy;
(2) Should be addressed in an A.I.D. strategy; or
(3) May be excluded from an A.I.D. strategy?"

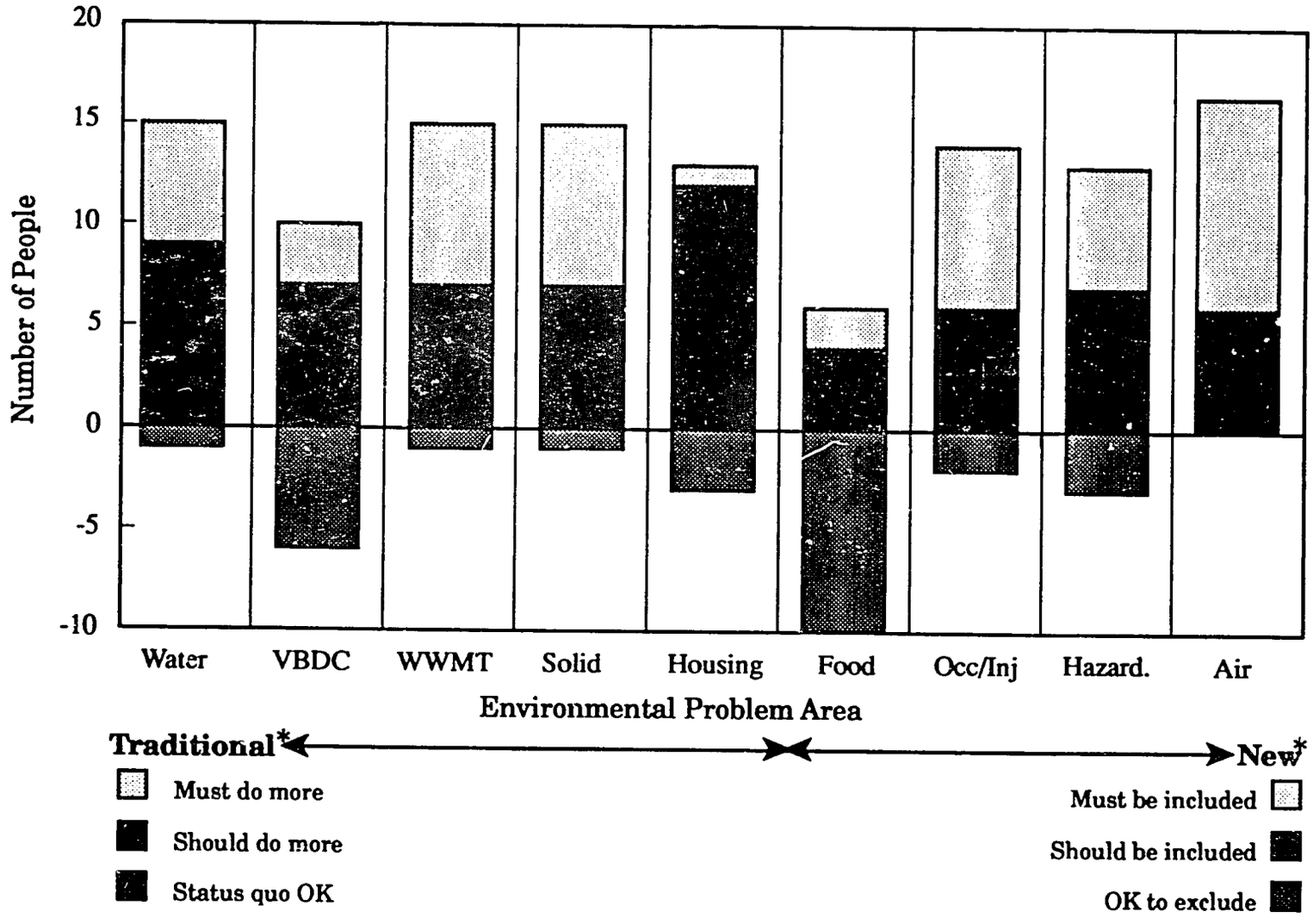
To ensure consistency in the participant responses, the following categories were classified as traditional: water supply & sanitation; vector-borne disease control; wastewater management; solid waste; housing & shelter; while the others were classified as new: food hygiene; occupational health & injury control; toxic, hazardous & radiological waste, and air pollution. While a clear classification was necessary, it was recognized that some areas are more or less traditional than others. For example, solid waste and wastewater management have received some but less attention in A.I.D. programs than water and sanitation.

Participants submitted their opinions in writing and then discussed the rationale for addressing or omitting each category. A tally of participants' opinions is presented in Figure 2. Note that the environmental problem areas are arranged on the chart from left to right; traditional A.I.D. program areas on the left and newer emerging areas on the right. The chart shows the number of responses in the categories "Must" or "Should", above zero, and the omit or "status quo ok" below.

Several observations are possible from the figure. First, air pollution was the only area that all participants felt should or must be included, and this was the only topic with such a strong ranking. Second, at the other extreme, more participants recommended that food hygiene be excluded from the strategy, than be included. Also, a substantial number of participants recommended VBDC be excluded from the strategy. It was recognized that these are important problems, however they may not fit well in an environmental health initiative. The other topics, such as water, wastewater, solid waste, housing, occupational health & injury control, and hazardous wastes were, on balance, important to include. Appendix H records opinions expressed.

These priority rankings differ considerably from those compiled from the A.I.D. Missions outlined in Figure 1 (page 4). The Workshop participants tended to place more emphasis on the newer emerging areas of environmental health, which A.I.D. has not addressed in its programs to date. A synthesis of these two pieces of information is attempted later in this report.

Figure 2. Workshop Priorities in Environmental Health



* For purposes of collecting participant opinion, traditional problem areas include: Water, VBDC, WWMT, Solid and Housing. while new problem areas include: Food, Occ/Inj, Hazard and Air.

5.2 Key Issues Regarding a Menu Approach

The discussions revealed a strong consensus that a broad-based "menu" approach was needed because:

- many of the problems discussed in the Workshop are interrelated, and must be addressed by an integrated and multifaceted strategy;
- different countries have different problems, and A.I.D. must have capabilities to respond to a broad range of problems.

However, it was noted that A.I.D. may not have the resources to address all of the problems with intensive and equal effort; therefore the Agency might examine three strategic options:

- A.I.D. could make efforts to build on the capabilities of contractors and other federal agencies;
- A.I.D. could develop a broad menu initially (possibly in a 2- year "pilot"), that would be narrowed over time to focus on the most important needs of the Missions; or
- A.I.D. could choose to select "focus countries" where it concentrates its efforts, and expand to others in the future. (This point was not discussed at the Workshop).

Adopting a broad menu approach has some risks. Countries need help, and A.I.D. will be called upon to deliver whatever services are requested. A.I.D. must be sure it can deliver on its promises; otherwise Missions may conclude that environmental health problems are not important.

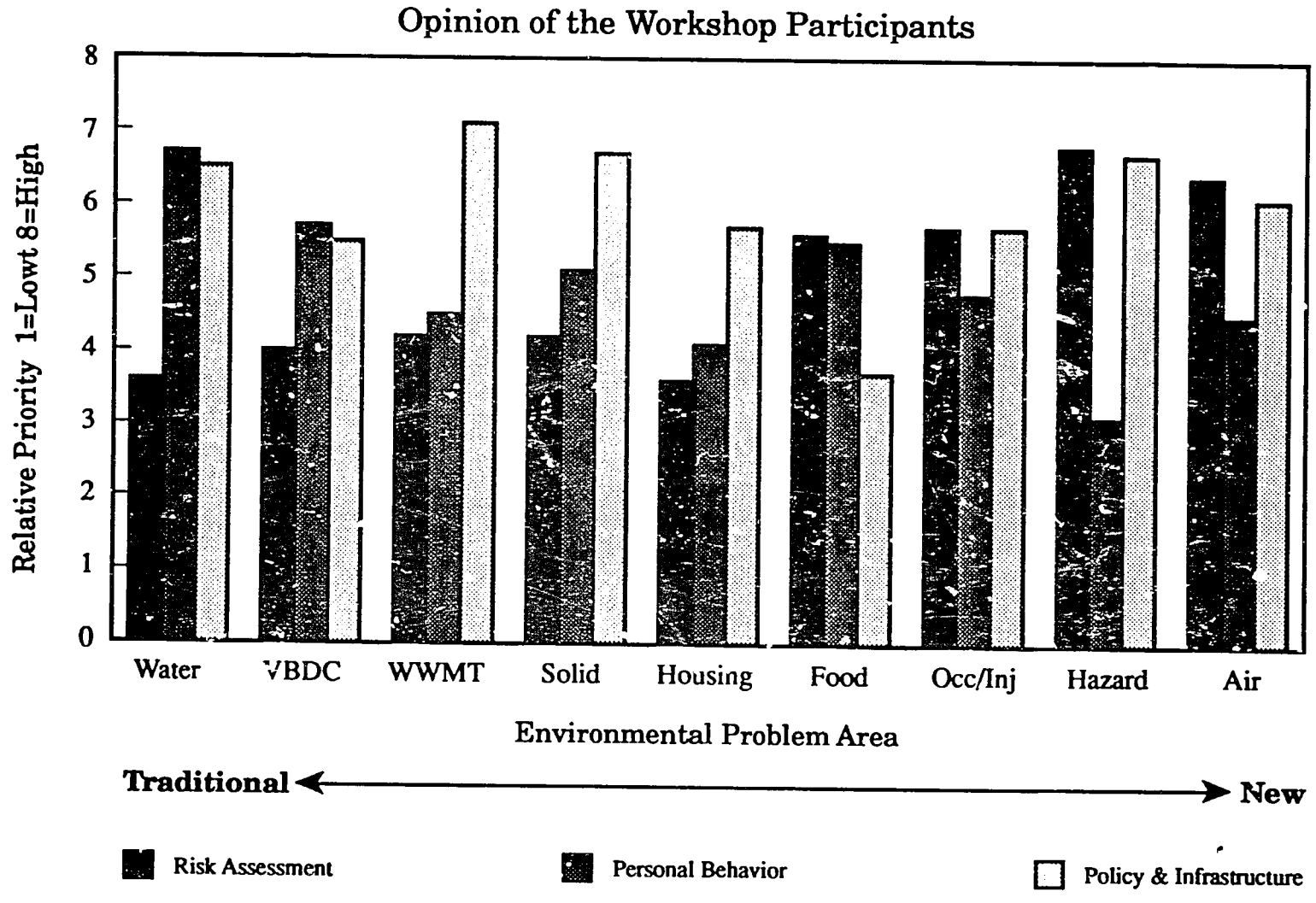
5.3 Priority of Intervention Options

After reviewing the output of the working groups, the participants were also asked to submit information on the importance of different types of interventions. They were asked to rate the importance of risk assessment, risk reduction through changes in personal behavior, and risk reduction through changes in policy and infrastructure for each of the nine areas, by indicating a low, medium, or high priority. Ratings were not restricted in any way; all things could be rated high if that was the opinion of the participant. Results were tabulated and a summary score for each of the three types of interventions in the nine topic areas was calculated. Figure 3 shows the results.

The results are a little difficult to interpret, because of the data is in two dimensions - problem area and type of intervention. Nonetheless, some observations can be made. First, the importance of risk assessment is relatively low for the "traditional" areas such as water & sanitation, but is high for newer emerging areas such as air pollution. The black bars for risk assessment show a clear rising trend from traditional to new. Other relative priorities within a given problem area can be explained by the nature of the area itself. For example, wastewater will require a large emphasis on policy and infrastructure issues, and less on risk assessment and personal behavior issues. The importance of personal behavior in hazardous wastes is low.

While this exercise has yielded some useful general information, a local, regional, or national context would yield more precise results.

Figure 3. Priority of Intervention Options



5.4 Important Issues not Addressed by the Workshop

Participants were asked to identify issues that had not been addressed in the Workshop but should be considered in either planning or implementing an A.I.D. environmental health strategy. The following list documents issues identified by the participants, as well as other points which came up in reviews of the Draft Report.

Strategic Issues:

- The Workshop proceeded from an assumption that mitigating environmental health problems will improve the quality of life in developing countries. Social well being (e.g., the absence of violent crime) is an indicator of quality of life, and should be considered just as important as mortality and morbidity.
- The Workshop did not have sufficient time to explore and define all the linkages between all the problem areas. The strategy development process needs to take into account more information on the linkages.
- The Workshop did not address the physical environment as a source of mortality and morbidity. A.I.D. could take a more preventive approach with respect to natural hazards and disasters.
- Environmental health problems can be addressed, in part, through initiatives in the private sector, consistent with an important A.I.D. focus. But A.I.D. has not figured out how to interact successfully with the private sector.
- The economic impact of environmental health problems was not discussed, but should be considered in the strategy.

Implementation Issues:

- The structure of the Workshop focused attention on technical and policy interventions, but did not address the possibilities of community based efforts to assess, or reduce risks. This approach should be considered closely by A.I.D.
- Empirical research is needed to determine which policy interventions are most effective.
- A.I.D. should apply the lesson from the WASH project that training is an important component of all intervention programs.
- Individual countries should develop their own methodological approaches to improving environmental health; for example, public participation initiatives such as MADD.
- Urban planning is a type of intervention not discussed in the Workshop; it is relevant to waste handling, transportation problems, and mitigating effects of natural disasters.
- A.I.D. should coordinate its efforts and policies with other donors, particularly with respect to the adoption of environmental standards; standards drawn from U.S. regulations are not appropriate in many LDC situations.
- The development and operation of information systems will be important in implementing an environmental health strategy.
- An environmental health program should include mechanisms for program review and adjustment over time.
- The U.S. regulatory paradigm may not be appropriate to LDCs. To identify approaches for dealing with environmental problems through government regulation, A.I.D. should examine other models such as regulatory approaches in Canada.

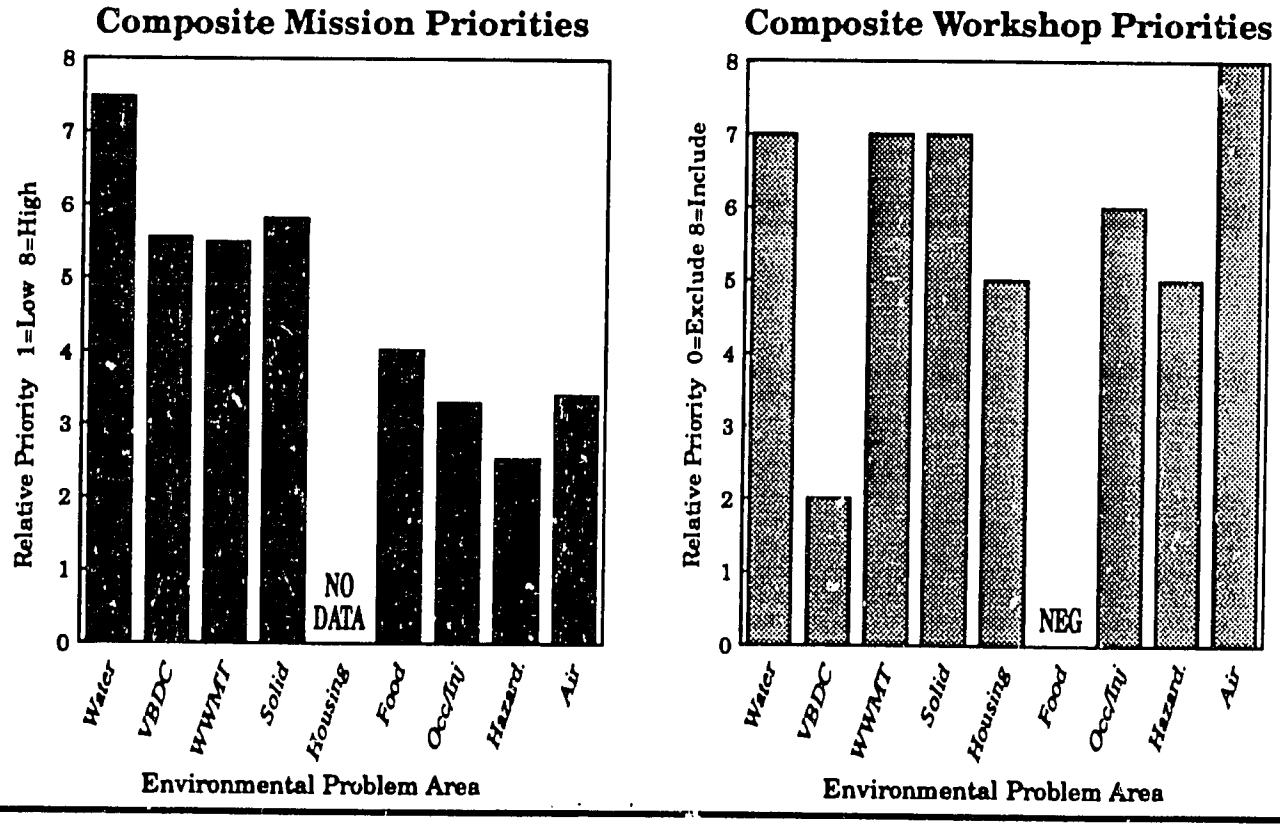
6. Priorities and Options for the A.I.D. Environmental Health Strategy

After closing the Workshop and reviewing and discussing the points and tabulations with A.I.D./S&T staff, the RTI team developed a set of concrete options for A.I.D. consideration in the strategy development process. These options present choices in terms of priority environmental health problem areas. In addition priority interventions were defined for each option. These options are shown in the boxes on the following pages.

The options must respond to the priorities of the Missions and the Workshop participants. These two sets of priorities are compared in the Figure 4 below. Note that Figure 4 aggregates the data from different regions, and presents a summary ranking by Participants to assist in comparison of the two sets of rankings. As noted above, the Missions have ranked traditional intervention areas high, while the Workshop participants made different rankings based on their appreciation of traditional and emerging areas.

A.I.D.'s strategic choice, in its simplest form would be to build a strategy around Mission priorities, or alternatively Workshop priorities. However other options which address both concerns are possible. Key points about the options include:

Figure 4. Comparison of Priorities



- ***Food hygiene has been dropped*** from consideration. It was ranked very low by the Workshop, and relatively low by the Missions, overall.

- ***The three options are additive.*** The first option recommends staying with traditional areas, but puts increased effort in areas which are only partly addressed now. This option responds best to Mission priorities. The second retains these elements but adds air pollution and toxic, hazardous, & radiological wastes. The third option adds occupational health and injury control (separately) to reach a full-scale broad-based menu approach, as recommended by the Workshop. The second option is somewhat of a compromise between the other two options.

- ***The inclusion of problem areas in the different options was based on several criteria: ranking by participants, ranking by Missions, linkages to other problem areas already included, and technical skills required.*** Specifically, air pollution was added into the second option because of its unanimous "must do" ranking by the participants, and moderate ranking by the Missions. Toxic, hazardous, & radiological wastes which had a moderate ranking from the participants and a low to moderate ranking by Missions was also added to the second option. It was included because it is extremely closely linked to solid waste and wastewater management. Dealing with hazardous wastes would be relatively simple to do if these other two waste issues were included. In fact, it would be an error to ignore this portion of the overall waste stream. In addition, the technical skills to deal with hazardous wastes are very similar to the skills for the other two waste elements. Occupational health & injury control were added only in the third option. It had a moderate to low ranking from both the Missions and participants. In addition, while it is linked to the other environmental problem areas, those links appeared less strong. Lastly it appeared that many of the skills required to deal with this area, especially injury control require very different skills than dealing with the other areas.

- ***The broader options may appear to require more resources, but there are approaches which could bring the resource requirements more in line with other narrower options.*** As outlined in Section 5.2 (page 28) A.I.D. could concentrate on selected countries or regions, or start broad and narrow the scope over time.

The priority interventions shown in the Box below come from the ranking of interventions derived in the final synthesis session as described in Section 5.3. Key points include:

- ***For efforts with a greater emphasis on newer emerging environmental health problems areas, there will be a greater emphasis on problem definition, risk assessment and comparative risk assessment.*** For the more narrowly focused option, highlighting traditional areas, these problems are well known in most countries, so efforts can concentrate on risk reduction/ management efforts in the personal behavior and policy and infrastructure arenas. This is not to say that no risk assessment should be done; in some locations the problems may not be well understood, and problem definition and risk assessment would be relevant.

- ***The interventions listed in the table are not listed in any priority order***; policy development is not viewed as more important than information systems.

Focus Options for A.I.D.'s Environmental Health Strategy

	Give Increased Effort in Traditional Areas	Develop a New Focus on Selected Emerging Areas	Offer a Broad-Based Menu
Sustained Effort In:	- Water Supply and Sanitation - Vector-Borne Disease Control	- Water Supply and Sanitation - Vector-Borne Disease Control	- Water Supply and Sanitation - Vector-Borne Disease Control
Increased Effort In:	- Solid Waste - Wastewater Management - Housing & Shelter	- Solid Waste - Wastewater Management - Housing & Shelter	- Solid Waste - Wastewater Management - Housing & Shelter
Add New Effort In:		- Air Pollution - Toxic, Hazardous & Radiological Wastes	- Air Pollution - Toxic, Hazardous & Radiological Wastes - Occupational Health - Injury Control

Priority Interventions for A.I.D.'s Environmental Health Strategy

	Give Increased Effort in Traditional Areas	Develop a New Focus on Selected Emerging Areas	Offer a Broad-Based Menu
For New Areas:		- Problem Definition - Risk Assessment - Comparative Risk Assessment	- Problem Definition - Risk Assessment - Comparative Risk Assessment
For Traditional Areas:	- Policy Development - Education/Risk Communication - Information Systems - Training & Institutional Development - Infrastructural Investment	- Policy Development - Education/Risk Communication - Information Systems - Training & Institutional Development	- Policy Development - Education/Risk Communication - Information Systems - Training & Institutional Development

7. Conclusions and Recommendations

7.1 General Conclusions

Numerous conclusions can be drawn from the information prepared for and generated in the Workshop. Perhaps the best way to present them is to briefly answer the five questions outlined for a successful Workshop, indicating what has been learned:

1. ***What environmental problems have the greatest effects on mortality and morbidity in A.I.D.-assisted countries?*** This is a more complex question than initially conceived. The Workshop dropped Matrix 1 as too limited in scope to be helpful in answering the question. Instead the group felt the best use of the limited Workshop time was only to outline rough disease associations rather than trying the very difficult task of impact assessment. More data are needed to arrive at any quantitative answer. An additional complicating factor is that the effects will vary from country to country and locale to locale. Still, considerable information has been collected on the associations and some data on the impact of environmental conditions on human health. The background papers and small group work sessions provided considerable detail. General priority ranking information has been collected from A.I.D. Missions as well as the Workshop participants, and a set of options developed as input to A.I.D.'s strategy development process.

2. ***What interventions would best alleviate these environmental problems or their effects?*** The background papers and work session outputs have also provided information on the possible interventions to address these problems. Efforts will probably fall into 2 classes: risk assessment, and risk reduction/management influencing personal behavior and extrinsic policy & infrastructure. Some information has been generated on priority interventions although more effort will be needed on this topic.

3. ***What are the most important information gaps regarding problems and interventions?*** There are considerable data gaps in the field of environmental health. There are often few direct hard data on the precise impact of health impacts of environmental problems, or on the attribution of existing health conditions on environmental or other causal factors. In addition there is a considerable lack of data on the cost effectiveness of different possible interventions to reduce risk, although preventive measures appear especially promising in environmental health.

4. ***What are other organizations doing and how should an A.I.D. project relate to their efforts?*** Numerous agencies, including WHO, World Bank, PAHO, UNEP, USEPA, other bilateral donors are involved in environmental health. WHO and the World Bank are both also involved in strategy development. A.I.D. should certainly establish links to exchange information, and where mutually beneficial should collaborate on improving the understanding of the problem, and taking action to reduce environmental health risks.

5. ***What unique capabilities exist in the U.S. that should be used in an A.I.D. environmental health strategy?*** This topic has only been touched on by authors of the background papers, but it is clear that the U.S. has strong capabilities in almost all the areas considered. The U.S. priority on environmental health and environmental issues in general has led to very strong capabilities in both the public and private sector.

The Workshop concluded that environmental health problems have a very large effect on human health. A number of the problems areas affect literally billions of people in the developing world, with the greatest effect on children, the poor, and women. The problems are magnified in rapidly growing urban areas, and will be exacerbated by continued economic development and population growth. A concentrated, yet broad-based effort by A.I.D. to assess the risks and assist governments and other local organizations to reduce and manage these risks, will be required. Such efforts will best be conducted in collaboration with groups operating in many sectors, and in coordination with other donors and international agencies. This Workshop has assembled considerable information and focused attention on the issue. Considerably more data need to be collected and assessed, key strategic options evaluated, and responses planned. While environmental health is a growing concern, A.I.D. has a good opportunity to be a focal point for broad efforts and to "lead the way" to a healthier environment.

7.2 Strategy Recommendations

While the paragraphs above, the background papers, and the work sessions have made numerous specific recommendations, some general recommendations on key strategic issues may be useful.

- ***Take a broad approach.*** A.I.D. should evaluate the options presented here. A.I.D. may wish to narrow the scope of the broader options by focusing on geographic areas or countries, or narrow the focus over time, or save resources through collaboration with other groups inside and outside of A.I.D.. However a broad capability will be required if A.I.D. is to assist Missions and countries to collect data and assess environmental health risks, in order to focus on the critical problems in those locations. The risk assessment, comparative risk assessment, and policy dialogue & implementation, and capacity-building capabilities must be considered indispensable.

- ***Work closely with other agencies or A.I.D. offices working in other sectors.*** As has been noted in discussions since the Workshops, many of the risk reduction efforts will perhaps best be done by non-health sector agencies or offices (industry, utilities, agriculture, etc.) However A.I.D., and especially the Office of Health, must develop the capability, skills and resources to bring concrete input to these potential partners in order to have health concerns addressed. Unless the environmental health strategy calls for a significant body of resources, the A.I.D./Office of Health will not be able to influence the agenda of those who intervene in these other sectors. Health issues will go unaddressed.

- ***Develop and maintain close working relationships with other US and international institutions working in environmental health***, such as EPA, WHO, World Bank, and others. A.I.D. may be able to learn from and take advantage of strategic approaches and technical skills in these organizations. Also A.I.D. could develop complementary efforts on risk assessment or risk reduction which will greatly help tackle the broad problem of environmental health. It must be noted that resources will have to be put in place for A.I.D. to work into and work together with these organizations. A.I.D. could also choose to take a lead role in coordinating widespread efforts in environmental health. Currently there is no clear international focal point in this field, and such leadership is needed.

Appendices

A. Scope of Work
B. Background Paper Outline
C. Workshop Agenda
D. Participant Lists
E. Data on Environmental Health Problems
F. Work Session Structure (Matrices)
G. Evaluation Form and Summary of Workshop Evaluation Responses
H. Workshop Participant Opinion on Environmental Health Priorities
I. Background Papers

Appendix A.

Scope of Work

DRAFT
SCOPE OF WORK

Background

The Office of Health is developing an environmental health initiative which may result in the establishment of a new project. This Scope of Work describes an activity which will assist the Office of Health in the development of an environmental health project.

For the purpose of this activity, environmental health is defined to include both those diseases which are environmentally determined, and those related to environmental degradation. A comprehensive environmental health program could include the following eight areas:

1. water supply
2. wastewater management
3. solid waste management
4. air pollution control
5. toxic/radiological/hazardous waste management
6. occupational health and public safety
7. food hygiene
8. vector borne disease control

Factors common to these eight topical areas which also need to be addressed include:

1. institutional and human resource development
2. health and management information systems
3. regulatory and policy development
4. population shifts (urbanization, migration, displacement)
5. environmental quality

Consistent with A.I.D. policy, the focus of the environmental health project is to be on prevention, rather than clean-up or curative measures. National, regional and community-based approaches which are technically sound, acceptable to local needs, socially accepted, and sustainable are required.

This is a complex and potentially multidimensional project. The Office of Health requires technical assistance in setting priorities and in developing sustainable interventions.

Scope of Work

The Contractor shall provide technical assistance to the Office of Health in the form of an "Options Paper". This Options Paper shall provide guidance in setting priorities and in developing sustainable interventions. In the pursuit of this objective, the Contractor shall perform the following:

I. Team Planning Meeting (One day, Washington D.C. area)
   a. purpose is to clarify the objectives, participants, and format of the workshop (See No. III, below)

b. To be conducted by the Contractor
c. Participants of the meeting will include Office of Health members and one-two Contractor furnished personnel

II. Research and development of the background papers on each of the eight topical areas, in preparation for the workshop (See No. III, below) (estimated 7 person days). The Contractor shall be responsible for the coordination of topics assigned to other participants. This will entail follow-up with others to ensure that input is submitted in the proper format, in a timely manner, etc. Each paper shall include:

a. brief technical review of the area, describing environmental determinants affecting health
b. relevance of the area to developing countries, and future trends
c. identification of research gaps
d. appropriate strategies, effectiveness, cost
f. A.I.D.'s competence in this area
g. reason to be included - i.e., meets list of prescribed criteria. Possible criteria include magnitude of the problem, U.S. capability to respond and cost-effectiveness of the solution. These criteria shall be further developed in the team planning meeting and finalized in the workshop.

III. Options/Priority Setting Workshop (two day workshop, estimated 12 person days)

a. Conducted by the Contractor
b. 2 day closed-door sessions for entire expert team
c. review environmental health and directions for A.I.D. (i.e., see the matrix in Figure 1, which provides a useful format for examining the interactions between the proposed topical areas and the five common factors)

IV. Final report preparations (estimated 7 person days)

a. The original and ten copies of the final report shall be submitted to the Cognizant Technical Officer by the estimated completion date of this Delivery Order. The precise format shall be discussed and finalized in the team planning meeting (See No. I, above)

Appendix B.

Background Paper Outline

Guidelines for Background Papers for the A.I.D. Environmental Health Workshop

Brief background papers are to be prepared for the A.I.D. Environmental Health Workshop to provide information for discussion and for work sessions. Papers are to be prepared on the following topics:

1) Water Supply and Sanitation/Wastewater Management
2) Solid Waste
3) Toxic, Hazardous and Radiological Waste
4) Air Pollution
5) Occupational Health & Safety
6) Food Hygiene
7) Vector-Borne Disease Control
8) Environmental Health Risk Assessment

The papers should briefly address the points below. A note on the relative priority of the topic for the workshop, to serve as a guide in preparation.

1. Characteristics of the Environmental Problem and its Impact on Health (High Priority)

   - brief technical description of the problem (sources, impacts, causes)
   - distribution of the problem (by geography, climate, urban/rural, level of economic development)
   - number and type of toxins, vectors, infective agents, routes, etc.
   - impact on morbidity and mortality (association with major diseases)
   - numbers of people affected
   - other relevant epidemiologic information
   - information on interactions with risk factors
   - relevance of the issue to developing countries, currently and in the future

2. Preventive Measures or Control Strategies Available (High Priority)

   - available options (assessment, curative/preventive)
   - effectiveness of the interventions/strategies
   - alternative or new technologies available
   - cost effectiveness of available interventions
   - types of economic benefits from effective control or prevention

3. Identification of Data Gaps and Applied Research Needs in the Area (Medium Priority)

   - types of data and applied research required for assessment of the problem area
   - general availability of data in LDCs or elsewhere
   - constraints on improved data collection and assessment

4. Information on U.S. Capabilities and Advantages (Lower Priority)

   - special experience and expertise we can bring to bear
   - research and methodological expertise
   - training and technology transfer capabilities

5. Information on Current Activities in Developing Countries (Lower Priority)

   - Major agencies, countries, and programs working in the problem area
   - Levels of funding, and types of work being done
   - Source and types of coordination, joint planning, etc.

6. Synthesis: Advisory comments on the Need, the Priority, and the Relevance of Interventions in the problem area in an A.I.D. funded project. (High Priority)

The paper on environmental health risk assessment would differ from the above papers, in that it would not focus on an environmental health "problem" area. Instead, this paper would present an introduction to environmental health risk assessment, review current activities and knowledge in developing countries, provide an overview of U.S. capabilities and methodological experience, and outline the linkage between risk assessment, policy and regulatory development, and project-type interventions.

There is no firm requirement on the length of the papers, but 10-12 pages would be appropriate.

ASW
February 1, 1991

Appendix C.

Workshop Agenda

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Appendix D.

Participant Lists

List of Presenters

Introductory Session:

- **Policy and Regulatory Options and Implications,** *Richard Andrews, University of North Carolina*
- **The Role and Methodology of Risk Assessment,** *Terry Pierson, Research Triangle Institute*
- **Population Growth: The Common Factor,** *Julie Johnson, A.I.D./S&T/H*

Technical Session 1:

- **Water Supply and Sanitation,** *J. Ellis Turner, WASH Project*
- **Wastewater Management,** *Rita Klees, S&T/H, A.I.D.*
- **Air Pollution,** *Fred Hauchman, OAQPS, EPA*

Technical Session 2:

- **Food Hygiene,** *Stephen Esrey, McGill University*
- **Solid Waste,** *Luis Diaz, Cal Recovery Systems*
- **Vector-Borne Disease Control,** *Robert Lennox, Vector Biology & Control Project*

Technical Session 3:

- **Housing & Shelter,** *Alexi Panehal, APRE/H, A.I.D.*
- **Toxic, Hazardous, & Radiological Waste,** *Allen White, Tellus Institute*
- **Occupational Health & Injury Control,** *Barry Levy, PRITECH Project*

Activities of Other Organizations:

- **Urban Environmental Health Activities of World Bank,** *Carl Bartone, World Bank*

- **Activities of the WHO Environmental Health Commission,** *Dr. Bernard Goldstein, Environmental & Occupational Health Sciences Institute - Panel Chair for WHO Environmental Health Commission*

List of Other Participants

Agency for International Development:

Nancy Pielemeier	A.I.D./S&T/H
Robert Wrin	A.I.D./S&T/H/CD
Dennis Long	A.I.D./S&T/H/CD
Eugene McJunkin	A.I.D./S&T/H/AR
Jim Gallup	A.I.D./S&T/FENR
William Douglas	A.I.D./S&T/RD
Frances Davidson	A.I.D./S&T/N
Gilbert Jackson	A.I.D./PPC/PDPR
Rosalie Norem	A.I.D./PPC/WID
Art Danart	A.I.D./LAC
Carol Dabbs	A.I.D./LAC
Don Foster-Gross	A.I.D./FM/PM/TD

Research Triangle Institute:

Alan Wyatt	Center for International Development
Gene Brantly	Environmental Research Planning Department
John Tomaro	Center for International Development

Other Organizations

Peter West	State Department
Hank De Koning	PAHO
Massee Bateman	WASH

Appendix E.

Data on Environmental Health Problems

Data on Environmental Health Problems	
Water & Sanitation	- Approximately 1 billion people lack safe drinking water and 2 billion lack sanitation (not counting China)
	- The ten principal water related diseases cause 5.5 million deaths per year, and over 28 billion incidence per year.
Wastewater Management:	- Sewerage connections only reach 14% of the urban population in Africa.
	- Surveys of wastewater treatment plants in Mexico and Algeria both showed that over 40% were out of service.
Air Pollution:	- Over 1 billion people live in urban areas where the level of particulate matter exceed the WHO chronic and acute guidelines. 96% of GEMS monitoring stations in Asia exceed the WHO guidelines for average particulate levels.
	- In Mexico City, the highest particulate levels are in the Northeast and Southeast, where the low income groups live.
	- Studies of the burning of biomass fuels inside homes in Nepal shows particulate levels several to ten times the WHO guidelines. WHO estimates about 1 billion people suffer from indoor air pollution.
Food Hygiene:	- Current knowledge indicates that 15 to 70% of cases of diarrhea are food borne.
Solid Waste:	- In many LDC's a large percentage of solid waste remains uncollected - 20% in Bangkok; 30% in Sao Paulo and 78% in Dar Es Salaam.
	- Studies of the health effects of contact with solid waste showed that over 40% of people at dumpsites had gastroenteritis and parasites, 50% had extremity wounds, and 70% with upper respiratory ailments.

Data on Environmental Health Problems	
Vector-Borne Disease Control	- Malaria is responsible for more than 1 million childhood deaths in Africa, primarily in infants. - Dengue hemorrhagic fever (DHF) in Thailand in 1987 resulted in 170,000 cases. The cost of an epidemic in Thailand in 1980 was about $7-10 million.
Housing & Shelter:	- Urban population growth in developing countries is very large - 6% in Africa, which means a doubling in 12 years. - A large portion of urban populations in LDCs live in slums - 50% in Tegucigalpa, 80% in Addis Ababa. - Chagas' disease, which causes heart damage, enlargement of the liver, spleen and lymph glands and can be fatal, is caused by protozoa which live in mud walls and thatch roofs. It infects an estimated 24 million people in Latin America.
Toxic, Hazardous & Radiological Waste:	- While data are limited, current information shows that 4 Sub-Saharan African countries imported over 25,000 tons of hazardous wastes in 1983. - The National Environment Board of Thailand estimates that hazardous waste generation grew 46% from 1986 to 1991, and is expected to grow an additional 84% in the coming 5 years.
Occupational Health and Injury Control:	- WHO estimates that there are 2 million unintentional acute pesticide poisonings among workers per year. - In Thailand, more person-years of life are lost from motor-vehicle injuries than from malaria and tuberculosis combined. - Unintentional injuries are the leading cause of death in Latin America for people aged 1-44 years.

Appendix F.

Work Session Structure (Matrices)

Matrix 1a - Impact of Environmental Problems on Mortality

Purpose: Identify connections between environmental problems and leading causes of mortality.

Ranked Causes of Mortality		Environmental Problem Areas								
Cause of Death	Deaths (1000s/yr)	Water & San.	Waste water	Air Poll.	Food Hyg.	Solid Waste	VBDC	Housing	Toxic Waste	Occup Hlth.
1. Respiratory	10,000									
2. Circulatory	8,000									
3. Diarrhea	4,300									
4. Measles	2,000									
5. Injuries & Accidents	2,000									
6. Neoplasms	2,000									
7. Malaria	1,500									
8. Tetanus	1,200									
9. Tuberculosis	900									
10. Hepatitis B	800									
11. Whooping Cough	600									
12. Typhoid	600									
13. Maternal Mortality	500									
14. Meningitis	350									
15. Schistosomiasis	250-500									
16. Syphilis	200									
17. Amebiasis	70									
18. HIV	50-70									
19. Trypanosomiasis	60									
20. Rhuematic Fever & Heart Disease	52									
21. Hookworm	50									
22. Rabies	35									
23. Diphtheria	30									
24. Dengue	15									
25. Hepatitis A	14									
26. Yellow Fever	9									
27. Jap. B encephalitis	7									
28. Ascariasis	10									

Notes: 1. Matrix can be completed on a local, regional, national or international level, or for different climates, levels of economic development, or geographic settings.

2. Intersections should be filled in with a disease/environmental area association rating L for low, M for moderate, and H for High. Additional information on conditions which aggravate the impact can be added if desired.

Matrix 1b- Impact of Environmental Problems on Morbidity

Purpose: Identify connections between environmental problems and leading causes of morbidity.

Ranked Causes of Morbidity		Environmental Problem Areas								
Disease	Episodes (1000s/yr)	Water & San.	Waste water	Air Poll.	Food Hyg.	Solid Waste	VBDC	Housing	Toxic Waste	Occup Hlth.
1. Diarrhea	28,000,000									
2. Respiratory	15,000,000									
3. Meningitis	1,000,000									
4. Malaria	270,000									
5. Measles	67,000									
6. Whooping Cough	51,000									
7. Amebiasis	40,000									
8. Typhoid	35.000									
9. Schistosomiasis	10,000									
10. Tuberculosis	7,000									
11. Hepatitis A	5,000									
12. Hepatitis B	3,700									
13. Rheumatic Fever & Heart Disease	2,200									
14. Tetanus	1,800									
15. Hookworm	1,500									
16. Trypanosomiasis	1,200									
17. Leprosy	1,000									
18. Leishmaniasis	1,000									
19. Filariasis	1,000									
20. Draculuniasis	1,000									
21. Ascariasis	700									
22. Diphtheria	600									
23. Giardiasis	500									
24. Syphilis	250									
25. Poliomyelitis	220									
26. HIV	140									
27. Yellow Fever	82									
28. Dengue	48									

Notes: 1. Matrix can be completed on a local, regional, national or international level, or for different climates, levels of economic development, or geographic settings.
2. Intersections should be filled in with a disease/environmental area association rating L for low, M for moderate, and H for High. Additional information on conditions which aggravate the impact can be added if desired.

Matrix 2 - Characterization of Environmental Health Risks - Worksheet

Purpose: Identify causes of and key factors which affect environmental health risks

Environmental Problem Area _____ Sheet ___ of ___

Associated Diseases (Morbidity) Associated Diseases (Mortality)

Problem Definition	Geographic Focus	Transmission Route(s)	Direct and Indirect Causes	Personal Behavior which Increases Risk	Other Factors which Increase Risk	High Impact Groups

Note: A sheet of this type would be completed for each environmental problem area, and could be completed for different localities, regions, nations, continents, etc. or different climatic, geographic or economic settings.

Matrix 3 - Environmental Health Interventions - Worksheet

Purpose: Identify potential interventions which address environmental health problems

Environmental Problem Area _____ Sheet __ of __

Problem Definition	Types of Interventions - Institutional Development & HRD & Training - Policy Dialogue and Development - Data Collection, Utilization & Management - Project Design and Evaluation		
	Risk Assessment - Methodological Research - Comparative Risk Assessment - Research/Case Studies	**Risk Reduction/Management** Personal Behavior - Risk Communication / Education - Program Impact Evaluation	Policy & Infrastructure - Infrastructure Investments - Policy & Regulatory Devel. - Project Impact Evaluation

Note: A sheet of this type would be completed for each environmental problem area, and could be completed for different localities, regions, nations, continents, etc. or different climatic, geographic or economic settings.

Characterization of Environmental Health Risks

Environmental Problem Area *AIR POLLUTION* Sheet *1* of *2*

Associated Diseases

RESPIRATORY

Problem Definition	Geographic Focus	Transmission Route(s)	Direct and Indirect Causes	Personal Behavior Which Increases Risk	Other Factors which Increase Risk	High Impact Groups
INDOOR AIR POLLUTION	*DOMESTIC* *(HIGHER RISK IN RURAL AREAS WHERE HOUSE HEATING NEEDED)*	*INHALATION* ** *INGESTION* *DERMAL*	*FIRES FOR:* *-COOKING* *-HEATING* *-LIGHT* *FUEL TYPE* *STOVE TECHNOL.* *LACK OF VENTILA-TION* *TOBACCO* *CROWDING*	*COOKING PRACTICE* *FUEL CHOICE* *HOUSE DESIGN* *TIME SPENT IN HOME* *SMOKING*	*LIMITED CHOICE IN FUEL TYPE* *LIMITED CHOICE IN STOVES* *PASSIVE SMOKING*	*COOKS* *WOMEN* *YOUNG CHILDREN* *ELDERLY*

Environmental Health Interventions

Environmental Problem Area *AIR POLLUTION*

Sheet *1* of *2*

Problem Definition	Types of Interventions - Institutional Development & HRD & Training - Policy Dialogue and Development - Data Collection, Utilization & Management - Project Design and Evaluation		
	Risk Assessment - Methodological Research - Comparative Risk Assessment - Research/Case Studies	**Risk Reduction/Management** Personal Behavior - Risk Communication / Education - Program Impact Evaluation	Policy & Infrastructure - Infrastructure Investments - Policy & Regulatory Devel. - Project Impact Evaluation
DOMESTIC INDOOR AIR POLLUTION	*RESEARCH ON RISK GROUPS* *HEALTH IMPACT STUDIES* *INDOOR PESTICIDE USE: IS IT A RISK?* *RADON: IS IT A RISK?*	*IMPROVED STOVES ** (TEST WILLINGNESS TO PAY)* *CLEAN FUEL* *HOUSE CONSTRUCTION* *ALTERNATE ENERGY SOURCES* *ASSESSMENT OF IMPACT OF INTERVENTIONS*	*DEVELOP A BETTER STOVE* *FUEL POLICY* *GOV'T SUBSIDY OR TAX* *CONSTRUCTION STANDARDS* *HOUSE SITING* *TOBACCO POLICY*

Appendix G.

Evaluation Form & Summary of Workshop Evaluation Responses

AID ENVIRONMENTAL HEALTH WORKSHOP
Workshop Evaluation

Please indicate whether you agree or disagree with the following statements.

1=agree strongly 2=agree 3=neutral 4=disagree 5=disagree strongly

Subject Matter

1 2 3 4 5	The workshop succeeded in identifying environmental problems that have an important effect on public health in AID-assisted countries.
1 2 3 4 5	The workshop succeeded in prioritizing among environmental health problems and identifying those that are the most important.
1 2 3 4 5	The workshop succeeded in identifying potential interventions that will be feasible and effective.
1 2 3 4 5	The workshop succeeded in prioritizing among potential interventions and identifying those that are most needed.
1 2 3 4 5	The workshop succeeded in identifying the most important data gaps.
1 2 3 4 5	The workshop was focused on the correct issues.

Structure of the Workshop

1 2 3 4 5	The lecture on Framework and Example Output prepared me for what to expect in my small work group.
1 2 3 4 5	The material covered in the lectures on Policy, Risk Assessment and Population proved useful to me in the work group sessions.
1 2 3 4 5	The papers introducing each work session were effective in getting my work group focused and started.
1 2 3 4 5	The work group sessions were an effective means of generating ideas and getting participants involved.
1 2 3 4 5	The worksheets used in the work groups were an effective way to organize the issues and elicit ideas from the group.
1 2 3 4 5	The presentations and discussion of initiatives by other organizations was valuable to me.
1 2 3 4 5	The final discussion was effective in synthesizing and prioritizing the output of the work group sessions.

Personal Reactions

1 2 3 4 5	I feel that environmental problems have an important effect on public health in AID-assisted countries.
1 2 3 4 5	The workshop helped me understand the effects that environmental problems have on public health.
1 2 3 4 5	Participating in the workshop changed my mind regarding the effect environmental problems have on public health.
1 2 3 4 5	I feel that the presentations and plenary discussions were efficient and stayed on track.
1 2 3 4 5	I felt comfortable and productive in the small work groups.
1 2 3 4 5	I feel that the last two days have been a valuable use of my time.
1 2 3 4 5	I am tired.
1 2 3 4 5	The workshop demanded too much from participants.

Please elaborate on any of your answers to the questions above that you feel need to be explained.

Should we have confidence in the output of the workshop? If not, why?

What should we have done differently?

You may sign this evaluation if you care to: _____

ENVIRONMENTAL HEALTH WORKSHOP EVALUATION

	1=Agree Strongly	2=Agree	3=Neutral	4=Disagree	5=Disagree Strongly	No Comment	Mean
SUBJECT MATTER							
The workshop succeeded in identifying environmental problems that have an important effect on public health in AID-assisted countries.	11	2					1.2
The workshop succeeded in prioritizing among environmental health problems and identifying those that are the most important.	1	5	7				2.5
The workshop succeeded in identifying potential interventions that will be feasible and effective.	1	7	4	1			2.4
The workshop succeeded in prioritizing among potential interventions and identifying those that are most needed.	1	3	5	3	1		3.0
The workshop succeeded in identifying the most important data gaps.	1	6	4	2			2.5
The workshop was focused on the correct issues.	7	6					1.5
STRUCTURE OF THE WORKSHOP							
The lecture on Framework and Example Output prepared me for what to expect in my small work group.	4	7	1			1	1.8
The material covered in the lectures on Policy, Risk Assessment and Population proved useful to me in the work group sessions.	5	5	1	2			2.0
The papers introducing each work session were effective in getting my work group focused and started.	8	4			1		1.6
The work group sessions were an effective means of generating ideas and getting participants involved.	6	6	1				1.6
The worksheets used in the work groups were an effective way to organize the issues and elicit ideas from the group.	3	6	2	2			2.2
The presentations and discussion of initiatives by other organizations was valuable to me.	7	4	2				1.6
The final discussion was effective in synthesizing and prioritizing the output of the work group sessions.	4	7	1	1			1.9

ENVIRONMENTAL HEALTH WORKSHOP EVALUATION

	1=Agree Strongly	2=Agree	3=Neutral	4=Disagree	5=Disagree Strongly	No Comment	Mean
PERSONAL REACTIONS							
I feel that environmental problems have an important effect on public health in AID-assisted countries.	12	1					1.1
The workshop helped me understand the effects that environmental problems have on public health.	10	2	1				1.3
Participating in the workshop changed my mind regarding the effect environmental problems have on public health.	1	3	4	5			3.0
I feel that the presentations and plenary discussions were efficient and stayed on track.	6	7					1.5
I felt comfortable and productive in the small work groups.	7	3	2			1	1.6
I feel that the last two days have been a valuable use of my time.	11	2					1.2
I am tired.	4	5	2	1	1		2.2
The workshop demanded too much from participants.		2	4	3	4		3.7

Should we have confidence in the output of the workshop? Yes=8 No=0 No Comment=3 Conditional=2

Appendix H.

Workshop Participant Opinion on Environmental Health Priorities

Workshop Participant Opinion on Environmental Health Priorities

The paragraphs below record rationales offered by participants in plenary discussion. Two points of view are presented here (must do more/need not do more), irrespective of the number of people that expressed these views. The tabulation in Figure 2 in the main text shows the number of people expressing these viewpoints.

Water Supply and Sanitation

Must do more: because potable water supply is still a problem, and its availability is related to many of the other categories of environmental health problems.

Need not do more: because the problem is being addressed; the present effort should be continued but does not need to be increased.

Wastewater Management

Must do more: because the problem with industrial wastewater is increasing, and because it is linked with other problem areas including solid waste management, hazardous waste and occupational health. Residential wastewater management also needs more attention.

Need not do more: because the problem is being addressed and other areas that are not being addressed have as great an impact on environmental health.

Air Pollution

Must address the problem: because indoor air quality has a major impact on public health; and because the problem is related to other environmental problems and A.I.D. initiatives, for example, population growth, global warming, deforestation, and acute respiratory infection.

Need not address the problem: because ambient air pollution is a problem in developing countries with more industrial economies, and A.I.D. focuses its efforts on less developed countries. Clean air is not a "basic service" of the type addressed in current A.I.D. health projects.

Food Hygiene

Must address the problem: because it has a major impact on public health; because food contamination is caused by other environmental problems (wastewater management); and because no one else is addressing food hygiene.

Need not address the problem: because it requires a different type of program and expertise than the other environmental problems and it is sufficiently important that it should be addressed on its own, rather than in the context of an environmental health strategy.

Solid Waste

Must do more: because the problem is growing rapidly, especially in urban areas; because handling solid waste is a "basic service"; and because solid waste management is a source of employment and private sector economic activity.

Need not address the problem: no rationale offered; all participants felt that A.I.D. must address this topic.

Vector-Borne Disease

Must do more: Because the interventions required to control vector-borne disease are mostly "environmental," VEDC should be thought of as an environmental initiative, not just as a health initiative. The environmental health strategy should take VBDC into account and ensure that actions are coordinated.

Need not do more: no rationale offered.

Housing and Shelter

Must do more: because improving housing directly improves quality of life and adequate housing is a basic service; also, because improving housing is a way of integrating a range of environmental interventions (indoor air quality, water supply and sanitation, residential wastewater management, solid waste management). Improving housing is related to "service extension."

Need not do more: because the A.I.D.'s existing program is effective; an environmental initiative should proceed with strong links to the housing program, but not duplicate or augment its efforts.

Toxic, Radiological and Hazardous Wastes and Materials

Must address the problem: because the problem is just beginning and early intervention will prevent its worst effects; and because managing such wastes prevents water pollution. Also, the problem is caused by development and imports, and A.I.D. has an obligation to address the environmental effects of U.S. development policies. The most important intervention at this time may be collecting information to better understand the problem.

Need not address the problem: no rationale offered; all participants felt A.I.D. must address this topic.

Occupational Health and Injury Control

Must address the problem: because the problem is widespread and morbidity in working population has a large effect on productivity; because the problem is caused by development and urbanization; because the problem can be prevented; and because the mechanisms for intervention promote institutional development and democracy.

Need not address the problem: because it is not an "environmental" problem and because it does not have a strong relation to child survival, a key A.I.D. focus.

Appendix I.

Background Papers

POLICY AND REGULATORY OPTIONS AND IMPLICATIONS

Richard N. L. Andrews*

Environmental health policies and regulatory options have two fundamental purposes. The first is to prevent or reduce direct risks to the health of human populations that are caused by environmental exposures: exposures to disease vectors and biological agents, to toxic chemicals and radiation, or to physically unsafe environmental conditions. The second purpose is to protect and sustain the environmental conditions that permit human populations to live healthy lives, such as food, potable water, shelter, heat, and other necessary resources and services. In both cases, the proper criterion, to the extent that it can be determined, is *relative risk*: that is,

- which environmental hazards present the most significant risks to human health? and

- which policy and regulatory options will bring about the greatest *reduction* of these risks?

Recent statements from USAID itself suggest three important considerations in developing answers to these questions.

First, they reflect an increasingly explicit recognition that environmental and natural resource degradation impose severe constraints on the economic prospects of developing countries as well as on the health and well-being of their citizens, and that these effects are too serious to continue to be treated as unfortunate but necessary side effects of development.

Second, they conclude that such degradation is most often driven not merely by ignorance, lack of resources, or ad hoc political obstacles, but by two overarching causal forces, *policy failures* and *market failures*.

Third, the recognition of the importance of these factors has led to a reduction in AID emphasis on field projects, and increased emphasis on broader policy options in the areas of economic policy reform, market liberalization, and most recently, promotion of democratization (USAID, 1991).

Background

The field of public health throughout its history has been concerned not only with providing health services per se, but with providing the conditions necessary to the health of human populations in a broader sense, including for instance nutrition, shelter, warmth, sanitation, and protection from exposure to hazardous materials. It has also been concerned with health as more than a matter of mere survival, but as including amenities as well as both material and spiritual aspirations.

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The public health professions of the 19th century achieved great improvements in providing basic sanitation and health services to the urban populations of the then-industrializing western nations; and in the 20th century, they have achieved even more dramatic successes in increasing life expectancy, first in the industrial nations and eventually worldwide, through the prevention and treatment of communicable diseases. They have also made important contributions worldwide to improving levels of personal hygiene, health education, and health services.

Changes now occurring in the global environment, however, have profound implications for the field of public health. These include, in particular:

- *Global-scale forces of environmental change*, including among others human population growth, world food supplies, energy resource utilization, and changes in the earth's climate.

- *Regional- and community-scale forces*, including for instance the degradation of ecosystems, the growth of mega-cities and industrial complexes, and increased demands for water utilization and waste management.

- *Changing patterns of exposure to environmental health risks*, such as agricultural versus industrial, ambient versus indoor, and acute versus chronic.

- *Changing behavior patterns involving environmental health risks*, such as smoking, sunbathing, and use of toxic consumer products, as well as more general behavioral causes of environmental problems.

Over the next 50 years, the great public health successes of the 19th and 20th centuries may well be overwhelmed by two new and increasingly powerful forces:

- the *public health needs* of a rapidly expanding and increasingly urbanized world population, living in environmental conditions that are less and less able to provide acceptable levels of health and welfare; and

- the *increased exposure* of human populations to health hazards resulting from environmental contamination by poisons and waste products from human activities.

The public health agenda of the future, therefore, must include sustaining the environmental conditions that are necessary to public health, not merely providing health services to existing populations. It must also address these conditions at a global scale, not merely their localized symptoms. Some of these threats can be addressed at the level of personal choice, but many of the root causes must also be challenged at the level of national and global forces, such as international trade, financial institututions, and government policies.

Human Causes of Environmental Health Risks

Both direct environmental health threats and non-sustainable pressures on environmental conditions can be interpreted as resulting from three sorts of human causes:

- *failures of economic markets* to place appropriate values on the full costs of degradation of human health and its environmental requisites;
- *failures of human behavior outside of markets* to reflect such values; and
- *failures of public policies* to correct these mis-valuations.

These failures typically take one or more of the following forms:

1. *Undervaluation of human health effects or of environmental processes.* This occurs in governmental as well as market and nonmarket decisions: for instance environmental benefits and costs which are not considered in policy decisions, or whose value is underestimated, or whose future values are inappropriately discounted, or whose true values to the society over time are greater than the values reflected in the preferences of political decisionmakers today. Such policy failures frequently take the form not only of specific policy failures but of whole world-views -- culturally shaped beliefs, attitudes, and resulting preferences -- that are inconsistent with the observable values of environmental conditions and resources to the present and future welfare of the society.

2. *Under- or over-correction of market failures*, such as policies that are simply ineffective in achieving their intended results, or that introduce more rigid restrictions than are necessary to protect health and environmental conditions.

3. *Introduction of new and undesireable market distortions* by the policies chosen, as for instance when a waste disposal tipping charge causes an increase in unsafe informal dumping rather than an increase in waste reduction or safe management.

4. *Cross-sectoral or jurisdictional externalities*, as for instance when a policy undertaken for one public purpose, or by one jurisdiction or level of government, causes adverse side effects on another (for instance the effects of agricultural or highway subsidies on environmental degradation, or of one jurisdiction's deforestation on its neighbor's water supply, or of national policies on local common property management regimes).

5. *Collective choice process failures*, resulting in policies which, regardless of their apparent merits, fail to achieve public and political legitimacy: for instance policies benefitting vested interests at the expense of the general good, and authoritarian policies imposed without negotiating their fairness on less powerful segments of the society.

Policy and Regulatory Options

Environmental policy in the United States -- *and* in the large number of other nations who have modelled their environmental policies on ours -- has been dominated for two decades by the implementation of broad national regulatory statutes. This emphasis has had only mixed success in preventing and cleaning up environmental damage. It has also diverted substantial scientific effort into justifying standards rather than investigating their environmental effects; and it has largely ignored the possibility of alternative and more effective policy solutions. The research program of the Environmental Protection Agency, for instance, has been devoted almost exclusively to natural science and engineering questions in support of current regulatory mandates,

not toward emerging environmental problems or alternative policy strategies and management approaches.

Recent reports from both EPA and the National Academy of Sciences have now signalled a national shift in environmental policy emphasis (USEPA, 1990). This shift includes major new emphasis on

. risk-based priorities;

. integrated management of hazards across all media;

. reduction of pollutants at their sources; and

. the use of a far broader range of policy tools to achieve these purposes.

International and global concerns -- over the magnitude and rate of global environmental changes, the rapid introduction of new and more stringent environmental policies in central and eastern Europe as well as the European Community, and calls for environmentally sustainable development patterns, for example -- all add further emphasis to this reassessment of ends and means.

Instruments of government action. A recent major report by the USEPA Science Advisory Board identified 6 primary types of policy tools that can be used by governments to prevent or reduce environmental health risks (USEPA, 1990). These include:

- *Scientific and technical measures* (e.g. research and development, and innovation in both pollution prevention approaches and control technologies).

- *Provision of information* (e.g. labelling and disclosure requirements, technical assistance, and provision of consumer information).

- *Market incentives* (e.g. pollution charges, marketable permits, deposit-refund systems, removal of market barriers, and revision of legal standards of liability).

- *Conventional regulations* (e.g. performance and design standards, use restrictions, and product specifications).

- *Enforcement* (including innovative approaches, such as statistically based compliance monitoring and incentive-based penalties).

- *Cooperation with other government agencies and nations.*

More generally, governments have four broad classes of policy instruments available to them (O'Hare, 1989):

- *Trade* (produce or purchase public services)
- *Transfer* (charge fees or taxes, or subsidize)
- *Regulation* (require or prohibit actions)
- *Knowledge* (inform/educate or persuade)

Consider for example the environmental policy issue of solid waste management. Using the instruments of trade, government can either provide a public

service itself (waste collection, recycling, treatment and disposal, etc.) or contract with a private firm to provide it (buy). Using economic instruments (transfers), it can either tax or charge people for what they throw away, or offer them monetary incentives (subsidies) for recycling. Using regulatory instruments, government can either prohibit or require particular behavior: for instance prohibit landfilling of recyclable materials, or require homeowners and businesses to separate them before collection. Finally, using the instruments of knowledge, government can either inform people, in the expectation that appropriate information will influence their behavior; or it can implore them, with leadership and persuasion and normative claims about community standards of behavior ("good citizens recycle").

There are of course many variants of these basic types of instruments, each of which may have different effects and effectiveness. Direct government services, for example, include a wide range of activities, from the construction of dams and highways and buildings to the management of public lands and parks, and even the operation of major industrial facilities as government enterprises, with all the direct physical interventions in the environment that such activities involve: controlling the flows of rivers, planting and cutting trees, spraying pesticides, building roads and facilities, and operating motor vehicles and incinerators and landfills. Government purchases include not just contracting out for garbage collection, but a myriad of procurement decisions which may either expand or constrain the markets for environmentally beneficial technologies -- recycled materials, for example, or solar water heaters.

Similarly, tax and subsidy instruments come in many forms and magnitudes, from direct charges and payments to accounting and liability rules and tax relief and deposit-refund systems, and from general taxes on everyone to levies specifically on producers or users. Regulatory instruments may be framed in many ways -- ambient or effluent standards, technology- or performance-based, reporting and labelling and information disclosure requirements, outright bans or conditional permits, and so on; and even knowledge instruments can range from mere factual publicity or public-service advertising campaigns to labelling and certification of products (hazardous, recyclable, energy efficiency, etc.), research, and data collection and monitoring of many kinds.

Not only these different types of instruments, but the individual instruments themselves (and most often, combinations of them) will have different effects and degrees of effectiveness when applied to different environmental policy problems in different circumstances. A second primary task for environmental policy analysis, therefore, is to evaluate how well these instruments work and what other effects they have, in order both to correct ineffective or perverse policies, and to recommend the most effective strategies for similar circumstances and problems elsewhere.

An extraordinary variety of environmental policy innovations has already begun to emerge. Many of these have been initiated by state and local governments, some by other nations and through international agreements, some even as unexpected consequences of U.S. policies. Examples include

- many types of economic incentives (earmarked taxes and user fees, deposit-refund and recycling credit systems, disposal charges and pre-disposal product fees, pricing preferences for recycled materials, and changes in financial liability principles, among others);

- information and education requirements (labelling of toxic, recycled, recyclable, and "environmentally friendly" products, environmental audit requirements, and "right-to-know" laws mandating disclosure of use and emissions of toxic chemicals, for instance);

- changes in public services (for instance solid waste recycling programs, public hazardous waste management facilities, privatization of waste management services, and others);

- proposals for changes in *macro*economic policies, such as in the basis for valuing environmental conditions and resources in national income accounts;

- and even many changes in regulatory instruments themselves (such as restrictions on product content or disposal of particular materials, waste separation and recycling requirements, and ambitious state strategies for shifting from landfilling and incineration towards waste reduction and recycling).

- Equally important innovations are occurring in the processes for developing environmental policies, such as negotiated decisionmaking and dispute resolution, joint fact-finding, and siting and policy dialogue processes.

As these innovations are introduced, it has become urgently important to compare and evaluate how they work and what they accomplish.

- What programs and policy incentives, for instance, actually do reduce risks to environmental processes and human health, and how much? Waste disposal fees, for instance, may promote either waste reduction and recycling or surreptitious dumping and burning.

- Is it more effective to introduce new policy incentives, or to eliminate perverse incentives in existing policies (for example, subsidizing recycling versus eliminating subsidies for extraction of virgin materials)?

- Which policies best combine environmental protection with other important values, such as economic development, equity and social justice, and political and economic freedom?

- Which localized solutions also help to solve global problems, and which may exacerbate them? And what problems arise in transferring policy innovations from one situation or level of government to another?

Regrettably, there has been little support to date for research on these fundamental questions of environmental policy innovations and effects.

Equally important is the challenge of actually *proposing and trying out* new policy innovations to address important environmental risks. Suppose, for example, that a state or a corporation were to broaden its management accounting procedures to include more fully the values of its environmental resources and the costs of waste disposal? Or that a community were to institute an economic development planning process, based explicitly on public environmental education and cooperative planning by citizens and businesses, to improve its environmental conditions as well as the welfare of its residents? Or that a coalition of business and environmental groups were to sponsor an "environmental Peace Corps" to restore degraded environments? Or any of a myriad more specific changes that could be imagined in information flows,

economic incentives, regulations, and decision processes to improve the environmental consequences of public policies. The 1990s will be an especially promising time not only for assessing existing policy innovations but for trying out new ones, in cooperation with both governments and citizen and business groups, and sharing the results with others.

Levels of Jurisdiction. Second, government can organize the use of these instruments at various levels of jurisdiction: international, national, state, or local, or at "regional" scales between these levels. In the estimate of one scholar, over 90% of all environmental policy today is a matter of intergovernmental relations, meaning the attempt to achieve coordinated and consistent policy purposes among these various levels of jurisdiction (and of course among adjoining jurisdictions at the same level, such as towns, states, and nations).

Many pollution control statutes and programs existed long before 1970, for example, but with few exceptions they were state rather than national policies: one of the fundamental policy changes of the 1970s was to create a national framework of policy approaches and minimum standards for environmental protection. Did this change the policy outcomes? Of course, and in many ways, some intended and some inadvertent. Were the results better or worse? In some respects both, depending on one's criteria, but in any case one task of environmental policy analysis is to document the effects from which one could draw such conclusions. Should authority over the siting of hazardous waste facilities be left to traditional local prerogatives, or should such authority be preempted by federal or state government? Should the nations of the European Economic Commuity have uniform environmental regulatory approaches and standards (and if so, how restrictive), or should they be allowed to continue their current diversity? Again the normative answers depend on one's criteria, but the decisions represent deliberate environmental policy choices leading to different outcomes.

Agencies and Missions. Third, at any given level of government jurisdiction, governments can organize the use of these instruments by different agencies pursuing differently defined missions, or even by differently structured agencies to pursue new missions; and these choices too are important and deliberate policy decisions whose consequences include substantive differences in health and environmental results. This point has several distinct nuances, each of which is important.

The first of these nuances is that environmental policy involves the behavior of many agencies, not just the official environmental ministry or agency. Public policies are not defined merely by the missions of particular agencies that wear the policy's label, nor even by those that share a particular set of policy values regardless of label. Many other agencies' policies may in fact have far greater impact on health and health-related environmental conditions than those of the environmental ministry or agency itself: examples include policies that encourage large-scale urban and industrial settlement, technology- and chemical-intensive farming, and others.

A corollary is that many of the most important instruments for environmental health protection policy are to be found not in creating *new* environmental regulatory or subsidy programs, but merely in the *redirection of archaic and perverse existing* policies pursued by other agencies (and sometimes, of course, by the environmental agency itself). To create new environmental policies merely to counteract continuing old ones is both fruitless and wasteful -- like stepping on the brakes while continuing to floor the accelerator.

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Third, any type of policy pervasively overlaps other policies, which are defined by other agencies and political constituencies and involve their own important concerns and issues. Air pollution policy is a matter not only of environmental health policy, but simultaneously of energy and transportation and industrial policy and perhaps others -- and depending on what instruments are proposed, of tax and budget and law enforcement policy as well. If one proposes a stiff tax on fossil fuels to encourage energy conservation and thus reduce air pollution, for example, what would its effects be not merely on air quality and the self-interest of the energy industry, but on the poor, and what compensating policies would be necessary to protect them? And what would be done with the resulting revenues? Environmental policy cannot be understood or pursued in a vacuum, or as an isolated agency or technical sector managed by environmental scientists and engineers alone.

Summary. In summary, therefore, environmental policy includes all purposeful government actions affecting environmental conditions; and the patterns in which these purposes are defined and allocated among agencies, the instruments as well as the resources they are given with which to execute them, the organizational structures of the agencies themselves, and the relationships between environmental purposes and other important considerations of public policy, are all centrally important aspects of environmental policy.

Environmental Health Policy Research Needs

In addition to the analysis and refinement of environmental health policies in practice, there is also a serious need for more systematic research on environmental health policy, to obtain more precise understanding both of the human causes of environmental health hazards and of the effectiveness of alternative policy strategies in preventing and reducing them.

Human causes of environmental health hazards. The traditional emphasis of the environmental science and engineering professions has been on technological causes of pollution, particularly industrial production processes and urban wastewater outflows. In the public health professions, the emphasis has been on biological and chemical agents (germs, microbes, bacteria, viruses, toxic chemicals) and on individual behavior (smoking, exercise, nutrition, sunbathing, sexual contacts, compliance with prescriptions, etc.). In fact, however, both technologies and behavior are important causes of environmental health hazards. To paraphrase the National Rifle Association, "Technologies don't cause pollution -- people cause pollution."

Other fundamental causal factors are often neglected by both traditions, particularly economic and political structures that encourage some technologies and behavior patterns and discourage or prevent others (Tesh, 1981, 1988). Changes in particular technologies or individual behavior alone may have no appreciable effect on global environmental trends unless the underlying political and economic causes are also addressed. Chlorofluorocarbons banned from aerosol use, for instance, have simply been redirected into other markets, and if banned entirely may be replaced by chemicals with equally serious though different hazards.

A key task for environmental health policy research, therefore, will be more active collaboration among the traditional public health and environmental professions and applied social scientists who can bring additional perspectives on causes and potential solutions.

Effective Instruments. Far more research is needed on effective strategies and instruments for achieving environmental and public health purposes. Systematic comparisons are needed across policies and national contexts, to determine what broader conclusions can be drawn about the relative effectiveness and transferability of policy instruments and institutional arrangements for environmental policy reform.

A wide range of such instruments is available for consideration: research and technological development themselves, information and persuasion, many sorts of economic incentives and regulatory tools, public services, and modification of the basic rights, duties, and opportunities of economic organizations, to name just a few -- not to mention the mere removal of existing disincentives, enacted for other purposes and often in other sectors, but now perverse in their effects on environmental, public health, and even economic purposes (USEPA, 1990).

Research is needed to document both the effectiveness of such instruments in achieving their intended purposes, and other effects -- fortuitous or unexpectedly adverse -- that they have also had in practice. Substantial bodies of relevant research do in fact exist on some of these instruments, but they are not yet well integrated. Important gaps and inadequacies also remain, especially at the level of global forces and patterns.

Methodological refinement. A significant increase in empirical work is needed, both to apply and validate theoretical principles for analysis of environmental health policy options (especially in settings applicable to developing countries), to refine methodologies for environmental policy analysis in real applications, and most important, to document the effects of environmental policy reform strategies in those situations where they have been introduced.

Examples of Research Needs

A few examples of particular areas of research need may be useful.

Environmental valuation has been the subject of considerable research in developed countries, but mainly from the perspective merely of current individual preferences and estimation of associated willingness-to-pay, option demand, etc. Recent work has only begun to characterize other real values of ecological processes -- which if sustained may continue to provide important services indefinitely but which if degraded would require expensive capital and operating costs to replace them -- and to propose methods for integrating more accurate estimates of such values into economic measures such as national income accounts. State of the art research is needed to extend this work and apply it to national policymaking in developing countries, through collaboration between economists and experts in environmental health, ecology and related environmental sciences.

Policy determinants of environmental behavior. A widespread assumption, implicit in virtually all proposals for public policy measures, is that human behavior patterns which cause environmental degradation are strongly influenced by government policies. Key questions for research, however, include better understanding of *how influential government policies are* in these patterns, compared to other determinants such as market forces, cultural norms and beliefs, and structural forces such as population pressures; and *which* policies are most influential, including for instance both microeconomic and macroeconomic incentives, regulatory measures and public services, information and disclosure requirements, and particular forms of each. This

This research can best be accomplished by comparative studies across selected developing countries, conducted by interdisciplinary collaboration among researchers in public policy, economics, anthropology, and the environmental sciences.

Comparative analysis of policy instruments. A growing research literature addresses the comparative effectiveness of different types of policy instruments for achieving increased environmental protection: for instance regulatory regimes and enforcement strategies, economic incentives, and information and disclosure requirements. Much of this literature to date, however, remains limited to advocacy of market incentives over command-and-control regulatory policies on theoretical grounds. But which ones really work, and how well, and with what side effects of their own? Do waste disposal charges encourage waste reduction and more efficient management, or merely illegal and unsafe dumping? Do pollution taxes influence pollution behavior, or simply increase government revenues? Key research needs include more empirical work on the actual effects of such policies, comparisons of different forms of them and at different intensities of application (e.g. price elasticities and impacts of varied levels of charges, etc.), and in particular, comparative evaluation of the effects of such policies where they exist in developing countries.

Institutional barriers. Many of the most influential environmental policies, both positive and negative, are made through institutions other than those whose primary mission is environmental protection and sustainable development: particularly for instance ministries of finance, economic planning, agriculture, and transportation, and international lending institutions. In addition, some of the most effective institutions for promoting sustainable development and environmental protection often appear to lie outside government entirely, such as in some leading businesses and non-governmental environmental groups. Key research needs include comparative empirical studies of effective environmental management institutions in developing countries, and of institutional mechanisms for incorporating sustainability and environmental health protection into the policies of those institutions whose policies in fact most strongly influence environmental conditions.

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U. S. AID ENVIRONMENTAL HEALTH WORKSHOP
DRAFT BACKGROUND PAPER
THE ROLE AND METHODOLOGY OF RISK ASSESSMENT

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INTRODUCTION

Environmental health has been defined to encompass those diseases and health problems that are environmentally determined and are increased through environmental degradation (Long, 1990). Such a broad definintion would include health risk from both natural and man-made sources. Examples of environmental health risk from natural sources include death and injury from floods, hurricanes and other natural disasters; skin cancer due to over exposure to the sun's rays; and death and hypothermia attributable to extreme ambient temperatures. Although the sources of each of these health risks are natural, the risks themselves may be mitigated through human interventions such as land use planning that protects human settlements from floods, modification of behavior that leads to overexposure to the sun, and adequate housing and heating for protection against extreme temperatures. Environmental health risks from man-made causes include death and disease associated with exposure to toxic substances such as chemicals and infectious microorganisms in polluted water and air; solid, hazardous and radiological waste; occupational settings; and contaminated food. Each of these man-made environmental health risks are the result of many different factors including individual behavior patterns, market systems, and government intervention strategies. The availability of information and complexity of issues involved in managing or mitigating these environmental health risk in both developed and less developed countries (LDC) has resulted in an overloaded agenda for environmental managers. Not only are there many environmental problems to address, but there are limited resources to address any single problem. Thus, managers are faced with a need to identify and prioritize environmental issues and to understand the likely outcomes of various risk reduction strategies.

In the United States (U.S.) risk management has emerged as a principal analytic activity for environmental managers. The U.S. Environmental Protection Agency (EPA) and other Federal

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agencies have been in the forefront of developing risk assessment methodologies that provide a mechanism for incorporating scientific evidence and scientific judgement into the decision-making process. There are four main uses of risk assessments which might provide input to risk management decisions:

1. To estimate an acceptable ambient concentration for a specific chemical or toxic substance that will be protective of human health and the environment (e.g. ambient air standard for lead);

2. To estimate the human health and/or environmental effects associated with current ambient concentrations of particular substances (e.g. number of cases of gastrointestinal illness attributed to the presence of fecal coliform bacteria in the water supply);

3. To estimate the human health and/or environmental effects associated with releases of one or more toxic substances from one or more sources (e.g. cancer cases associated with drinking water contaminated with toxic chemicals from nearby industries); and

4. To compare estimated risks from specific substances or sources in order to set priorities for regulatory actions or motivation for source mitigation.

The extent of the risk analysis needed will vary depending on the decision context. For example, a comparative risk analysis being conducted in order to set priorities and allocate resources will require a less rigorous analysis than a risk analysis being conducted in support of a regulatory action. The decision context, in large part, determines the methodological approach for the analysis.

The focus of this paper is to present an overview of the risk assessment methodology as applied to environmental health risk, to review current activities and knowledege in developing countries, provide an overview of U.S. capabilities and methodological experience, and present some potential linkages between risk assessment, policy and regulatory development, and project-type interventions.

OVERVIEW OF THE RISK ASSESSMENT PROCESS

Risk assessment is defined as the overall procedure by which potential adverse health effects of human exposure to toxic agents are characterized. It includes the following four

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components: hazard identification, exposure assessment, dose-response assessment, and risk characterization (U.S. EPA, 1986; National Research Council, 1983). Figure 1 shows these components of risk assessment in relation to each other. Each of these components is further described below.

HAZARD IDENTIFICATION

Hazard identification is a qualitative determination of whether human exposure to an agent has the potential to produce adverse health 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

Clearly, the most direct evidence for hazard identification comes from human studies. However, 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, 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.

The results of any hazard identification should include a summary of all key findings of the qualitative assessment and the rationale that forms the basis for the conclusion reached. All assumptions, uncertainties in the evidence, and other factors that may affect the relevance of evidence to humans should be presented. The U.S. EPA has developed a classification system based on the weight of the underlying evidence for carcinogenicity and reproductive toxicity. As

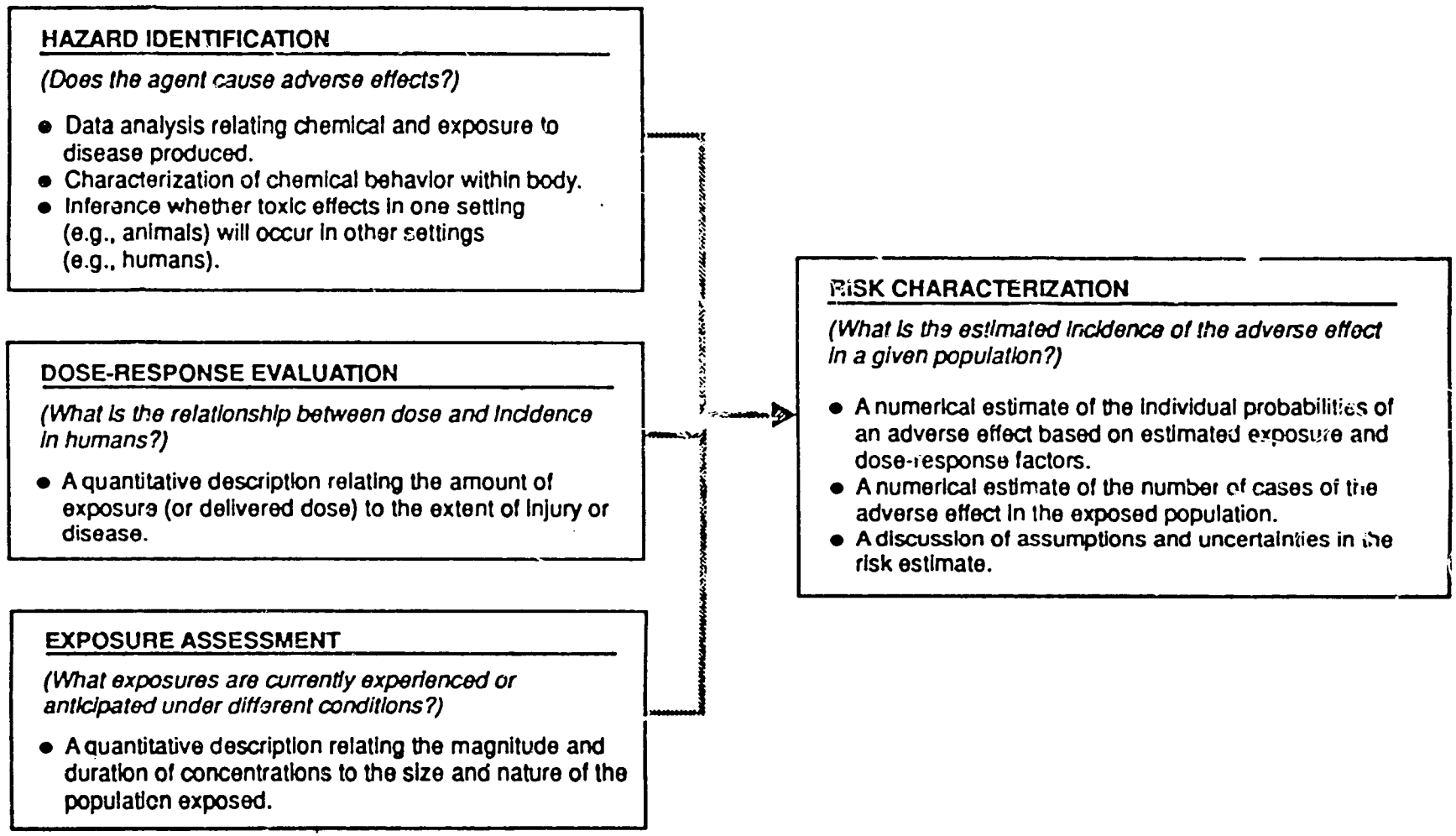

Figure 1. Traditional components of risk assessment (from Naugle et al., 1990)

an example, within the weight-of-evidence system for carcinogenicity agents are categorized into six groups:

- Group A - Human Carcinogen (sufficient human evidence)
- Group B1 - Probable Human Carcinogen (limited human evidence)
- Group B2 - Probable Human Carcinogen (sufficient animal evidence; inadequate or no human evidence)
- Group C - Possible Human Carcinogen (limited animal evidence; inadequate or no human evidence)
- Group D - Not Classifiable as to Human Carcinogenicity (inadequate or no human and animal evidence)
- Group E - Evidence of Noncarcinogenicity for Humans (no evidence for carcinogenicity in at least two animal tests in different species or in both adequate epidemiologic and animal studies)

The hazard identification summary should include a weight-of-evidence categorization and a discussion of the nuances of the evidence that may not be evident from the classification.

EXPOSURE ASSESSMENT

Exposure assessment involves the characterization of the nature and site of various populations exposed to a toxic agent, and the quantitative estimation of the level and duration of their exposures. Current methods of exposure assessment are primarily medium- or route-specific, so that at present there is no single approach that is appropriate for all cases. Appropriate methods must be selected on a case-by-case basis, depending on the available data and the level of sophistication required.

In general, exposure assessment consists of four steps:

1. Determination of environmental concentrations
2. Estimation of the magnitude, duration and frequency of human exposure;
3. Estimation of dose received, usually expressed as Maximum Daily Dose for acute, subchronic or chronic exposures to noncarcinogens, or as Lifetime Average Daily Dose for carcinogens; and

4. Characterization of exposed populations and individuals (e.g., by magnitude of dose received, age, sex, health status, time in life of exposure, other concurrent exposures) and identification of subpopulations with heightened sensitivity.

Ideally, independent exposure assessments are performed for each potential route of exposure (i.e., inhalation, ingestion, dermal absorption) within each identified population subgroup. These independent exposure assessments can then be aggregated over the different routes of exposure to estimate the overall exposure for each subpopulation. However, methods for aggregating exposures across different routes have not been standardized. A complete exposure assessment also should include a summary of all underlying assumptions and approximations, and a quantitative estimate of the level of uncertainty associated with the assessment.

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 most 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 data sets should be presented. The U.S. EPA Risk Assessment Guidelines (1986) 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.

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The use of animal data to estimate risks from human exposure requires at least two major extrapolations: (1) interspecies dose extrapolation to adjust for differences between humans and laboratory animals in factors that may potentially affect the response to the toxic agent (e.g., site, genetic variability, life span, population homogeneity, exposure regimen, and pharmacokinetic effects such as absorption, metabolism, and excretion patterns); 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. In addition, where the exposure route in the animal studies from which the dose-response information is obtained differs from the exposure route occurring in human exposures, a route-to-route extrapolation is required. Although methodologies have been developed for route-to-route extrapolations, often the data needed to apply these methodologies are not available and thus various simplifying assumptions must be made. All assumptions used in making these extrapolations must be consistent with existing metabolic and pharmacokinetic information. These assumptions should be clearly stated and presented with estimates of the uncertainties in the extrapolation and in the overall dose-response assessment.

RISK CHARACTERIZATION

Risk characterization is the quantitative estimation of human health risk due to exposure to harmful substances or organisms. This characterization requires that each of the first three components of the risk assessment process be evaluated in the most rigorous and scientifically defensible way, with all assumptions and uncertainties clearly documented in order to obtain the most reliable quantitative estimates of human health risk.

Numerical risk estimates of human health effects are typically presented either in terms of excess individual lifetime or annual risks, or excess risk in an exposed population in a given time period, or both. Other forms of expressing numerical risk estimates include relative risk, standardized mortality ratio and loss of life expectancy (Cohrssen and Covello, 1989). Figure 2 presents simplified equations to illustrate the differences in each of the various risk characterization measures.

Characterization of risk often depends on the data available and the way the analyst collects and organizes these data. The more common risk characterization estimates require a two-step

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Individual lifetime risk	=	Dose x Potency[a]
Population risk[b]	=	Individual lifetime risk x Population exposed
Relative risk	=	$\frac{\text{Incidence rate in exposed group}}{\text{Incidence rate in nonexposed group}}$
Standardized mortality or morbidity ratio	=	$\frac{\text{Incidence rate in exposed group}}{\text{Incidence rate in general population}}$
Loss of life expectancy	=	Individual lifetime risk x 36 years (avg. remaining lifetime)

[a] For substances with a threshold for exposure, potency of the substance is zero below the threshold. For substances with no threshold, a linear dose-response relationship is assumed.
[b] Population risk is the number of individuals adversely affected as a result of lifetime exposure to the substance.

Figure 2. Risk characterization measures (adapted from Cohrssen and Covello, 1989).

procedure whereby a single point estimate is calculated for individual lifetime risk for an exposed population and point estimates aggregated across all exposed populations to get a population risk. Uncertainty in estimates of both individual lifetime risk and population risk should be addressed either qualitatively or quantitatively.

The existing methods for risk characterization are far from ideal, largely because of data limitations and incomplete knowledge of the biological mechanisms of action of toxic agents on the human body. There are four major sources of uncertainty in estimating point risks of adverse health effects:

1. uncertainty due to statistical sampling issues,
2. uncertainty in the exposure or dose-response models,
3. uncertainty in the input parameters for these models, and
4. uncertainty due to lack of completeness in the models.

At each point in the risk characterization process where an uncertainty exists, an assumption or scientific judgement must be made in lieu of firm scientific evidence. Specific examples of uncertainties that require the insertion of some assumption into the risk characterization process include those related to:

- extrapolation from animal to human exposures,
- extrapolation from high to low doses, and
- extrapolation from one route of exposure to another.

Under ideal circumstances each uncertainty should be assigned individual and joint probability distributions, from which average or worst case point estimates of adverse health effects are generated. In addition, these probability distributions should be used to perform a sensitivity analysis for the point estimates for each input parameter and to generate overall probability distribution for the estimated risks.

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RISK ASSESSMENT IN DEVELOPING COUNTRIES

Although considerable uncertainties exist in risk assessment methodologies and their applications, risk assessment has been adopted by government agencies in the United States and elsewhere to provide a quantitative and consistent framework for systematically evaluating environmental health risks and options for their control. The major criticisms of the methodology are that the data requirements are both time and resource intensive and that scientific judgement is often presented as scientific fact. Both of these criticisms may have an impact on the application of risk assessment methods in LDCs. First, many LDCs do not have extensive environmental data bases. The information needed to quantify exposure does not exist and, in some instances, the availability of data may not even support logical assumptions to be made regarding exposure. Second, scientific judgement embedded in all risk assessments needs to be understood and communicated to decision makers and other users of the risk information. This requires those knowledgeable in risk assessment to be accessible and to have access to the decision makers.

Several efforts are currently underway to identify and review cases where risk assessment methodologies have been used to evaluate environmental health problems in LDCs. Currently there is no comprehensive list of such case studies. However based on an initial review of a number of such case studies, it appears that most applications of risk assessment to environmental health problems in LDCs have been sponsored by donor agencies. Current activites include projects sponsored by the U.S. EPA, AID, and the World Bank, among others. Discussed below are two risk assessment methodologies that have been used in LDCs to evaluate environmental health probelms.

The Environment and Policy Institute (EAPI) of the East-West Center held a three week workshop in 1987 to test the applicability of "Western" risk assessment methods to hazardous chemicals management in developing countries of the Asia-Pacific (Smith et. al., 1988). A description of risk assessment and a set of guidelines for its performance were developed during the workshop. A framework for ranking risks developed at this workshop is presented in Figure 3. This framework may be more applicable in characterizing environmental health risk in many developing countries than the more quantitative approach presented in the previous section due

Hazard severity	Potential consequences: Life/safety	Potential consequences: Mission downtime	Potential consequences: Monetary loss $	Probability of occurrence: Frequent, repeatable	Probability of occurrence: Reasonably probable, several times	Probability of occurrence: Occasional, sometimes	Probability of occurrence: Remote but possible
Catastrophic	Death or system loss	> 4 months	> 500,000	High risk: Imperative to reduce hazard before proceeding			
Critical	Severe illness, injury, or damage	2 weeks to 4 months	50,000 to 500,000		Medium risk: Proceed only with specific management approval of risk acceptance		
Marginal	Minor illness, injury, or damage	1 day to 2 weeks	1,000 to 50,000			Lower risk: Assurance of compliance with standards and safety criteria	
Negligible	No illness, injury, or damage	< 1 day	< 1,000				Acceptable risk with normal operating procedures

Figure 3. Risk ranking based on probability and severity (from Smith et al, 1988)

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to the semiquantitative nature of the methodology. The framework provides a means of ranking risks based on their probability of occurrence and severity of hazard. Categories can be established in a semiquantitative way based on consequence to life or safety, time of interrupted operations, and monetary loss. The result is flexible set of categories ranging from high risk to acceptable risk. The general risk assessment methodology described in the previous section is still applicable in the sense that all four components of the process are addressed. However, the level of quantitation is adjusted to fit the available data. Several examples of this risk assessment methodology are presented in the proceedings of this workshop.

In recent years, the U.S. EPA Office of Policy Analysis has conducted and supported a series of projects aimed at better integrating risk analysis into environmental priority-setting at EPA. These "Comparative Risk Projects" use estimates of risk as a common measure for comparing and setting priorities among environmental issues. The methodology was first applied at a national level to rank environmental health problems according to three criteria: health effects, ecological effects and welfare effects (EPA, 1987, "Unfinished Business: A Comparative Assessment of Environmental Problems"). This comparative risk methodology has been or is being applied to all 10 EPA regions in the U.S. to better understand the environmental issues in the regions and how the regions may differ from one another (EPA, 1989, "Comparing Risks and Setting Environmental Priorities: Overview of Three Regional Projects). Recently, the comparative risk methodology has been applied to at least one major city in an LDC.

To provide some perspective on the comparative risk methodology, Figures 4 and 5 present the results of several of these studies. Figure 4 shows the rankings of current environmental health problems in the Southeastern United States (Region 4) according to three criteria: human health effects, ecological effects, and welfare effects. It is important to note that these results are based on analysis that takes into account current environmental regulation, thus the risk estimates are the residual risks remaining after current environmental controls are applied. As can be seen from the figure, the rankings differ substantially depending on which criterion one is considering. Figure 5 presents a comparison of the rankings based on the human health criterion for three studies which include the Southeastern United States, the Northwestern Untied States (Region 10) and a major city in an LDC. Although there are some similarities between the two U.S. regions, there are also some significant differences. However, the LDC city shows significant differences in the rankings.

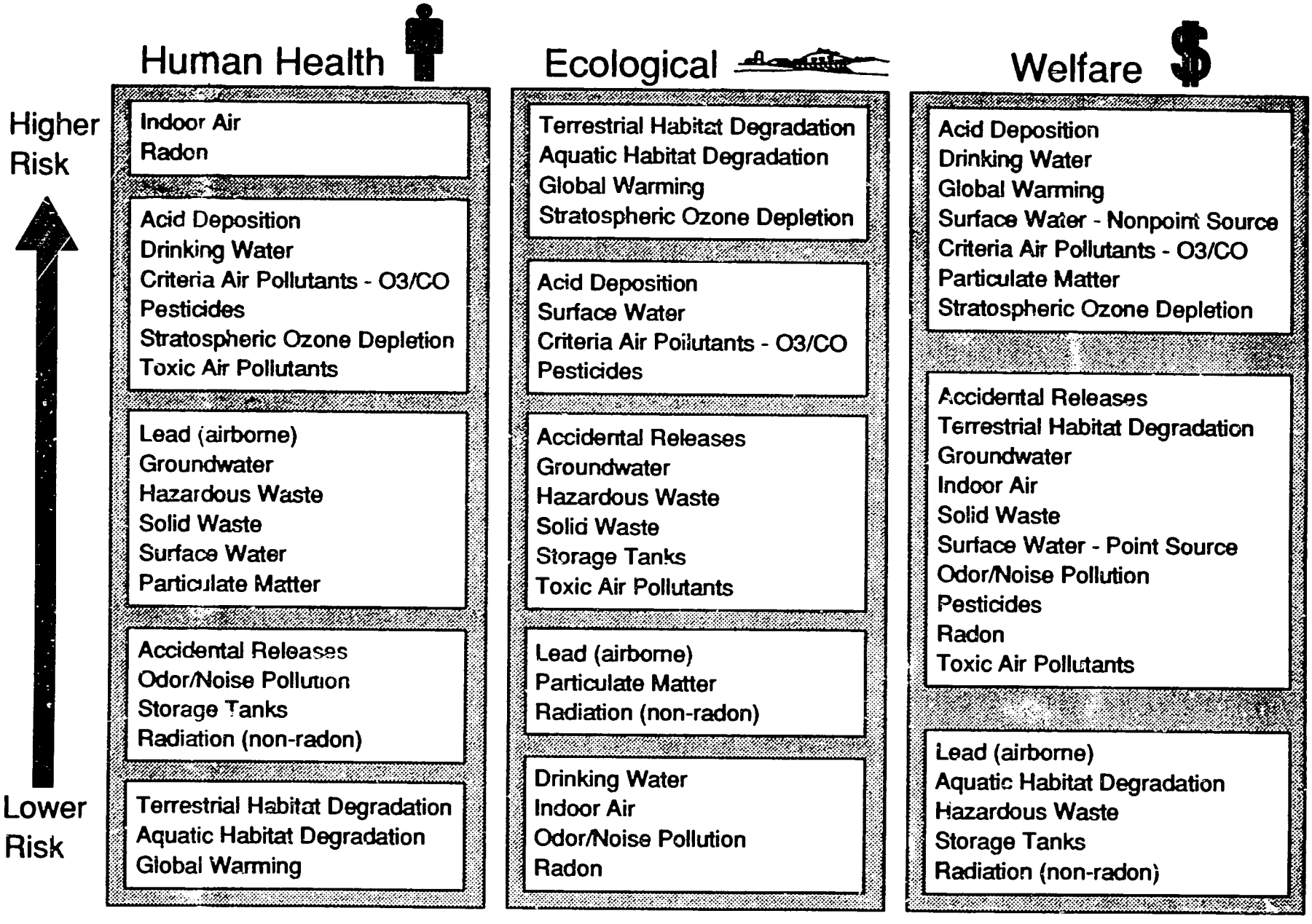

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Figure 4. Comparative Ranking of Current Environmental Problems - EPA Region 4

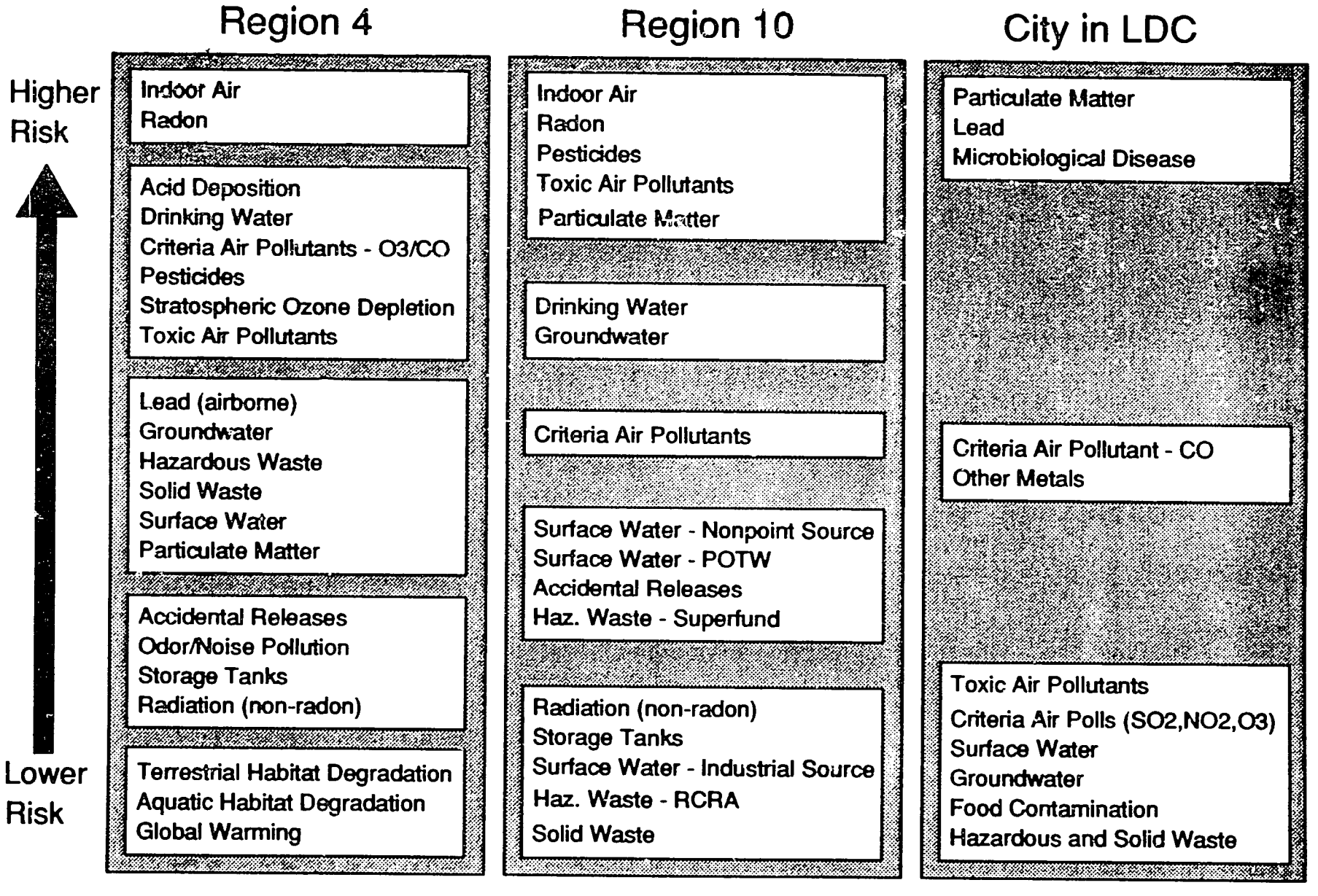

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Figure 5. Comparative Ranking of Current Environmental Problems - Human Health

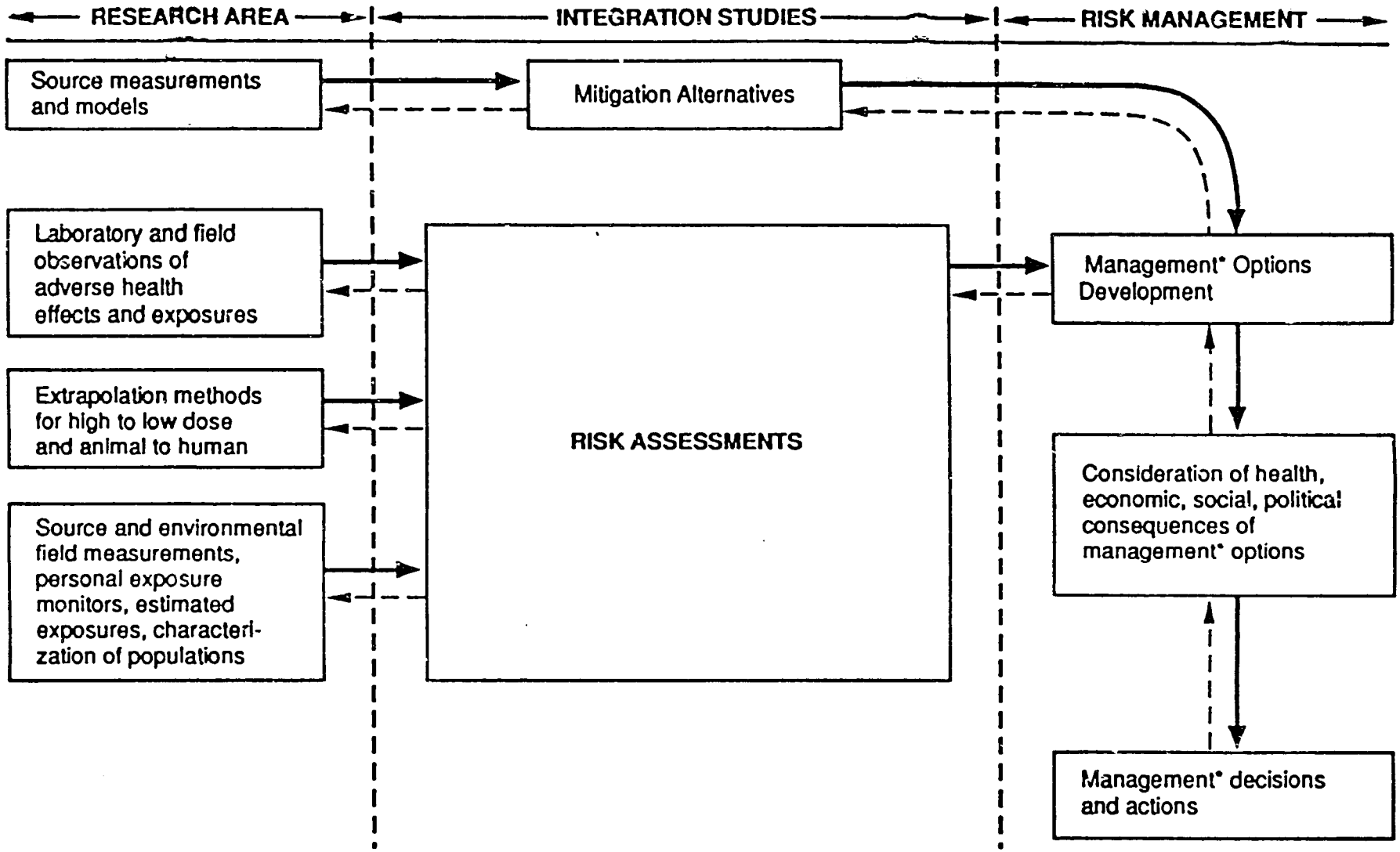
These figures together point up several important considerations in the application of risk assessment methodologies to environmental health problems in widely diverse settings around the world. First, the methodology provides a systematic approach to determining relative rankings among a widely diverse set of problems and circumstances. Second, the use of a single criterion, human health effects, will give a different ranking than the use multiple criteria, as shown in Figure 4. Third, between countries and even within a single country there will be different rankings depending on geography, climate, human settlement patterns, economic development, and the extent of existing environmental programs as illustrated in Figure 5.

RISK ASSESSMENT AND RISK MANAGEMENT

The relationships between basic environmental research, risk assessments, and risk management, are shown in Figure 6. A few of the key research areas which provide the foundation to manage environmental risks are shown in the left column. This research is appropriately conducted in great technical depth and replicated by independent laboratories. For this reason, integration studies are also needed to combine individual research projects covering different technical disciplines and to draw general technical conclusions on both the risk to people and the alternatives for mitigation. These integration studies form the basis for risk management options and decisions.

The risk assessment methodology provides a tool for synthesizing information on hazard identification, exposure assessment, and dose-response assessment into a characterization of human health and environmental risk. The methodology can be used to provide relative rankings of environmental health risks or, at a micro level of analysis to identify the main factors contributing to the health risk posed by a specific environmental problem. Both the macro and micro level analyses are useful in identifying and evaluating management options that can be effective in addressing the problem.

Identification of data gaps and weaknesses in a study can also be used to prioritize future research. These research needs may include source measurements and models, health effects data, environmental and exposure data, among others. Thus, there is a natural feedback mechanism between the risk assessment process and research.



*"Management" can be within federal agencies, state and local agencies, industries or even households.

Figure 6. Relationship between research, risk assessment, and risk management

(from Naugle et al., 1990)

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WATER AND SANITATION
FOR HEALTH PROJECT

1611 N. Kent Street, Room 1002
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Sponsored By
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Office of Health
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ENVIRONMENTAL HEALTH:
WATER, SANITATION, WASTEWATER MANAGEMENT, AND DRAINAGE

Prepared for the Office of Health
Bureau for Science and Technology
U.S. Agency for International Development
under WASH Task No. 232

by

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WASH Project Director
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Preamble

NOTE ON TERMINOLOGY

In this paper, "water supply" is defined as the treatment and distribution of safe drinking water, and "sanitation" the disposal of human excrement. Water and sanitation are services provided to families. The management of wastewater and drainage is an environmental problem: how to prevent stormwater runoff and the liquid wastes from homes, municipalities, businesses, and industry from polluting water sources or from creating other hazards to health. For A.I.D.'s Environmental Health Strategy, solid wastes and toxic, hazardous, and radiologic wastes are being covered in separate papers. Therefore, this paper will only mention solid wastes peripherally, and toxic/hazardous wastes will be discussed only as they apply to the management of wastewater and drainage. It should also be mentioned that in the pages to follow, "sanitation" will be taken to mean not only providing people with safe facilities for excreta disposal but also passing on to users the know-how and motivation to adopt health-enhancing behaviors as regards water and sanitation.

In attempting to illustrate where water and sanitation, drainage and wastewater management fall within the spectrum of environmental and environmental health activities, the Water and Sanitation for Health Project (WASH) developed the attached "Environmental Framework." This framework, presented through the perspective of water and sanitation professionals, helps illustrate the types of water and sanitation activities that are relevant to A.I.D. It also helps illustrate the role of management in relating the use and development of natural resources to producing a safe and healthy environment. Note, however, that, although water (as a resource) is a critical component in the inter-relationship between health and the environment, it is not discussed in detail in this paper.

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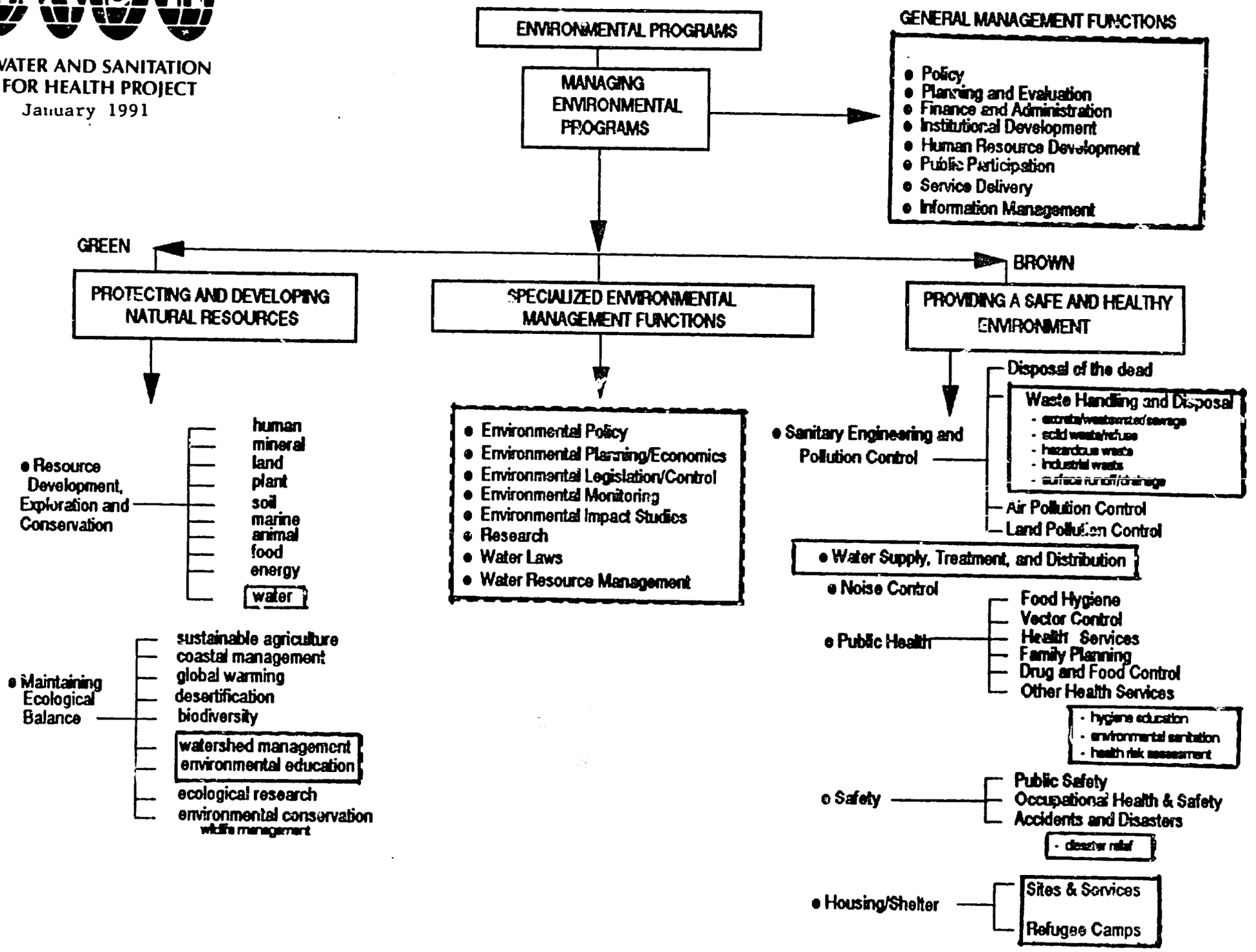
WATER AND SANITATION FOR HEALTH PROJECT
January 1991

ENVIRONMENTAL FRAMEWORK



Part 1

THE PROBLEM

Water Supply and Sanitation

Everyone alive has a water supply, because without water life is not possible. But not all water supplies are safe. At present a billion people lack access to safe drinking water (not counting China). For a large percentage of people in developing countries, the water supply is a river, lake, stream, spring, or well that is a breeding ground or carrier of disease-causing organisms or the home of disease-carrying insects. In recent years, chemical and industrial pollution has also become a threat to the water supply of many people.

As for sanitation facilities, they are available mainly in established urban areas and generally lacking in most rural areas and urban fringe settlements. Two billion persons today are without access to appropriate sanitation (again, not counting China).

The lack of safe and adequate water supplies and sanitation in developing countries has many implications, for like other basic infrastructure—roads, electricity—water and sanitation is a fundamental building block of economic development. Solely from a health point of view, the lack of safe water and sanitation causes serious problems.

Table 1 lists the 37 diseases that are the primary causes of death in the developing world. These statistics are compiled primarily from World Health Organization reports and represent our best estimate of the magnitude and relative importance of diseases in the developing world (Walsh, 1990). Twenty-one of the diseases listed in Table 1 are water and sanitation related in some fashion. These are printed in boldface type in the table. Figure 1 categorizes water-related diseases, lists the major ones, and explains the main modes of prevention.

Water and sanitation is considered *a primary intervention for prevention* for ten of the diseases listed in Table 1: diarrhea, typhoid, schistosomiasis, amebiasis, hookworm, hepatitis A, ascariasis, giardiasis, trichuriasis, and dracunculiasis. The annual death toll from these ten diseases is just under 5.5 million, and the number of cases per year is over 28 billion. (Another important water-and-sanitation related disease, trachoma, causes an estimated 500 million cases of eye infection each year [Dawson, 1981]. The serious sequelae of this disease is blindness rather than death.)

Providing people with an adequate water supply and sanitation reduces morbidity and mortality from many water-related diseases. Clean water prevents the spread of waterborne diseases, such as common diarrheas and the classic waterborne disease, cholera. Increased quantity and access to water provides the opportunity to improve hygiene—for example, through washing hands and cooking utensils—and prevents the direct spread of pathogens

Table 1

Causes of Death for Individuals of All Ages in the Developing World

Conditions	Number of infected persons	Deaths	New cases
		(thousands per year)	
Respiratory disease (upper & lower)	—	10,000 [1]	15,000,000 [2]
Circulatory system	—	8,000	*
(Low birth weight)[3]	—	(5,000)	(18,000)
Diarrhea	—	4,300	28,000,000
Measles	67,000	2,000	67,000
Injuries[4]	—	2,000	*
(Malnutrition)[5]	—	(2,000)	(5-8,000)
Neoplasms	—	2,000	*
Malaria	2,600,000 [6]	1,500	150,000
P. falciparum	—	1,350	120,000
Tetanus	—	1,200	1,800
Tuberculosis	1,000,000	900	7,000
Hepatitis B	300,000	800	3,700
Whooping cough	55,000	600	51,000
Typhoid	70,000	600	35,000
Maternal mortality	—	500	—
Meningitis	—	350	1,000,000
Schistosomiasis	200,000	250-500	10,000
Syphilis[7]	15,000	200	250
Amebiasis (Amebic dysentery)	500,000	70	40,000
Human immunodeficiency virus (HIV)	4,000	50-70	140
South American trypanosomiasis (Chagas disease)	24,000	60	1,200
Rheumatic fever and heart disease	—	52	2,200
Hookworm	800,000	50	1,500
Rabies	35	35	35
Diphtheria	60,000	30	600
Dengue	*	15	48
Hepatitis A	*	14	5,000
Yellow fever	*	9	82
Japanese B encephalitis	*	7	28
Ascariasis	700,000	10	700
Giardiasis	250,000	10	500
Poliomyelitis	150,000	2	220
Leprosy	1,000	1	1,000
Leishmaniasis	1,000	1	1,000
Trichuriasis (Whipworm)	500,000	1	100
Filariasis (Elephantiasis)	90,000	1	1,000
Dracunculiasis (Guinea worm disease)	1,000	1	1,000
Onchocerciasis (River blindness)	1-5,000	1	*
African trypanosomiasis (Sleeping sickness)[8]	*	1	*
Other[9]		1-2,000	

[1] 4 million of these deaths occur in children under 5 years old.
[2] 25 million episodes of acute lower respiratory tract infectious disease and 15 billion episodes of acute upper respiratory tract infectious disease.
[3] Low birth weight is the underlying cause of death, although the immediate cause may be respiratory, diarrheal, or other disease; therefore, these deaths have also been counted in the other categories.
[4] Drownings may be related to water supply conditions.
[5] Severe malnutrition is the underlying cause of death, although the immediate cause may be respiratory, diarrheal, or other disease; therefore, these deaths have also been counted in other categories.
[6] This is the population at risk inhabiting infected areas: 365,000,000 live in highly endemic areas.
[7] Endemic syphilis (pinta and yaws) is water-related.
[8] Only that caused by T.b. gambiense is transmitted by riverine tsetse flies and therefore water-related.
[9] Deaths of unclear etiology or diseases with relatively small numbers of cases.

Note: — not applicable; *no data.

Adapted from Walsh, 1990.

Figure 1

WATER-RELATED DISEASES

Waterborne Diseases:

Definition: Waterborne diseases are diseases in which the pathogens or toxins are in the water and, when ingested in sufficient dose, cause disease in the drinker.

Prevention modes: Waterborne diseases may be prevented by improving the quality of drinking water and preventing the casual use of unimproved water sources for drinking.

Major Diseases:

- Common Bacterial Diarrheas (numerous etiologies including Shigella, Campylobacter, E.coli)
- Common Viral Diarrheas (Rotavirus and others)
- Enteric Fevers: Typhoid and Paratyphoid
- Hepatitis A
- Cholera
- Amebiasis (Amebic Dysentery)
- Giardiasis
- Dracunculiasis (Guinea Worm Disease)

Water Washed Diseases:

Definition: Water washed diseases, also called water hygiene diseases, are diseases whose incidence, prevalence or severity can be [illegible] using water to improve personal and domestic hygiene. Water washed diseases include those requiring ingestion of pathogens, such as diarrheal diseases, and superficial infections, such as trachoma and skin infections.

Prevention modes: Water washed diseases may be prevented by increasing the quantity of water used, improving the accessibility and reliability of domestic water supply, and improving hygiene behaviors.

Major Diseases:

- Common Bacterial Diarrheas (numerous etiologies including Shigella, Campylobacter, E. Coli)
- Common Viral Diarrheas (Rotavirus and others)
- Enteric Fevers: Typhoid and Paratyphoid
- Hepatitis A
- Amebiasis
- Giardiasis
- Ascariasis
- Trichuriasis (Whipworm)
- Endemic Syphilis (pinta, yaws)
- Trachoma

Water Contact Diseases:

Definition: Water contact diseases depend on human contact with unimproved water sources for transmission. These include water based diseases where the pathogen spends part of its life cycle in water and skin contact with the water source is required to release the pathogen (Guinea Worm Disease) or to become infected (Schistosomiasis). Also included are diseases requiring contact with contaminated or unsafe water sources.

Prevention modes: Water contact diseases may be prevented by decreasing the need for contact with unsafe water sources, controlling water based vector populations, and reducing the contamination of surface waters.

Major Diseases:

- Drowning
- Schistosomiasis
- Dracunculiasis (Guinea Worm Disease)

Water-Related Insect Vectors:

Definition: These are diseases which depend during part of their life cycle on vectors which live all or part of their lives in or adjacent to a water habitat. This includes insects that breed in water (eg mosquitos) or bite near water (eg the Glossina spp. that transmits sleeping sickness).

Prevention modes: These diseases may be controlled by improving surface water management, destroying the breeding sites of the vectors, and decreasing the need for humans to visit the breeding sites, aside from other specific vector control measures.

Major Diseases:

- Mosquito Vector Diseases (Yellow Fever, Dengue, Other Arboviral diseases, Malaria, Filariasis)
- Fly Vector Diseases (Onchocerciasis, African Trypanosomiasis)
- Snail Vector Diseases (Schistosomiasis)

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through contamination of food, water, and other objects that may be put in the mouth. Improved water and sanitation may lead to decreased contact with unsafe, unimproved water sources and prevent health problems such as schistosomiasis and dracunculiasis. Water-based disease vectors may be controlled by improving water sources and eliminating breeding sites of insects that carry a variety of diseases, including dengue and malaria.

Provision for operations and maintenance of the services that exist must be kept in mind. Unsanitary latrines and overflowing sewers and septic tanks can all lead to increased environmental fecal contamination and increased risk of disease. Improperly maintained water supplies may, similarly, become contaminated and become a source of waterborne diseases.

Of course adequate water supply and sanitation will not prevent all cases of these diseases, but it will have a significant effect. Table 2 summarizes the impact of improved water supply and sanitation on six water-related diseases with distinct transmission patterns. The data in this table comes from an analysis of 144 peer-reviewed studies. Of these 144 studies, median reductions in disease could be calculated in 93 studies ("all studies") and in 35 methodologically superior studies ("better studies") (Esrey, 1990).

The review found that improvements in water supply and sanitation brought about marked reductions in five of the six diseases. The median reductions in incidence for the better studies range from 26% for diarrhea to 78% for dracunculiasis. Despite the mix of both positive and negative studies, the results show a substantial positive impact.

The review also concluded that, as far as reducing the incidence and severity of the six diseases was concerned, the *most effective intervention was safe excreta disposal*, followed by increased water quantity and improved water quality.

From a health standpoint, it follows from these and other findings that sanitation, including hygiene education, should be given greater attention than it has to date. Instead of referring to WS&S, we ought to use the acronym SAWS (sanitation and water supply) to show the primary importance of sanitation. Sanitation facilities should be installed in conjunction with water facilities, and water supply and health programs should emphasize hygiene education to encourage people to use more water for personal and domestic hygiene. Also, access to a water supply should be as close to the home as possible to foster the use of more water for hygiene practices.

The review emphasized that water and sanitation facilities must operate consistently throughout the year to have a health impact. If facilities fail during the critical seasonal transmission periods for some diseases, they will have no effect on the incidence of the disease.

Table 2

Expected Reduction in Morbidity and Mortality
from Improved Water Supply and Sanitation*

	All Studies			Better Studies		
	No.	Median	Range	No.	Median	Range
Diarrheal Diseases						
Morbidity	49	22%	0-100%	19	26%	0-68%
Mortality**	3	65%	43-79%	—	—	—
Ascariasis	11	28%	0-83%	4	29%	15-83%
Guinea Worm	7	76%	37-98%	2	78%	75-81%
Hookworm**	0	4%	0-100%	—	—	—
Schistosomiasis	4	73%	59-87%	3	77%	59-87%
Trachoma	13	50%	0-91%	7	27%	0-79%
Overall impact on child mortality	9	60%	0-82%	6	55%	20-82%

* Indicates morbidity reduction unless noted otherwise.
** There were no "better" studies.

Source: Esrey, 1990.

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The impact of improved water supply and sanitation on child survival was also considered in the review. Data from nine studies (of which six were better studies) show a tremendous impact of water supply and sanitation on child mortality: 55% in the better studies. In addition to eliminating the cause of diarrhea in some cases, improved water supply and sanitation may lessen the severity of the disease. Also, multiple beneficial effects of improved water supply and sanitation on the health of the child, the mother, and other family members as well as money and time savings may decrease the likelihood of child death. It should be added that, from a purely methodological point of view, child mortality is more readily ascertained than is diarrhea morbidity and estimates of the impact of water supply and sanitation on diarrhea morbidity may be falsely low.

Another health risk associated with water supply and sanitation is the ingestion of water contaminated with organic or inorganic compounds. Data on the magnitude of these problems in the developing world are difficult to come by, but may represent significant health risks in some locations. This type of water pollution may be associated with toxic, hazardous, and radiological waste, or it may be due to the natural presence of metals, such as arsenic. The more common substances that may be found in water, and a summary of health effects, may be found in Table 3 (McJunkin, 1982).

Let us now look in more detail at coverage statistics in the developing world in light of the information above. As we look at these statistics, which show the large numbers of people without access to safe water and adequate sanitation, it is easy to overlook the significant accomplishments of the U.N. International Drinking Water Supply and Sanitation Decade (1981-1990) in bringing water and sanitation coverage to more people. According to the World Health Organization, 1.348 billion people received adequate water supply services during the Decade: 368 million in urban and 980 in rural areas. An estimated 748 million received satisfactory sanitation services: 314 million in the urban areas and 434 in the rural. This accomplishment, achieved in spite of the very adverse economic conditions that prevailed in most developing countries, was the result of the unprecedented mobilization of international and national resources.

Figure 2 and Table 4 show the progress made during the U.N. Water Supply and Sanitation Decade. Note that with the exception of rural water, little progress was made in covering larger proportions of the total population. Globally, the Decade began with 180 million urban dwellers and 1 billion rural dwellers unserved with a safe water supply. At the end of the Decade, 254 million urban and 880 million rural dwellers were still unserved, 74 million more urbanites than at the beginning of the Decade. Progress lagged in sanitation: numbers of people not covered went from 1.3 billion to 1.5 billion in rural areas and from 308 million to 400 million in urban areas. Even given the growth of urbanization, the greatest number of unserved is found in the rural sanitation sector: 1.5 billion. As the next figure shows, this situation will not change appreciably in the next decade.

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Table 3

The Health Effects of Common Substances
Found in Water

Source	*Disease or Syndrome*	*Remarks*
Metals	Toxicoses	Intake of metals in drinking water, food, and air from both natural sources and human activities. These include arsenic, cadmium, copper, chromium, lead, marcury, selenium, vanadium, zinc, *et al.* Can be important on a local basis, e.g., arsenic in parts of Argentina.
Organic Chemicals	Toxicoses Cancers Mutations Birth Defects	Intake of certain chemicals, esp. certain synthetic organic chemicals, including some pesticides. Also some trihalomethane byproducts of chlorination are suspect carinogens.
Radio-nuclides	Cancers	Natural and man-made radioactivity.
"Hardness"	Cardiovascular Disease	Some epidemiological evidence indicates an inverse correlation of cardiovascular diseases with hardness of drinking water.
Others	Fluorosis	Damage to teeth and bones resulting from long-term ingestion of high concentrations of naturally occurring fluorides.
	Methemoglo-binemia	Serious, sometimes fatal poisoning of infants following ingestion of well waters containing nitrates (NO_3) at concentrations higher than 45 milligrams/liter.
	Endemic Goiter	Iodine-deficient water or water containing goitrogens.
	Asbestosis and Mesothelioma	Asbestos in lungs known to cause cancer. Fate in gastrointestinal tract unknown.
	Hypertension	Sodium-restricted diets necessary for parts of population.

Source: McJunkin, 1982

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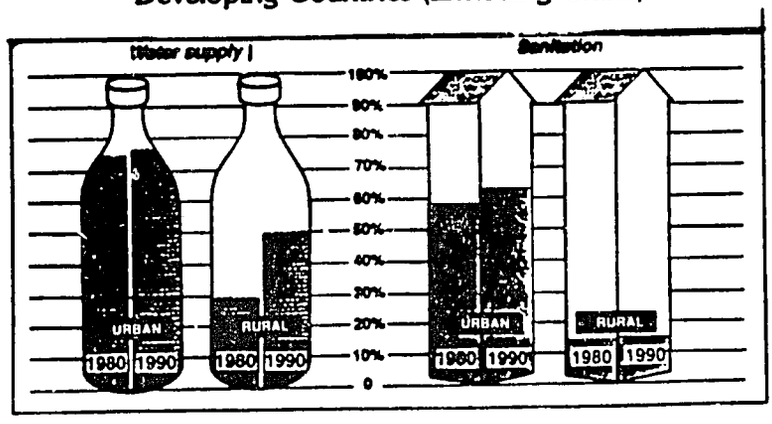
Figure 2

Decade Performance in
Developing Countries (Excluding China)



Source: UNICEF, 1988

Table 4

Evolution of Water and Sanitation Coverage Percentages
by Region, 1980-1990

	Water				Sanitation			
	Rural 1980-1990		Urban 1980-1990		Rural 1980-1990		Urban 1980-1990	
Africa	22	29	83	74	18	19	67	74
Latin America & the Caribbean	41	51	83	88	11	21	74	82
Asia & the Pacific	31	57	66	69	13	13	42	44
Western Asia (Middle East)	51	56	95	100	34	15	79	100
Global Totals	30	50	75	77	14	15	58	63

Source: UNICEF, 1988

Figures 3 and 4 project coverage statistics for the year 2000, based on the investment level of the 1980s. Figure 4 demonstrates how difficult it is to make progress given population increases. Unless some dramatic changes are made, at the end of the century 85% of the persons in rural areas in developing countries will still be without sanitation. These people, and the millions more with inadequate or non-existent services, are a population at high risk for many of the diseases that cause illness and death.

High rates of population growth make advances in coverage difficult. Most developing countries just managed to stay even during the Decade regarding the percentage of people covered. Growth in population has a great impact on the sector because service is directly proportional to population. (By way of contrast, in toxic waste management, increases in population do not have such a one-to-one effect on the scope of the job to be done.) Population growth does not appear to be slowing, but the flow of resources is. This means that it may not be so easy to stay even during the next decade.

There has been an unalterable flow of people to urban areas in recent decades. Many developing countries are now primarily urban. New urban residents usually settle first in urban fringe areas with grossly inadequate or non-existent water and sanitation facilities. In these makeshift areas drainage can be a major problem, as will be discussed in the next section, as well as solid waste disposal. These settlements are often technically illegal and thus fall outside governmental plans for urban improvement. High rates of urbanization mean that governments have to spend more per capita to provide water and sanitation, for urban systems are more costly than rural ones.

Environmental health issues are a central concern in urban and peri-urban populations. Some of the issues are apparent: crowding with increased intra- and interfamilial transmission of disease, the lack of extension of municipal water services combined with the lack of traditional water sources; fecal and/or toxic contamination of local water sources; the lack of sanitation services combined with crowding and the lack of traditional options for excreta disposal (open space); the attendant, and well-documented high level of environmental fecal contamination; fragmentation of families combined with the time demands of a cash economy that decrease the amount of time that mothers have for childcare, and household and personal hygiene; air pollution; and occupational exposures and hazards. The list is quite long.

To conclude, the coverage statistics are not the whole picture. They do not tell how facilities are being used or even if they are being used at all. New facilities may provide many and various benefits to a community, but health benefits per se will not be forthcoming unless the facilities are used consistently and in ways that promote health. There is no reliable way to collect statistics on how new and improved systems are being used, but we do know that most water and sanitation projects do not have a hygiene education program and that many existing hygiene education programs do not yield the required changes in behavior. Changing ingrained human behaviors is not an easy matter.

Figure 3

Projected Water and Sanitation Coverage in the Year 2000, Based on Investment Rates of the 1980s

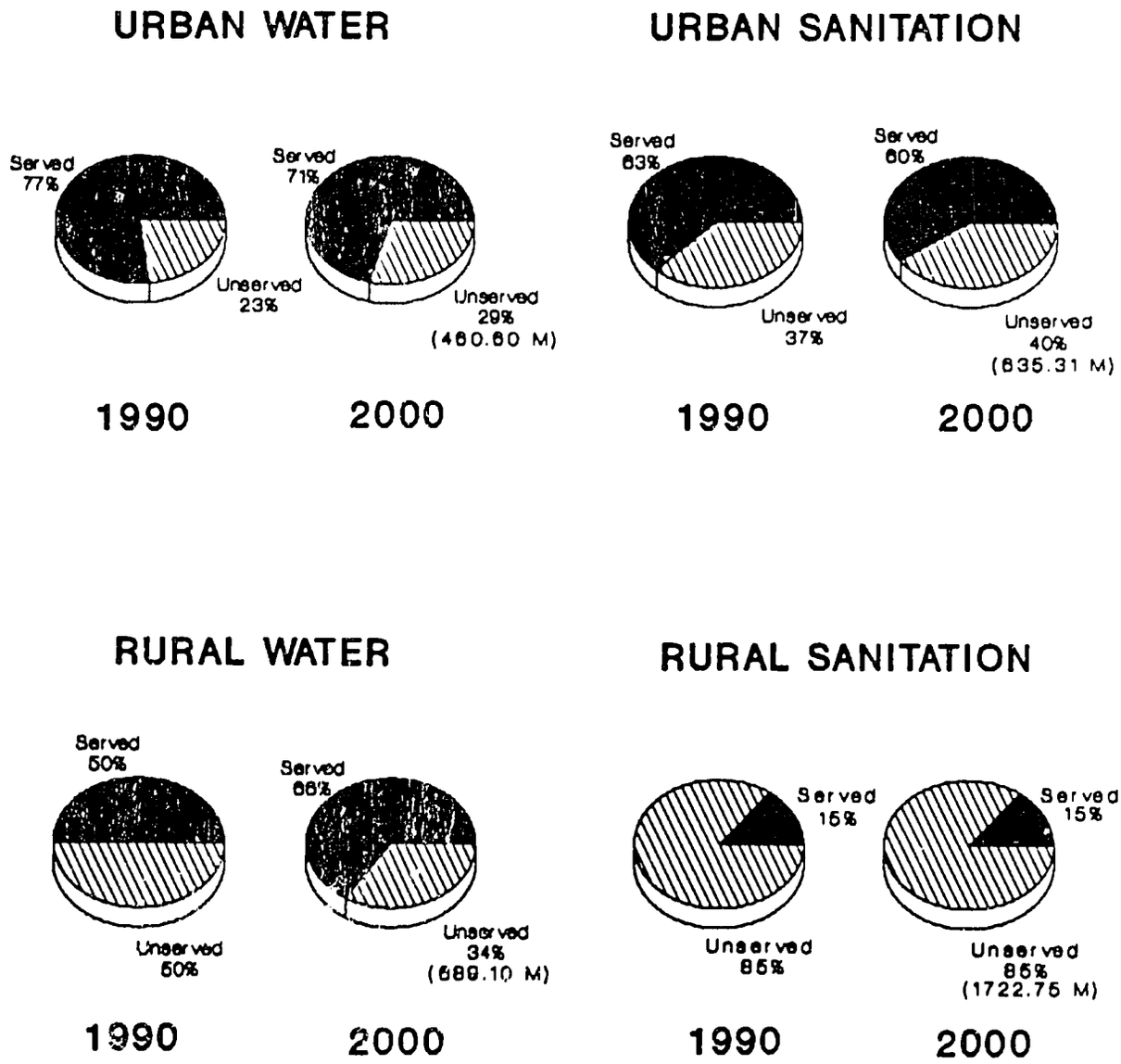


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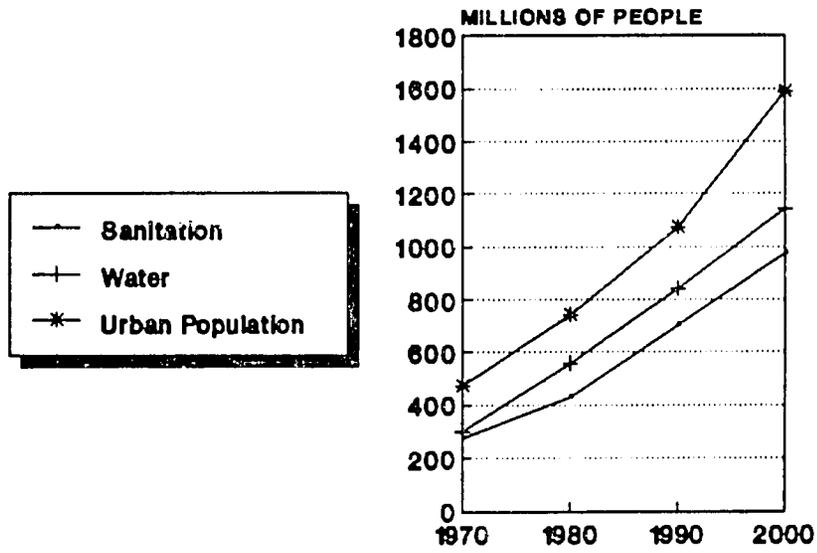
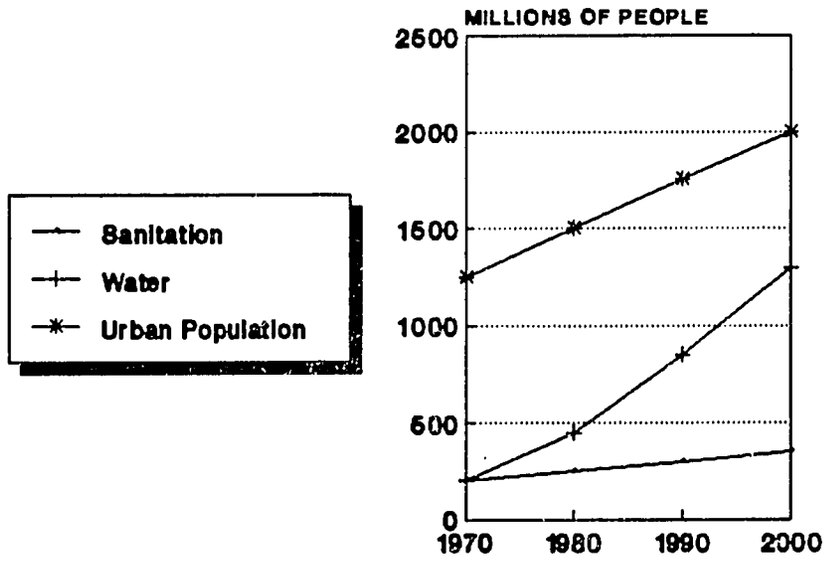
Figure 4

Projected Water and Sanitation Coverage in the Year 2000, Based on Investment Rates of the 1980s, Compared with Population Growth

URBAN AREAS



RURAL AREAS



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Wastewater Management

Wastewater refers to the liquid waste produced from homes, commercial premises, industries and urban runoff. It consists mostly of human excreta and used water. Management of wastewater is critical to the maintenance of public health because it contains high levels of pathogenic organisms and organic and inorganic chemical substances. Treatment of wastewater prior to discharging it into receiving waters (rivers, lakes, oceans) or to reusing it for irrigation is necessary to prevent health problems.

There are multiple health risks from untreated wastewater. If inadequately treated wastewater is discharged into a river or lake, pathogens present in the wastewater may be ingested by human populations who use the river for domestic purposes, including for drinking water. People in arid regions are particularly at risk because they may have no other water source for drinking water supply and the river flow may be insufficient in some seasons to dilute the contaminants in the water. Another negative outcome is that, when discharged in fresh water, untreated wastewater may promote the transmission of parasitic worms that have aquatic intermediate hosts. When discharged in coastal waters, wastewater effluents can contaminate fish and shellfish and bathing areas. Outbreaks of poliomyelitis, hepatitis A, and diarrheal diseases all have been associated with the ingestion of shellfish from polluted water (Feachem *et al.*, 1983).

Waste stabilization ponds are usually the wastewater treatment method of choice in warm climates wherever land is available at a reasonable cost. These are increasingly being overloaded. In Botswana for instance, discharge from waste stabilization ponds to receiving waters has been found to be the single largest contributing factor to surface water pollution. On-site disposal can also contaminate the groundwater and affect adjacent wells.

Wastewater management through reuse for irrigation has increased in the past two decades especially in the semiarid areas of developing countries, due to the scarcity of alternative waters for irrigation, the high cost of artificial fertilizers, and the high cost of advanced wastewater treatment plants. In arid and semi-arid areas water resources are so scarce that there is often a major conflict between urban (domestic and industrial) and agricultural demands for water. One way to resolve the conflict is the reuse of the wastewater, after proper treatment, for agricultural use. Some governments have been cautious in actively promoting wastewater use for agriculture because of potential health risks and lack of design guidelines for treatment of wastewater before use.

In spite of the advantages of using wastewater for irrigation, there is always the prospect of groundwater contamination by the infiltrating wastewater irrigation. The most susceptible water supplies are shallow wells.

A number of health risks arise for both consumers and farm workers from the use of wastewater for irrigation. Such use has increased substantially in the past two decades,

especially in semi-arid areas. Besides the agriculturally beneficial nutrients present in wastewater, it also contains contaminants which pose a public health risk. Pathogenic viruses, bacteria, protozoa, and helminths escape from the bodies of infected persons in their excreta and, if they reach other people, may enter via either the mouth (from eating vegetables contaminated from irrigation wastewater) or the skin (as in the case of hookworm and schistosomiasis). If wastewater used for irrigation includes a significant proportion of industrial effluent, it may contain compounds that are toxic to humans. Cholera and typhoid can be transmitted by the irrigation of vegetables with untreated wastewater (Shuval *et al.*, 1986). In Santiago the widespread practice of irrigating vegetables with untreated sewage or with polluted river water has been implicated in the unusually high typhoid morbidity rates (Strauss and Blumenthal, 1990). Reviewing the literature on the topic, Mara and Cairncross (1989) conclude that when untreated wastewater is used for crop irrigation, intestinal nematodes and bacteria present high actual risk and the viruses little or no actual risk. The actual risks of protozoal infection, they note, are not yet well established. The review indicated that it is clear that wastewater treatment using water stabilization ponds is a very effective method of safeguarding public health. However, reuse of untreated wastewater for irrigation in Peru has been linked to an increased risk for farm workers and consumers of Giardia (Strauss and Blumenthal, 1990).

Industrial wastewater is the water used in industrial processes which gets discharged into the natural water bodies or sewer systems. The rapid industrialization which has accompanied urban growth has led to sharp increases in the volume and the toxicity of industrial wastewater effluent. For example, between 1970 and 1986 the number of registered industries using and disposing of toxic chemicals in Thailand (primarily in Bangkok) rose from 78 to 615 (Phantumvanit and Liengcharemsit, 1990).

Industrial wastewater of concern comes from a variety of sources including pesticide, fertilizer, and petrochemical complexes; tanneries; paper and pulp mills; and rubber factories. Toxic organic solvents used in manufacturing processes are a concern. However, inorganic chemicals or heavy metal wastes are of greater immediate concern in terms of health impact. The high degree of chemical pollution of receiving waters which may result from discharge of untreated industrial wastewater is demonstrated in the case of the Tunjuelito river in Bogota, Colombia. High levels of cadmium and lead recorded in the river are the result of industrial discharge.

Both acute and chronic effects on health of contaminants found in industrial wastewater have been documented. The major pathway is through ingestion either directly through untreated water or indirectly by eating food which was irrigated with water polluted from industrial discharges. However, for certain chemicals, exposure may also occur through skin contact, or by inhalation as a result of human activities, such as bathing.

Domestic wastewater is produced by households that have an in-house tap water supply service and flush-toilets connected to a sewer system into which all other household

wastewater (sullage) is discharged. This kind of conventional waterborne sewerage is prohibitively expensive. Indeed, as might be expected, sewage coverage in urban areas throughout the developing world is very low. For example only 14% of the urban population in Africa has sewerage connections. In Latin America, sewerage currently extends to some 41% of the urban population. In Manila, 15% of the population is served by sewers or individual septic tanks. In Bangkok, sewerage coverage extends to only 2% of the population. Capital cities and large metropolitan areas in Latin America tend to have higher coverage, often between 50% and 85%, but secondary cities are well below this average (Bartone, 1990).

The presence of sewers alone does not ensure adequate wastewater disposal. The collection system must be followed by an operational treatment system in order to protect public health. However, in the developing world most of the wastewater collected by sewers is discharged without treatment of any kind. It is estimated that, in Latin American urban centers, about 90% of collected sewage is emptied untreated into surface waters (PAHO, 1990).

Furthermore, even in countries where sewage systems are used and treatment is practiced to some degree, operational difficulties are common and desired effluent quality is often not achieved. A survey of 223 municipal wastewater treatment plants in Mexico found that 45% of the plants were out of service and 35% suffered severe operational problems. Similarly, a World Bank study in Algeria showed 33-42% of the wastewater treatment plants being out of service (Bartone, 1990).

Urbanization has exacerbated the problem of wastewater management. The increasing number of people and factories strain available urban infrastructure and services and generate more urban wastes, including wastewater. These wastes outstrip the capacity of cities to efficiently collect, treat and dispose of them. They also exceed the capacity of authorities to control them and of nature to assimilate them. "The solution to pollution is dilution" credo is no longer an option in most urban situations. For example, in one study using bacterial cultures from a river running through a residential area in Jakarta it was found that the river water contained a density of fecal bacteria of the same order as the human intestine. It is probable that such heavy environmental contamination is partly responsible for the high incidence of diarrheal diseases in Jakarta (Gracey *et al.*, 1976). In India, where the urban population has more than doubled in the past 20 years, 115 cities discharge municipal wastes, untreated sewage, and industrial wastewater into the Ganges River, making it one of the most polluted rivers in the world.

Drainage

Drainage serves to remove excess water from an area by surface or subsurface means. Excess water in urban areas may be domestic and industrial wastewater and/or stormwater run-off. Drainage is a necessary component of wastewater management, especially in

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urbanized areas, to prevent spread of waterborne diseases. Land subject to flooding by rainwater is often the only land available to the urban poor. Huge areas of frequently flooded, swampy land are occupied by substantial proportions of the low-income populations of such cities as Guayaquil, Recife, Lagos, Mombasa, Madras, Calcutta, Dhaka, Rangoon, Bangkok, Colombo, and Manila. Watermains are submerged by these conditions and contaminated or exposed and even washed away. Flooded latrines turn the flood water into diluted sewage and can create a situation worse than if the latrines were not there. Without the proper management of stormwater to prevent flooding and ensure ground stability, sanitation measures are practically impossible.

Inadequate drainage of urban run-off, stormwater, and sullage (wastewater excluding exreta) can lead to a number of public health problems. The breeding of Anopheles mosquitoes, the carrier of malaria, is made possible by stagnant water from rainfall and domestic wastewater which is common in poor urban areas where malaria is a significant problem (Harpham *et al.*, 1988). Epidemics of other vector-borne diseases such as dengue hemorrhagic fever and the increased transmission of filariasis are associated with the accumulation of wastewater around settlements in poor urban areas. Urban filariasis, transmitted by mosquitoes which lay their eggs primarily in open drains and puddles containing domestic watewater, is a major public health problem in India (Caircross *et al.*, 1988).

A frequent problem in drainage is the blockage of urban drainage channels by accumulated domestic refuse. This situation demonstrates the need for an integrated approach to wastewater/solid waste management.

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Part 2

PREVENTIVE MEASURES OR CONTROL STRATEGIES

Economic Development

Before listing the options available for involvement in the sector it should be mentioned that the cure for underdevelopment and its attendant problems—lack of water, sanitation, and wastewater management being only a few of many manifestations—is economic development. Measures that improve the economic health and development of Third World countries should be given the highest priority.

Available Options

For external support agencies, there are essentially four types of program activities available for improving water supply, sanitation and wastewater/drainage management. These are listed below roughly in order of the priority they have traditionally been given.

1. Capital Investment
2. Capacity-Building
3. Policy Formulation
4. Providing and Increasing Access to Information
5. Research

In the following sections, each of these program activities will be discussed briefly as to its effectiveness and potential impact. No one activity will fit everywhere; program elements should be tailored to specific country and local needs and conditions and donor capabilities and objectives.

Capital Investment

Water Supply Systems

An extensive and acceptable range of water supply options (technology) exists to meet the needs of the sector. Both urban and rural systems are needed to expand coverage and keep up with future population growth. Urban water system investments should focus on poor neighborhoods and peri-urban areas that have been neglected. The largest growth, particularly in Latin America and the Caribbean, will come in urban areas.

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While rural growth rates are slower than urban, existing coverage is much lower in rural areas and most people still live in rural areas of developing countries. Because of all the attention focused on urban problems, there is a danger of overlooking the significant needs of the rural poor for sustainable basic services.

A decision to finance the construction or rehabilitation of a water supply system needs to be based on the prospect for achieving an acceptable level of impact and the likelihood that the investment/system will be sustainable. It makes no sense to overextend the government just to get a higher rate of coverage. This is the basic pitfall of the donor-driven approach.

Sanitation Systems

A great deal more emphasis has been placed on water supply than sanitation even though sanitation, including hygiene education, appears to be more important as a health intervention. Here again, the greatest need is in the rural areas where coverage is extremely low and projected to remain low.

In the urban sanitation sector, the main problem is that relatively costly technologies have been used and insufficient consideration has been given to alternatives that are cheaper but more labor intensive.

Rural sanitation systems can be built cheaply and should be emphasized but always in conjunction with hygiene education programs to increase effectiveness and health impact.

In all cases sanitation systems must be culturally appropriate to be accepted and sustained.

Wastewater Systems

The single most effective and reliable strategy for preventing transmission of disease caused by pollution from wastewater is to collect and treat the wastewater. However, conventional waterborne sewerage is prohibitively expensive, almost impossible to install in narrow winding streets that characterize many developing country towns and cities, and requires a constant supply of large amounts of water for its function. (Table 5 shows relative costs for treatment options for systems in Yemen.)

Other options are available, principally on-site disposal (pit latrines, pour-flush toilets, septic tanks systems). However, on-site disposal systems can become overloaded by sullage water due to the low infiltration capacity of rock or clay soils. One method to upgrade pour-flush toilet septic tank systems is small-bore sewers. Compared to conventional sewerage, small-bore sewers can be half the cost to construct and operate while providing a similar level of service (Bartone, 1990).

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Table 5

Wastewater Treatment Costs
(Example from Yemen)

	Waste stabilization pond system	Aerated lagoon system	Oxidation ditch system	Conventional treatment (biofilters)
Costs (million US$)				
Capital	5.68	6.98	4.80	7.77
Operational	0.21	1.28	1.49	0.86
Land area (ha)	46	50	20	25

Adapted from Mara and Cairncross, 1989.

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Off-site disposal sewerage technologies using modified design standards are increasingly being considered and explored. Smaller, shallower, and flatter sewers which have fewer manholes or cleanouts have been used in Brazil and other Latin American countries with cost savings ranging from 20% to 50% of conventional sewerage costs.

More than 95% of urban wastewater produced by developing countries is discharged into receiving waters or fields without treatment (Global Consultation, 1990). Further, many of the treatment facilities that currently exist are often not able to remove excreted pathogens sufficiently to ensure public health. Many systems were designed to treat water of a higher quality than what they are now receiving. In addition, there is more wastewater to be treated, due to rapid urbanization and industrialization, and plants are hydraulically overloaded.

Little attention has been paid to appropriate, affordable technologies for wastewater treatment. Smaller regional sites for treatment might be one option. To combat the prohibitive capital costs of traditional sewer systems, simplified sewage systems or small-bore sewer systems might be viable alternatives. Linking municipal wastewater management to solid waste management and promoting reuse and recycling as well as co-composting of garbage and wastewater or sludge should be considered. Combining more than one waste-stream (human/domestic/animal waste) is another option. Collaborative work with other related sectors would promote a broader approach to the problem. Finally, alternatives to water-carriage waste disposal systems should continue to be explored.

In addition to exploring alternative technologies for treatment of wastewater, we should also give some attention to disposal options which require little or no treatment. Wastewater reuse for irrigation requires less treatment than direct discharge; the recommended technology is low-cost stabilization ponds. Where land is expensive or climatic conditions do not allow for ponding systems, alternatives must be found. Research is needed on low-cost, sustainable processes such as roughing filters, chemically assisted sedimentation, and rapid filtration. Wastewater discharge to wetlands areas or through ocean outfalls can be done with little treatment in some cases and with environmental benefits.

Generally there is a low level of public interest in wastewater management, because, relative to other concerns, wastewater treatment seems trivial. Most people do not make the connection with human health but see improvements in this area as having only aesthetic merit—a luxury they cannot afford.

Drainage

Rainwater drainage is often the measure given the highest priority by those who live in poor urban neighborhoods (Harpham *et al.*, 1988), but it has been overlooked both from the health point of view and from the perspective of protecting water and sanitation infrastructure from damage or reduced effectiveness from flooding.

Some situations clearly call for investments in drainage facilities to protect public health, i.e., where ponding of water provides an environment for mosquitos to breed or creates conditions for helminthic infections.

Little data is available on relative cost-effectiveness of drainage as a health intervention. More research is needed in this area, and more attention needs to be paid to the role of the community in design and maintenance of drainage facilities. Some drainage problems can be attacked to some degree through community education by increasing understanding of the importance of environmental hygiene.

Capacity-Building

The overwhelming current needs of the sector, the projection of future demands from rapid population growth and urbanization, the limited capability of governments to meet even current needs, and reduced funding for development all point to the importance of capacity-building. Again and again, lack of developing country capacity to plan, finance, and implement sector projects that will last over the long term is mentioned as a primary constraint to achieving full coverage.

Capacity-building involves a whole range of activities; the specific ones to be undertaken by a given country will depend on its needs, priorities, and commitment to follow through. The goal of capacity-building is to allow governments to organize the sector, obtain financial resources, plan and implement investment and other programs, and ensure the sustainability of facilities that are built and the programs that are implemented—especially hygiene education and other high impact health interventions.

Policy Formulation

Central to capacity-building is the development and implementation of policies that will allow efficient sector organization and institutional development to take place. Key issues that need to be addressed include the following.

> The development by governments of national sector plans that clearly establish goals and objectives and foster a sense of organization and purpose that will attract external donor support.
>
> Setting up institutions that have the autonomy and government support that will enable them to establish goals and priorities and operate efficiently.
>
> Creating institutions that respond to public needs and that are oriented to providing services as commercial enterprises.

Widening government acceptance to the role of the private sector in providing financing for and participating in meeting sector goals. This includes taking needed steps to lower the barriers to private sector involvement.

Developing appropriate policies for the regulation of the sector and for the use and protection of natural resources.

Research

While there are many research needs for the sector (see part 3 of this paper), research is not a high priority. Generally speaking, both "hard" and "soft" technologies needed for success in the sector in general terms are now available.

Providing Information and Increasing Access to Information

Numerous efforts are underway to promote better collection and use of information for the sector—including monitoring of sector progress in a given country. Efforts include the development of the Country External Support Information System (CESI) by the World Health Organization and the upcoming establishment of the sector monitoring program (a $4 million plus effort by UNICEF and WHO). Additional work by the Collaborative Council of External Support Agencies is directed to establishing a series of informal decentralized information networks to exchange reports, findings, etc. on critical applied research issues. A.I.D., through the Water and Sanitation for Health Project, has established several of these networks.

Information systems for national program planning, monitoring and evaluation are notoriously weak. But, like other types of technology transfer, can only be successful in the context of an adequate institutional environment.

The greatest need and priority however, is in finding ways to efficiently distribute information, the results of applied research, and experience to persons involved in the day-to-day activities of the sector in developing countries.

New Priorities

The possible interventions listed at the beginning of this section was given in order of the priority given them by developing country governments and external support agencies. From a health-impact point of view, these priorities need changing:

- Capital investments should not be given first priority; instead, capacity-building and policy formulation should take first place. Without strong institutions and a clear sense of direction and practical plans, capital investments can be wasted or at least not used to best advantage. Capital investments, however, can be a good vehicle for leveraging or implementing policy changes and new approaches, as well as meeting sector needs.

- When it comes to capital investment, sanitation should be given priority over water supply. Not only is lack of sanitation a wider problem, it is also a more serious one than lack of water. Without complementary sanitation programs, water supply programs can be jeopardized. All water supply projects should include sanitation.

- Hygiene education is a key element of sanitation and should be the constant theme of sector activities from policy formulation to research to information. It is more important to take steps to assure that all water/sanitation projects have well thought-out hygiene education components than it is to launch new projects.

- Wastewater treatment and drainage, although they should probably remain in third and fourth place after water and sanitation, will be growing problems and will impinge increasingly on the ability of countries to provide safe drinking water. Specific situations will present a strong argument for these interventions in order to avoid or ameliorate severe health impacts.

- Information probably has a greater potential for impact than research; both should concentrate on gaps in our understanding of how to plan and implement successful hygiene education programs.

How A.I.D. should set its agenda for water, sanitation, and wastewater activities is covered in Part 6.

Part 3

DATA GAPS AND APPLIED RESEARCH NEEDS

Lack of Data

The dearth of reliable data and information is a problem that impedes sector programs from three perspectives.

- *For country-level planning.* Most developing countries do not have effective systems for collecting data on sector programs. Data is lacking on such topics as number of operating systems, hydrological conditions, unit costs for systems, and so on. It is no surprise, given this lack, that most developing countries have no water master plans or policies in place.

- *For program development.* Not only is there a lack of published information on successful approaches, but what there is is not easily accessible due to language problems, lack of libraries and documentation centers. This can lead to a serious waste of resources due to the selection of inappropriate solutions (UNICEF, 1989).

- *For improving sector performance worldwide.* Priorities must be set for research so that we know how to use available resources to the best advantage and so that we take careful account of changing economic, social, and environmental conditions that leave an impact on sector activities. Research gaps and priorities are covered in the next section.

Much was accomplished during the Water and Sanitation Decade in developing models for sustainable water and sanitation programs. It is fair to say that the elements of sustainability are now fairly well identified: institutional development and sector planning, development of community awareness and participation—including the increased participation of women, utilization of appropriate, affordable technologies, the integration of water supply with sanitation and hygiene education, the importance of adequate operation and maintenance systems, the mobilization of communities to manage their programs—including cost-recovery measures, and the significance of human resources development. Lack of awareness of these elements can no longer be considered a constraint.

Research Needs

In 1989, the Temporary Working Group on Applied Research, established in 1988 by the International Drinking Water Supply and Sanitation Decade Consultation in The Hague, published the report of its findings (WASH Field Report No. 281). The list of applied research topics contained in the report were developed with the involvement of developing country government officials and representatives of external support agencies. In addition a survey questionnaire was sent out to Collaborative Council members and many research institutions asking for their assistance in defining the issues. The results of this survey were incorporated into the report.

Four basic research gaps were identified. First, given the still very large number of people without water and sanitation services, research is needed to help developing countries determine realistic levels of service for different communities and realistic ways to accelerate their programs. Second, too little information exists about the health benefits of water supply and sanitation or about the preconditions necessary for achieving optimum benefits. Third, applied research should be able to find answers to many vexing operations and maintenance questions: Why are facilities underused? Why do they go out of service so rapidly? Finally, the fourth gap concerns environmental sustainability. Industrialization and modernization can have detrimental side effects on potable water supplies. Conversely, water and sanitation projects may have a deleterious effect on the environment. Applied research is needed on ways of achieving integrated water resource management.

The following is a list of research topics organized under the four gaps discussed above. These were derived from the report of the Temporary Working Group. Only those topics of special significance to the health impacts of water and sanitation are given.

Enhancement of Service

1. *Review and develop methodologies for improving the cost-effectiveness of investment in sanitation.* This research would include studies on the costs and benefits of community participation in WS&S programs and ways in which women and children can be motivated to press for and initiate sanitation improvements.

2. *Study methodologies for selecting particular service level norms and water quality criteria, in particular the trade-offs between the quality and quantity of water needed for domestic purposes in different circumstances.* The aim should be to demonstrate the links between choice of service level and coverage achievable with available resources and to develop guidelines for choice of technology and service level in conjunction with the community.

3. *Investigate ways of encouraging review and use of local norms and standards for service level and water quality and design criteria for WS&S and drainage facilities.* This research should be directed towards ways of changing attitudes and expectations to match realistically achievable targets.

4. *Provide guidance on appropriate ways of mobilizing community support for and participation in the provision of sustainable WS&S in urban fringe and slum areas, with special emphasis on integrated development of water, sanitation, drainage, and waste management.*

5. *Investigate ways of integrating low-cost sewerage into urban housing programs, techniques for retrofitting sewers in built-up areas, and appropriate methods to reclaim wastewater and other wastes for reuse.*

6. *Develop guidelines for training courses, curricula, career structures and incentives to create and retain enough skilled staff to plan, implement, and sustain community-managed WS&S projects.*

Benefits of Improved Water and Sanitation

1. Assess how water supply and sanitation facilities and hygiene education messages and methodologies may best be designed to maximize health benefits and minimize health risks.

2. Develop methodologies for appraising the environmental benefits of waste disposal, drainage and pollution control measures.

3. Evaluate the cost-effectiveness of combining implementation of water supply, sanitation and hygiene education programs, and of integrating there with other activities in the health and education sectors and with solid waste and drainage programs.

4. Examine ways to encourage demand for and use of enough water and sanitation facilities to achieve optimum benefits. At the community level, demand could also be stimulated by investigating ways to make sanitation facilities more appropriate and attractive to beneficiaries. For water-short areas, there is also a need to investigate measures to reduce extravagant demand, or to make most effective use of available resources.

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System Sustainability

1. *Compare different strategies for raising official and public awareness of the need for maintenance of installed facilities.* A review of existing educational materials, health and hygiene education methods, and public awareness campaign strategies should lead to development of guidelines for sector agencies and ESAs on ways of strengthening the promotional messages.

2. *Examine ways in which health education contributes to sustainability of WS&S systems, including cost-effectiveness.*

Environmental Sustainability

1. *Identify which WS&S activities are most at risk from environmental damage to water resources and prescribe protective measures.* Guidelines should be developed which allow planners and designers to anticipate and guard against competing demands for water resources, potential threats from industrial or agricultural pollution, or activities such as deforestation or flood protection.

2. *Determine what environments are most at risk from WS&S activities and what actions are required to protect them.*

3. *Review and develop methods and models for waste management and water resource protection.* Reviews of existing experience should lead to development of a series of models, including legal and organizational frameworks and technical recommendations, for implementing sound environmental management policies.

4. *Identify the potential of and appropriate methods for optimizing reuse of wastewater and other wastes.* The aim should be to review standards and develop a sound scientific basis for water quality standards for different types of use. This should be accompanied by studies of the cost-effectiveness of various water reclamation techniques, and ways of promoting resource recycling, including safe reuse of sewage solids and household waste.

During its deliberations, the temporary working group noted five themes that kept reappearing in the replies from the questionnaire and in the group's discussions. These are

listed below. Note that three of the five apply directly to the environmental health aspect of water supply and sanitation.

- Two shifts in the sector may be noted. One is towards a greater emphasis on sanitation and waste management and away from a disproportionate emphasis on water supply. The other is toward informational and institutional mechanisms to promote the use of existing technologies and away from research on specific technological developments.

- Shortage of water for drinking water supplies is a growing concern. Shortages are being experienced in arid areas and where there is heavy competition from other sectors for the available water or where water sources are being contaminated.

- Institutional development is considered a top priority across the board, especially the need to devise practical community managed approaches to service delivery and other roles for beneficiaries and the private sector.

- Concerns about waste management have come to the fore. There is a need to investigate waste resource and water conservation and to assess what water resource environments are most at risk and which water and sanitation activities are most at risk from environmental damage to water resources.

- A significant level of concern for the problems of urban and peri-urban areas.

Part 4

U.S. CAPABILITIES AND ADVANTAGES

A number of U.S. institutions have significant technical expertise to offer in the area of sanitation, water supply, and wastewater management. These include *professional associations* such as the Water Pollution Control Federation (WPCF), the American Water Works Association (AWWA), and the International City Managers Association (ICMA); many private sector consulting firms, contractors, and equipment manufacturers; private voluntary organizations that fund water and sanitation projects, such as CARE, World Vision, Save the Children, and the World Environment Center; government agencies, such as the U.S. Public Health Service and the Environmental Protection Agency; and institutions of higher learning with significant international programs, such as the University of North Carolina, Johns Hopkins University, and Boston University.

While many U.S. institutions have the required technical expertise, their experience is often limited to the United States and therefore does not automatically qualify them to work effectively in a developing country. They need to develop a special set of skills if the assistance they provide is to lead to long-lasting improvements in developing countries. Most of these are obvious upon reflection. For example, the institutions and their staffs should be able to

- Work professionally in a foreign language and demonstrate an understanding of how cultural norms and values affect behavior;
- Deal with logistic concerns such as compatibility of equipment, travel, transfer of funds, etc.;
- Plan and suggest ideas which are within the capacity of the local institutions to absorb;
- Assess the external environment (legal, political, and regulatory) in which the local institution operates and recommend actions within those constraints;
- Understand the importance of using technology appropriate to the situation;
- Assess the skill levels of local staff and understand the organizational constraints they operate under (compensation, access to equipment, etc.);

- Transfer skills to counterparts through training and coaching; and

- Understand that the end goal of development is the creation of conditions for local institutions to carry on themselves after the technical assistance is terminated.

Few organizations have acquired the skills necessary to work successfully in the Third World. However, as A.I.D. shifts its attention to urban problems, more of the U.S. experience will become relevant.

In the area of *research* in sanitation and water supply, U.S. organizations are concerned almost entirely with the problems of the United States and other industrial countries. The principal research for developing countries is carried out by such organizations as the World Bank, the United Nations Development Program (UNDP), the International Development Research Center (IRDC), the International Reference Center (IRC), the London School of Tropical Medicine and Hygiene, and the International Diarrheal Disease Research Center, Bangladesh. To be relevant to developing countries, the very considerable U.S. research organizational skills would have to be reoriented, as discussed above.

Despite the long learning curve for making the transition from U.S. experience to competence in the Third World, in the last several years a number of U.S. organizations have manifested an interest in working in developing countries. For instance, the American Water Works Association (AWWA) is forming Water for People, a private voluntary organization that will fund some rural water supply and sanitation projects and develop technical assistance activities for cities in the Third World. The National Rural Water Association (NRWA) is providing the services of its members to replicate overseas its successful U.S. rural operations and maintenance schemes. Some U.S. universities are expanding or starting up international development programs—often with a focus on environmental health issues.

A.I.D. and its program can play an important role in helping U.S. organizations develop the skills to work effectively in developing countries. First, a careful assessment should be made of organizations favorably disposed to moving up on the learning curve. Following that, A.I.D could support various activities: preparing written materials, holding workshops, teaming up with organizations already experience in working the developing countries, and so on.

U.S. institutions with the required technical background but without developing country experience will need to be brought along carefully. The transition will take time—years, not months—and should be viewed as an investment for the future.

Part 5

CURRENT ACTIVITIES IN DEVELOPING COUNTRIES

Water and sanitation activities in developing countries are carried out by governments, external support agencies, private businesses, and individual households. Information on the relative contribution to the sectors of these four entities is not very reliable, and there is almost no information on private businesses and households. It is clear, however, that most investments in the sector are made by governments and external support agencies.

According to the Canadian International Development Agency (Grover, 1988) 95 external support agencies are active in the water and sanitation sector: 21 bilateral programs, 32 multilateral institutions, and 42 major nongovernmental organizations. There are also several international reference and research centers in various parts of the world concerned with water and sanitation.

Of the 21 bilateral agencies, 12 are in Western Europe, 2 in North America, 4 in the Middle East, and 3 in Asia. No reliable information is available on development assistance provided by the U.S.S.R., China, or Eastern Europe.

Eighteen of the 32 multilateral agencies are United Nations organizations. The most active in the sector are the World Health Organization, UNICEF, and the U.N. Development Program. In addition to the World Bank—the largest single source of finance in the sector—and the European Economic Community, there are 12 regional banks and funds including the Inter-American Development Bank, the Asia Development Bank, the African Development Bank, the Arab Fund for Economic and Social Development, and the Islamic Development Bank.

There are hundreds of NGOs. It is an extremely diverse group that has been active in the sector longer than most bilaterals and multilaterals. The projects they support are small and usually located in rural areas. In recent years, bilaterals have begun to channel their support through NGOs.

According to WHO estimates governments and external agencies provided $70 billion to the sector in the 1981-1985 period. That is an average of $14 billion per year. For the period 1985-1989, the World Bank puts the yearly level of sector investments at $9.3 billion for governments and external support agencies (in 1985 dollars). The lower rate of investment probably reflects slow or negative economic growth in many developing countries. According to CESI data, external support agencies provided about $3 billion per year of the $9.3 billion during 1985-1989. (Global Consultation, 1990) In some countries external support agencies play a very significant role, providing up to 80 or 90 percent of the investment in the sector.

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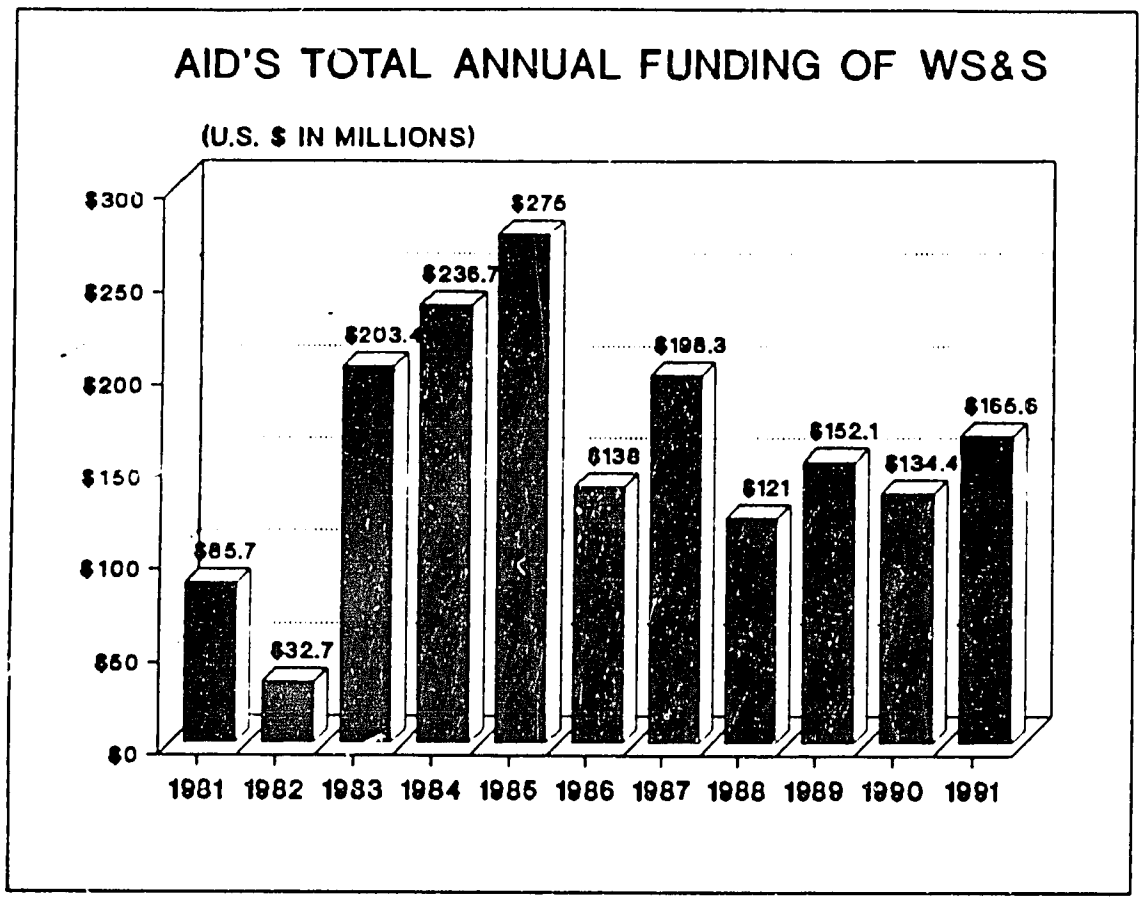
Of the external support agencies, multilaterals accounted for about 60% of the $3 billion and bilaterals for about 40%. The remainder comes from NGOs.

During the 1981-1988 period A.I.D. funding for water supply and sanitation totalled approximately $1.2 billion (11% of bilateral funding). Much of this went to large infrastructure projects in Cairo and Oman. Not counting those two countries the total funding for A.I.D. projects worldwide was only about $120 million (excluding housing-related projects). The annual and regional amounts are shown in Figure 5.

Even though A.I.D. is not a major funder it can still play a major role if it selects its activities carefully and aims for collaboration with another organization and stimulation of private sector involvement. A.I.D. was the first bilateral to provide significant bilateral assistance (Grover 1988) and as such has 30 years of experience and lessons learned to share with other agencies. In addition, the Water and Sanitation for Health Project (WASH) is a valuable A.I.D. resource in the sector.

As the Decade drew to a close, agencies in the sector realized more and more the importance of collaboration. In November 1988, representatives of external support agencies met to establish a Water and Sanitation Collaborative Council. The aims of the council are "To maintain Decade Momentum beyond 1990 and accelerate the provision of water supply and sanitation services to all, with emphasis on the unserved rural and periurban poor, by using a coordinated programme approach." The council is part of a Framework for Collaboration that includes governments and NGOs. Improved cooperation has the potential to increase the flow of funds, rationalize investments, increase the impact of applied research, and improve the sharing of information. (Carnemark, 1989). During the 1990s the need for cooperation will become even more important due to the worsening of environmental problems (many of which have no national boundaries), the needs of Eastern Europe, and the increased role of Japan in development assistance.

Figure 5



Funding for Water and Sanitation
By Region and Account
(in millions of dollars)

Region	FY90	FY91
Africa	3.7	4.1
Asia/Near East	112.8	142.4
Latin America/ Caribbean	12.4	14.2
Global	5.5	4.9
Total	134.4	165.6

Part 6

ADVISORY COMMENTS

The Context

Advisory comments on the need, the priority, and the relevance of programs in the water and sanitation sector should be placed in the context of the goals and objectives of A.I.D., the nature of the A.I.D. organization, and the strategies that A.I.D. is supporting. A quick review of these points follows:

A.I.D. published a mission statement in a December 1990 document entitled "Toward Strategic Management." According to this document, A.I.D.'s mission is to assist nations throughout the world "to improve the quality of human life and to expand the range of individual opportunities by reducing poverty, ignorance and malnutrition." A.I.D. meets these objectives through a worldwide network of country missions which develop and implement programs guided by six principles:

- "support for free markets and broad-based economic growth;
- concern for individuals and the development of their economic and social well being;
- support for democracy;
- responsible environmental policies and prudent management of natural resources;
- support for lasting solutions to transnational problems; and,
- humanitarian assistance to those who suffer from natural or man-made disasters."

Most of these principles have been a part of A.I.D.'s mission for a long time. However, several areas are new or have been given a high priority in the formulation of A.I.D.'s programs. These include the support for free markets and democracy, an emphasis on achieving long-term economic growth, and a real concern for the impact of development on the environment. Along with a shift in emphasis, several strategies (like non-project assistance, decentralization of governments, opening of markets and increasing private sector roles) have emerged. These strategies reflect not only the new priorities but they also recognize key A.I.D. strengths—its worldwide network of development professionals and experience with policy reform—and, some of its limitations—limited financial resources facing

an ever-growing portfolio of potential programs. These strategies also attempt to place project development in a context in which the conditions exist for a high likelihood of achieving sustainable, high-impact results.

The development of an environmental health strategy should be based not only on how well each of the program elements meshes with the explicit A.I.D. objectives but how well the strategies for the potential program element coincide with the strategies being selected by A.I.D. to accomplish its overall mission. A program to finance the construction of wastewater treatment plants in urban areas around the world, for instance, will not likely find much support within the agency. On the other hand, programs that use the priority strategies to help developing countries develop their own capacity to build such plants, necessary regulatory frameworks, open markets with private sector involvement, and systems for selecting, financing and managing sound pollution control programs and facilities, will likely be supported.

The following sections of this paper describe how sanitation, water supply, drainage and wastewater management fit within and enhance the A.I.D. portfolio.

The Need

Throughout this paper the discussion of basic sanitation and water supply has emphasized their relevance to improving environmental health in and around the home—phrased above as the, "concern for individuals and the development of their economic and social well-being." Sanitation and water supply are services that not only address the fundamental question of well-being but they are also critical elements of preventive primary health care. *Significant burdens to the health care systems of developing countries could be eliminated through adequate water supply and sanitation services and practices.* The burden of water and sanitation-related diseases in developing countries was highlighted earlier in this paper.

Water supply also addresses other key areas of development. No country has every developed into a stable economic force without adequate water supplies and services for its population and industry. A strong correlation exists between per capita water use and per capita gross national product (GNP). In fact, some countries like Thailand, which have successfully developed economically with easy access to water resources, are facing diminishing economic returns on investments because of the lack of adequate water supply infrastructure for ever-increasing growth. In addition, water resources, the upstream portion of the water supply equation, is often a critical transnational issue. It is well known that the settlement of antagonism among the middle east countries of Turkey, Israel, Syria, Jordan, and Iraq lies partially in the resolution of water resource allocations.

Drainage and wastewater management are less directly related to the home environment but play a key role in making the community a sanitary environment to live in under conditions

that will support economic development. When drainage or wastewater management are inadequate, it is not only the immediate community that is at risk. The downstream population may also be exposed to or adversely affected by the contamination and watershed deterioration that often results. Much less data is available on the health impact of these two areas than for basic sanitation and water supply. However, support could be drawn from the high level of need for selected wastewater management expressed by A.I.D. missions. It should be noted that attempts to blindly direct developing country capital investments to wastewater treatment facilities are increasingly being met with resistance and suspicion—probably from the fear that these investments will not meet the immediate needs of the country and will be a drain on financial resources.

Drainage improvement appears to have more appeal as a general sites and services investment rather that as a broad-based health intervention. Some flexibility should be used, however, to allow for the support of those drainage project investments that could have a direct and demonstrable impact on overall community disease reduction—diarrhea, malaria, dengue, or typhoid or protect other health related investments.

Recommendations

Using the goals and objectives and the priority strategies of A.I.D. as a guide, we have developed a list of three priority interventions for A.I.D. as the highest priorities for the sector. Note, however, that, in general, within the sector, health impact could best be achieved by emphasizing:

Sanitation
Water Supply
Wastewater Management (Selected)
Drainage

in that order, but allowing for mission priorities to be dictated by the specific needs, objectives, and capabilities of the mission and the country.

There are other worthwhile activities for A.I.D. to undertake; many of those are mentioned in other sections of this report; here the concentration is on establishing clear priorities.

Capacity Building

The emphasis on capacity-building comes from several points of view: The very high demand for sanitation, water supply, drainage, and wastewater management facilities to meet developing country health and infrastructure needs; continued or accelerating growth in the demand for services and increased urbanization; the difficulty, despite the impetus provided by the Water and Sanitation Decade, of increasing coverage much beyond the pace of

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population growth; the important role that management plays in managing and developing natural resources (water being a prime one) and preventing pollution of the environment (see Figure 6); and A.I.D.'s ability and willingness to implement long-term institutional development projects and to address the parallel policy and sectoral reform issues that are critical to success.

It is also important to note assessments by the World Bank and others that the external financing agencies will only be able to meet a small percentage (perhaps 10% or less) of the long-term financing needs of the sector. Table 6 shows the amount of investment in 1985 dollars that would be needed to meet relatively modest coverage goals (for water supply, 75% coverage in urban areas and 50% in rural; for sanitation, 50% in urban areas and 20% in rural), by the year 2000, given projected rates of population growth and urbanization. The table assumes the use of low-tech, affordable technologies whenever possible. Unit costs are from World Bank estimates.

According to the projections in the table the yearly investment necessary is over $15 billion. This should be compared with the estimated level of investment of $9.3 billion yearly on the part of developing countries and external support agencies from 1985 to 1990 (see Part 5). The shortfall is substantial, and it holds several implications for developing countries. They must be able to use what resources they have most effectively; they must be able to find and integrate new sources of finance; and they must take advantage of all opportunities to coordinate efforts on all levels.

These observations argue for a capacity-building strategy rather than a capital investment strategy. By combining capacity-building and selected capital investment, A.I.D. would be able to use capital projects as a vehicle that would address the wider policy and sectoral reform issues and have benefits beyond the project at hand. Alternatively A.I.D. could use its resources and skills to accomplish the institutional development and sector reform objectives while the capital financing is provided by another donor. In addition, building capacity at the country level will give recognition to the fact that progress in achieving full, sustainable service coverage is currently limited by country capabilities (regardless of how much capital is available) and will help provide the infrastucture needed for the self-sufficiency in basic service provision that can only come with high levels of economic growth.

Sanitation Interventions

Despite the progress in water supply achieved during the Decade, sanitation did not keep pace. And, sanitation facilities coverage is expected to decline in the next ten years in absolute numbers. In peri-urban areas, where private sector water vendors often step in to fill the gap in public water supply, there is little support for a parallel option for sanitation. Furthermore, even where water supply and sanitation facilities are constructed, the hygiene education that should accompany them is often missing—resulting in a lessened or non-existent health impact.

Figure 6

The Cycle of Resource Development and Pollution

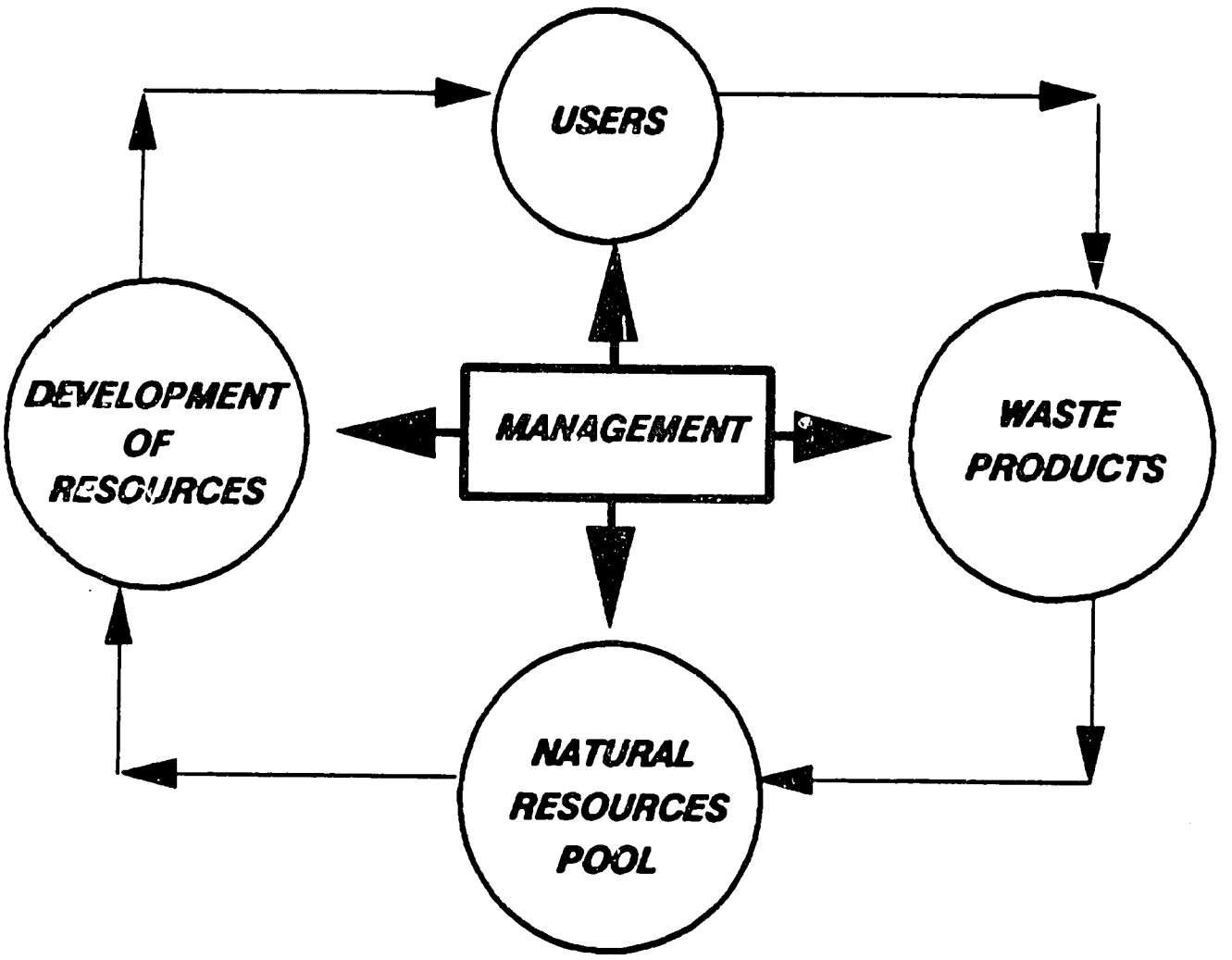

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Table 6

Water Supply and Sanitation Services and Investment Requirements in Developing Countries, 1990-2000

	1990		Annual Growth %	2000	
	Number (10^6)	%	1990-2000	Number (10^6)	%
Population					
Urban	1446	36	(3.5%)	2050	43
Rural	2614	64	(0.5%)	2750	57
TOTAL	4060	100	(1.75%)	4800	100
Served					
Urban	983	68		1538	75
Water Supply	550	38		1025	50
Sanitation					
Rural					
Water Supply	1100	42		1375	50
Sanitation	392	15		550	20

	Incremental Population to be Served 1991-2000		
	Pop. 10^6	Cost/ Person	Total Cost in 10^6 (1985 US$)
Urban			
Water Supply	555	120	66600
Sanitation	475	150	71250
Sub-total			137850
Rural			
Water Supply	275	40	11000
Sanitation	158	20	3160
Sub-total			14160

Urban/year: $13.8 Billion
Rural/year: $1.4 Billion
Bank investments in WSS/year 1991-2000 in lending at $900 million/year would finance only about 6% of expected investments.

Source: Rietveld, 1988.

Because of the significant health impact that can be achieved through hygiene education and sanitation facilities construction, these areas should receive priority attention. Even without any construction, significant reductions in water and sanitation-related diseases could be achieved with low-cost, culturally appropriate hygiene interventions. In addition, more attention to the institutionalization of options to high-cost sewerage systems could help lower the per capita cost of sanitation and ensure extension of service to greater numbers of the poor.

Environmental Protection (with a Health Focus)

As mentioned above, in developing countries, little attention has been given to environmental protection in general and to wastewater management and drainage in particular. In some cases the lack of attention is due to the assumed low impact that wastewater management might have in reducing the disease burden, in others it is lack of recognition that there is a severe health problem. However, given the state of economic development of many developing countries, it is pointless to try to introduce such interventions as wastewater treatment (with its high operations and maintenance costs) unless there is an immediate need for the facility and an adequate capability and budget to support its ongoing operation. Instead of embarking on wastewater treatment campaigns, A.I.D. should:

- Be selective in its financing of wastewater treatment facilities—recognizing that construction for many can be deferred to the future while others are needed to address immediate and/or irreversible health or environmental impacts.

- Assist countries in developing the necessary regulatory frameworks and institutional capacities that are needed for pollution control.

- Assist countries to develop the capacities and tools that are needed to set priorities and determine what actions need to be taken—including strategies that rely on waste minimization and resource conservation.

- Assist countries in developing an awareness of the need to address sanitation and wastewater components of environmental health.

It goes almost without saying that all these priority interventions should be carried out with careful attention to the elements of sustainability: community participation, use of appropriate technologies, cost recovery mechanisms, operations and maintanance, etc. An approach to water supply and sanitation development that stresses community participation and hygiene education is essentially a democratic initiative, and stressing capacity-building underlines the autonomy and dignity of other nations.

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AIR POLLUTION AND HEALTH IN DEVELOPING COUNTRIES

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AIR POLLUTION AND HEALTH IN DEVELOPING COUNTRIES

INTRODUCTION

Air pollution is no longer a problem that is limited to the urban areas of industrialized countries. Increasing urban populations in developing countries, accompanied by growths in transportation, energy consumption and industrial activity, contribute to the poor quality of the ambient air in many of the major industrializing cities of the world. An estimated 60 to 80% of the urban population worldwide breathe ambient air of marginal or unacceptable quality (PAHO, 1990).

Although not well documented, the adverse health effects associated with exposure to ambient air pollution in developing countries may be substantial, particularly in high risk groups such as the young, elderly, and those with preexisting disease. Pollution of the indoor environment from the combustion of fossil and biomass fuel, primarily for cooking and heating in poorer nations of temperate zones, has been associated with respiratory disease and cancer in exposed individuals. Air pollution may play an important role in the etiology of respiratory infections, which are responsible for approximately one-third of the deaths in children less than five years old in developing countries.

This report reviews the available information on air pollution and health in developing countries, discusses strategies for air pollution prevention and control, and identifies data gaps and applied research needs. The welfare and ecological effects of air pollution, acid rain, and the global issues of stratospheric ozone depletion and global warming are outside the scope of this report. An additional area that is not discussed, but that is of particular relevance to developing countries, is the issue of accidental releases of pollutants to the environment. The devastating effects of Bhopal and Chernobyl are reminders of the potential threats to human health and the environment that accompany the growth of developing and industrialized nations.

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THE MAJOR AIR POLLUTANTS OF CONCERN

Air pollution is a complex mixture of substances emitted as a result of a variety of human and natural activities. The major air pollutants of concern can be divided into two groups: (1) the often ubiquitous pollutants for which air quality criteria, standards or guidelines have been developed by the United States and other nations, including particulate matter, sulfur dioxide, carbon monoxide, lead, nitrogen dioxide, and photochemical oxidants (ozone); and (2) the large group of agents referred to as toxic air pollutants, including substances such as benzene, asbestos, polycyclic organic matter, methyl isocyanate, metals, and thousands of others.

Exposure to air pollutants is associated with a variety of health effects, ranging from mortality at high concentrations to more subtle biochemical, physiological or pathological effects. Air pollutants may cause cancer or toxicity to the respiratory system, central nervous system, reproductive system, heart, and other organ systems. Effects may be short-term or chronic in nature, and may be reversible or permanently debilitating. The likelihood that a pollutant will cause adverse health effects depends upon the nature and concentration of the pollutant, the effect of concurrent exposure to other pollutants, and such factors as the age, sex and sensitivity of the individual.

The important sources of air pollutants and their health effects are discussed below. A summary of this information is provided in Table 1. Ambient air standards and guidelines established by the U.S. Environmental Protection Agency (EPA) and the World Health Organization (WHO) for air pollutants are shown in Table 2.

Particulate Matter

Particulate matter consists of a broad class of solid and liquid materials that are physically and chemically diverse, ranging in size from 0.005 μm to around 100 μm. The most significant anthropogenic source of particulate matter is the combustion of fossil and biomass fuels. Other sources include motor vehicles, industrial processes, agricultural practices, smoking, and gas-particle conversions of sulfur dioxide. Important natural sources include road and desert dust, volcanoes and forest fires.

The impact of particulate matter on health is related to its varied physical properties and chemical composition. Data on respiratory tract deposition and health effects indicate that respirable particles with an aerodynamic diameter smaller than or equal to 10 μm (designated PM_{10}) are most likely responsible for lung damage and aggravation of existing respiratory disease. The U.S. EPA, following the convention of the International Standards Organization (ISO, 1981), has adopted PM_{10} as the indicator for particulate matter. Other countries and organizations (including WHO) continue to use total suspended particulates (TSP, which includes particles up to sizes of 25-45 μm) and smoke as indicators for particulate matter.

Information on the health effects of particulate matter come from a number of community epidemiological studies and from controlled human and animal studies (EPA, 1986a; 1986b). Due to the coexistance of particulate matter, sulfur oxides and acid sulfate aerosol in most urban situations, it has been difficult to quantify the association between levels of these individual pollutants and the morbidity and mortality observed in epidemiological studies. Analysis of air pollution episodes has shown that short-term concentrations of particulates and sulfur dioxide in excess of 1000 $\mu g/m^3$ can result in an increase in mortality. Short-term extreme exposures have also been associated with an exacerbation of existing respiratory conditions, such as bronchitis and asthma. Concentrations of PM_{10} in the range of 140-350 $\mu g/m^3$ (approximately 200-400 $\mu g/m^3$ of TSP) may be associated with small, reversible declines in lung function. Increased respiratory symptoms and disease, and reductions in lung function, have been attributed to long-term PM_{10} exposures above 80 $\mu g/m^3$ (180 $\mu g/m^3$ TSP). Carcinogenic substances, such as many polycylic aromatic hydrocarbons and metals, may also be present as particulate matter.

Sulfur Dioxide

Sulfur dioxide is a colorless, corrosive gas that is emitted in large quantities by the combustion of sulfur-containing fuels in utility and industrial boilers and in numerous smaller coal and oil combustors. Other sources include the smelting of nonferrous ores and natural sources (e.g., volcanoes).

The most striking acute response to sulfur dioxide is bronchoconstriction, or narrowing of the airways, in exercising asthmatics and other sensitive individuals at levels generally above 0.3 ppm (about 700 $\mu g/m^3$).

Epidemiological data suggest that long-term average concentrations exceeding 100 $\mu g/m^3$ may be associated with respiratory illness and symptoms. High concentrations of sulfur dioxide in combination with particulate matter have been associated with increased risk of mortality (EPA, 1986a; 1986c).

Carbon Monoxide

Carbon monoxide is a colorless, odorless gas that is formed naturally in the decomposition of organic matter, which accounts for 60-90% of global emissions (WRI, 1988). The most important anthropogenic source of carbon monoxide in some urban environments is motor vehicles. Other sources include industrial processes, incomplete combustion of gas and biomass fuels in stoves and heaters, and smoking.

Cardiovascular effects, particularly in individuals suffering from chronic angina pectoris (pain or pressure in the chest due to insufficient oxygenation of heart muscle), are the effects of greatest concern from exposure to ambient levels of carbon monoxide. Exposure to carbon monoxide has been associated with central nervous system effects such as impaired visual perception and learning ability. Limited animal toxicity data suggest that carbon monoxide may produce adverse effects on the developing fetus or newborn. The 8-hour and 1-hour standards of 9 ppm (10 mg/m^3) and 35 ppm (40 mg/m^3), respectively, are considered by EPA to protect sensitive individuals from the adverse effects of carbon monoxide (EPA, 1984).

Lead

Humans are exposed to lead in a variety of media, including the air, food, water and cigarette smoke. Although dietary consumption is considered to be the main route of exposure to lead in the general population, exposure through the ambient air can be significant. The largest ambient air source of lead in urban areas is from the use of leaded gasoline in motor vehicles. Other sources include industries involved in the production and use of lead, such as smelters and battery plants.

Studies have shown that exposure to lead is especially toxic to children (EPA, 1986d; 1990). Elevated blood lead levels have been associated with neurological effects such as decrements in IQ and behavior changes, hematological alterations such as increases in blood pressure, and metabolic

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alterations. Prenatal lead exposure may pose a hazard to the developing fetus by altering fetal growth. In addition, animal data support the classification of lead as a probable human carcinogen (EPA, 1989a).

Nitrogen Dioxide

Once released to the atmosphere, nitric oxide is rapidly converted by photochemical oxidation to nitrogen dioxide. Anthropogenic sources of nitric oxides far outweigh natural sources (primarily lightning), particularly in temperate industrialized regions (WRI, 1989). The most important anthropogenic sources of nitrogen oxides are motor vehicles and the generation of energy by utility and industrial boilers. Other sources include gas stoves and heaters.

Adverse health effects associated with exposure to nitrogen dioxide have generally been reported at concentrations above 1 ppm. Effects of concern include acute respiratory effects (particularly in asthmatics, individuals with chronic respiratory disease, and children), and increased susceptibility to infections (EPA, 1982). Intermittent exposure to high concentrations of nitrogen dioxide appear to be more important from a health standpoint than long-term exposures to lower levels.

Photochemical Oxidants (Ozone)

Ozone, which is a major component of urban smog, is formed in the troposphere by complex photochemical reactions involving anthropogenic and natural hydrocarbons, nitrogen oxides and oxygen. Hydrocarbons are emitted primarily from incomplete combustion of fossil fuels, particularly by motor vehicles. Other sources of hydrocarbons include industrial processes, the storage and transportation of fossil fuels, and solvent evaporation (WRI, 1989).

Exposure to ozone can cause a wide range of effects, including eye and lung irritation, acute and chronic lung function impairment (especially in sensitive individuals), increased susceptibility to respiratory infection, and possible lung damage from long-term exposures. The susceptibility to ozone exposure has been related to activity level and environmental stress (e.g., humidity, high temperature). Exercising individuals and those with preexisting respiratory disease appear to be at greater risk to the effects of ozone exposure (EPA, 1989b).

Toxic Air Pollutants

In the U.S., the term "toxic air pollutants" includes all air pollutants for which ambient air criteria do not exist. Over 3000 substances have been detected in the ambient air. In addition to the estimated 70,000 chemicals that are known to be in commerce today, a substantial number of chemicals are formed in chemical processes and by atmospheric reactions. Toxic air pollutants are emitted from a wide variety of stationary and mobile sources. Major sources include large industrial facilities, combustion sources of various types and sizes, and motor vehicles. Other sources include commercial facilities that use solvents and facilities that treat, store and dispose of hazardous wastes. Elevated ambient concentrations of toxic air pollutants are generally found in large urban or industrialized areas. The residential combustion of fossil and biomass fuel is an important indoor source of toxic air pollutants in developing countries.

Toxic air pollutants include a large number of known or suspected carcinogens, such as benzene, asbestos, formaldehyde, vinyl chloride, and many products of incomplete combustion (e.g., benzo-a-pyrene). Occupational and indoor air exposures to carcinogens have been associated with elevated rates of cancer. The evidence of cancer from ambient air exposure to air pollutants is inconclusive, although cancer dose-response data from occupational and animal studies have been extrapolated to estimate public cancer risks at lower ambient levels. Exposure to toxic air pollutants may also be associated with respiratory effects, reproductive and developmental toxicity, neurotoxicity, and other systemic effects.

POLLUTION LEVELS IN DEVELOPING COUNTRIES

The nature and magnitude of the air pollution problem in developing countries, as elsewhere in the world, is related to the types of pollution activities, the geographic location and the climate. While many areas have similar types of industrial, commercial, residential and transportation-related sources of pollution, the complex mixture of substances in the air of different urban or rural areas can vary considerably (WHO, 1984). There may also be large temporal and spacial differences in pollution within one geographic location.

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In the following section, ambient and indoor air pollution are discussed separately. This distinction is somewhat artificial, since indoor sources of pollution may impact ambient air quality, and vice versa. Furthermore, people typically spend time in several microenvironments throughout the day. The quantitative aspects of the indoor/outdoor relationship in developing countries are not well understood.

Ambient Air Pollution

The available information on levels of air pollution in developing countries is limited. An important source of information on air pollution in urban areas of the world is the Global Environmental Monitoring System (GEMS) air monitoring network, which was established by WHO and the United Nations Environment Programme (UNEP) in 1973 (Akland et al. 1991; de Koning and Kohler, 1978; WHO, 1984). The objectives of GEMS are to assist countries in air pollution monitoring, promote the global exchange of environmental information, and provide a basis for assessing the impact of air pollution on public health. Monitors are located in approximately 50 counties (175 sites in 75 cities), with several dozen stations in Latin America and Asia, and a few in Africa (Figure 1). Pollutants measured routinely include sulfur dioxide and suspended particulate matter, with some additional measurements of nitrogen dioxide, carbon monoxide and lead.

Data from GEMS indicate that over one billion people live in urban areas where the levels of particulate matter exceed the WHO chronic and acute guidelines (Table 3). An estimated 625 million people live in areas where the level of sulfur dioxide exceeds the chronic health guideline, and nearly one billion people live in areas where the peak sulfur dioxide concentrations are unacceptable. Figures 2 and 3 show that with few exceptions, the worst polluted cities that report data are in industrializing countries. The concentrations of suspended particulate matter in many cities are especially high, often reaching levels up to several-fold higher than the WHO guideline[1]. The GEMS data show that the majority of the monitoring stations in South America and Asia exceed the WHO guidelines for particulate matter (over 90% exceed the guidelines in Asia), while a lower but significant number of stations in these

[1] The GEMS particulate matter data should be used with caution in assessing the severity of pollution from a health perspective. Samples from some areas may contain high concentrations of nonrespirable, naturally occurring dust.

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countries exceed the sulfur dioxide guidelines (Table 4).

Less information is available concerning ambient levels of carbon monoxide, lead, nitrogen dioxide, ozone and toxic air pollutants in developing countries. A trend of increasing emissions of carbon monoxide in industrializing countries is likely, primarily due to the rapid growth in the number of motor vehicles. As many as half the cities in the world may be experiencing concentrations in excess of WHO guidelines (Akland et al., 1991). Lead exposures in urban areas may be a major problem due to poorly controlled industrial emissions and the continued use of leaded gasoline. Average nitrogen dioxide concentrations are below levels of concern in most urban areas of developing countries for which data exist. Levels of ozone may be high in developing countries due to large emissions of precursors (nitrogen oxides and hydrocarbons) and atmospheric conditions that are conducive to ozone formation, but quantitative information is lacking. Information on levels of toxic air pollutants are insufficient, although high levels may exist close to poorly controlled industrial sources and in urban areas with high numbers of motor vehicles.

The effects of these high levels of air pollutants on health in developing countries have not been well studied, but the impact may be substantial. In general, it is very difficult to quantify adverse health effects of ambient air pollution, except under severe pollution episodes, because of the complex nature of environmental exposures and the many confounding variables (e.g., lifestyle, smoking, existence of preexisting disease, etc.).

Indoor Air Pollution

An increasing number of studies have documented the public health importance of indoor exposure to such pollutants as carbon monoxide, particulates, nitrogen dioxide, and gas-phase volatile organic compounds. Although the special characteristics of indoor environments in developing countries have not been as well studied as in industrialized nations, there is a growing recognition that indoor air exposures in rural and urban areas of the developing world may pose significant public health risks. The combustion of fossil and biomass fuel for domestic heating and cooking in temperate climates is of particular concern from a health perspective, especially for women, infants, the elderly, and other sensitive populations (de Koning et al., 1985; Smith, 1987).

About half of the world's population uses biomass fuels (wood, crop residues and animal dung) as a major source of energy for cooking and heating (de Koning et al., 1985). Cooking and heating stoves range in design from open burning with no combustion chamber to enclosed chambers with a flue vented to the outside. Many of the stoves are primitive or poorly designed, and ventilation is often inadequate. Studies have shown that in numerous locations around the world, the burning of biomass fuels has routinely produced particulate concentrations exceeding 1000 $\mu g/m^3$ (several-fold higher than WHO guidelines), carbon monoxide levels exceeding 35 ppm, and concentrations of the carcinogen benzo-a-pyrene exceeding 1000 ng/m^3. Information on the acute and chronic health effects associated with exposure to biofuel emissions comes from a number of anecdotal reports and quantitative studies (Smith, 1987). The most significant health effects for which evidence exists include chronic obstructive lung disease (from studies in Papua New Guinea, India and Nepal) and acute respiratory infection (in Africa, Papua New Guinea, India and Nepal). Additional effects may include cardiovascular disease, low birth weight and other perinatal effects due to maternal exposure. Biomass and fossil fuels contain numerous carcinogenic species (e.g., polycyclic aromatic hydrocarbons, formaldehyde). While the association of biomass fuels with cancer is primarily anecdotal, high rates of lung cancer have been related to the combustion of domestic "smoky coal" (a fossil fuel) in China (Mumford et al., 1987).

CASE STUDIES

The following case studies illustrate the varied nature of the air pollution problem in selected countries and the types of monitoring and health information that are available.

Beijing, China (from Krupnick and Sebastian, 1990)

Beijing is a densely populated urban area with a large number of industrial enterprises, high levels of natural dustfall, relatively few motor vehicles, and many low efficiency coal burning stoves used for household cooking and heating. The known air pollutants of greatest concern in Beijing are particulates and sulfur dioxide. Other pollutants of concern include lead and carbon monoxide. The major sources of these pollutants are: (1) the use of unwashed, unscreened bituminous coal with high ash content; (2) combustion of

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coal in industrial and commercial boilers that are old and inefficient, and in residential stoves for cooking and heating; (3) severe dust storms that may contribute from one-third to 60% of the total dust fall; (4) high energy requirements due to poor insulation; (5) inadequate pollution controls; (6) proximity of population to sources of pollution; and (7) limited market incentives for pollution control.

The health effects associated with exposure to air pollution in Beijing are not well quantified. Studies have shown that rates of lung cancer, chronic bronchitis and chronic respiratory infections are higher in urban areas of China compared to the countryside. One study estimated that air pollution causes 3.5 million work loss days per year and 600 premature deaths in Beijing and other urban areas of China.

Ankara, Turkey (from Sebastian, 1990)

Ankara is a rapidly growing city with a high level of commercial and government-related activities and relatively few large-scale industries. The major known pollutants of concern are sulfur dioxide and particulate matter, which are emitted in large quantities from the combustion of coal and lignite by residential, commercial and industrial sources. Very little information is available on the emissions of other pollutants. Mobile source emissions are likely to be high near the center of the city. The main causes of pollution in Ankara are: (1) the widespread use of lignite, which has a high sulfur and ash content, as a heating fuel; (2) the high urban population growth, and resulting increased use of lignite; (3) topographic and climatic conditions that favor inversions and air stagnation; and (4) the use of leaded gas for motor vehicles.

Information on the relationship between air pollution and health in Ankara is inadequate. Local studies have suggested a link between decreased respiratory function in children and high levels of sulfur dioxide and particulates. Clinical cases of respiratory disease and decreased lung function have been observed during periods of severe air pollution.

Bangkok, Thailand (from AID/EPA, 1990)

This recent comparative risk study of environmental problems in Bangkok, Thailand, attributed rising levels of pollution to increasing population,

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industrial activity and motor vehicle use. Two air pollutants that ranked in the high risk category are total suspended particulates and lead.

The most important sources of particulate matter include industry, construction, transportation, fuel combustion and trash burning. Particulate levels exceeded the WHO guideline by up to two-fold. Data on ambient levels were used to estimate that particulate matter pollution could be responsible for up to 50 million restricted activity days and up to 1400 excess deaths annually.

Sources of lead include motor vehicles, industrial sources and smelters. Levels of lead monitored at curbside were up to several-fold higher than the WHO guideline. Adverse health effects from total exposure to lead could be responsible for many cases of neurological, cardiac and other effects in children and adults.

Motor vehicles were identified as the major source of ambient carbon monoxide, which was ranked in the medium risk category. With ambient concentrations at curbside up to twice the WHO guideline, an estimated 20,000 people with heart disease could be at moderate risk of angina pain. Nearly one million people could be at low risk of milder symptoms. Other pollutants (sulfur dioxide, nitrogen dioxide, ozone and air toxics) were assigned to the low risk category. Little information was available on the levels of these pollutants in Bangkok.

Brazil (from PAHO, 1990; Briscoe, 1990)

São Paulo is the most densely industrialized region in South America, with an estimated 45,000 industries and a population of 16 million inhabitants. A considerable amount of pollution is attributed to diesel-fueled vehicles. In the 1970s, high air pollution levels were responsible for mortality and respiratory morbidity. The situation has improved considerably since that time, due to a State program to control industrial pollution and the use of alcohol-fueled vehicles. Particulate, smoke, ozone and hydrocarbon precursors continue to be high, but levels of sulfur dioxide, carbon monoxide and nitrogen oxides have decreased.

Little quantitative information is available on air pollution levels in other parts of Brazil, including the highly industrialized cities of Rio de Janeiro and

Rio Grande do Sul. In northeastern Brazil, there are reports of heavy sulfur and fluoride pollution from an aluminum plant in São Luiz, and high levels of sulfur dioxide in Salvador, Recife. There is no information on air pollution-related health effects in this part of Brazil. The capacity for environmental analysis and control outside of São Paulo and Rio de Janeiro is limited.

Nepal (from Smith, 1987)

In a review of studies from Nepal, Smith (1987) presented data suggesting that exposure to emissions from the domestic combustion of biomass fuels may be an important risk factor for cardiovascular and respiratory disease. In two villages at the edge of Katmandu valley, firewood is used as the main fuel for cooking and heating. The two types of stoves that are used are a simple cooking stove with a small combustion chamber, and a brick or rock-lined depression in the floor. The stoves may be in use for many hours each day, and ventilation is poor. An evaluation of risk factors for chronic bronchitis in the two villages indicated a strong association with the number of hours spent near stoves and with smoking (Pandey, 1984). A positive correlation was found between impaired lung function and domestic smoke exposure in smoking and nonsmoking women (Pandey et al., 1982). The high levels of indoor smoke in Jumla, a remote mountain district in Nepal, may contribute to the extremely high prevalence of infant and childhood acute respiratory infection and related mortality (Pandey, 1985). Qualitative and quantitative characterization of the domestic smoke was not conducted in these studies.

Personal indoor air pollution monitoring in two villages in the Middle Hills region of Nepal demonstrated high exposures of women to particulate matter (1,100-3,000 $\mu g/m^3$) and carbon monoxide (70-300 ppm) during cooking periods (Reid, 1986). Exposure levels were significantly higher for cooks using traditional cookstoves with no flues than for those using improved cookstoves with flues . No assessment was made of possible health effects that may have been associated with these exposures.

STRATEGIES FOR PREVENTION AND CONTROL OF AIR POLLUTION

The diversity of pollution activities, population factors, meteorological conditions and topographical features make generalized approaches to

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controlling pollution impractical. Area-specific strategies to control air pollution in developing countries must achieve an appropriate balance of technological interventions, institutional and human resource development, health and management information systems, regulatory and policy development, and economic incentives to promote pollution reduction.

A listing of interrelated strategies for pollution prevention and control in developing countries is presented below. The extent to which one or more of these strategies may be applicable to a particular urban or rural area will depend upon a variety of environmental, economic, cultural, legal and political factors. Additional research is necessary to help identify the most appropriate strategies for a given area.

Ambient Air Pollution

1. *Environmental legislation.* Includes regulations and standards, with provisions for pollution abatement, monitoring, enforcement, and restrictions on locating new sources in populated areas. Institutional arrangements must be made to insure close coordination between central and local governments.

2. *Pollution prevention.* Includes reduction or elimination of pollution at the source, such as by the use of cleaner burning fuels for energy generation, industrial process substitution, and the use of new technologies. In many cases, costs will be reduced after such activities are instituted. Educating people to the concept of pollution prevention is a key component of such an intervention strategy.

3. *Air pollution control devices.* Examples include scrubbers and baghouses on utility and industrial sources. This approach is generally capital intensive, and may shift pollution burden from the air to other media due to the need to dispose of collected wastes.

4. *Transportation interventions* (see Faiz et al., 1990). Includes the use of clean fuels, controlling traffic flow patterns, instituting policies (such as a tax on leaded gasoline, mandating the use of catalytic converters) that reduce pollution.

5. *Market incentives* to promote energy efficiency and pollution control.

6. *Environmental and public health education* for all sectors, including the general public, government officials, health professionals and industry representatives.

Indoor Air Pollution

The following strategies are primarily for reducing pollution associated with the domestic combustion of fossil and biomass fuels (see Smith, 1987; de Koning et al., 1985):

1. *Improved cooking stoves and heating units.* Includes the use of flues (which reduce indoor pollution but elevate outdoor pollution) and more energy efficient units that emit less smoke (e.g., "smokeless" cooking stove).

2. *Improved housing and ventilation.* Includes the addition of windows, moving or redesigning cooking areas.

3. *Cleaner energy sources.* Includes the use of upgraded forms of fuels.

4. *Enhanced public awareness.* Involves the dissemination of information about health risks from domestic fuel combustion, and development of training programs.

DATA GAPS AND APPLIED RESEARCH NEEDS

A better understanding of the impact of air pollution on health is one of the biggest information needs. Monitoring data for many of the criteria pollutants (ozone and lead in particular) in developing countries are limited, and information on levels of the toxic air pollutants is virtually nonexistent. More information is needed on emission inventories to help identify the most important sources and the pollutants of greatest concern. Although the limited available information on pollutant levels indoors and outdoors in some developing countries suggests that the public health impacts may be significant, relatively few attempts have been made to characterize and quantify these effects. This will help to assign priorities so that limited resources may be used to address the most significant problems.

Assessment of the relative costs and benefits of different control strategies for developing countries is needed to identify and prioritize appropriate types of interventions. Area-specific evaluations of the existing institutions, policies and particularly the economic system are needed to help identify factors that contribute to the problem and that can be modified to promote pollution reduction without discouraging economic growth.

An examination of pollution prevention applications in developing countries should be a high priority. This might include, for example, assessing the feasibility of using cleaner fuels for industrial, commercial and residential combustion, or evaluating new technologies such as more efficient domestic stoves.

SUMMARY AND CONCLUSIONS

The impact of air pollution on health in developing countries may be substantial. High ambient concentrations of particulate matter and sulfur dioxide have been measured in urban areas, often at levels that are several-fold higher than WHO health guidelines. It is likely that levels of other substances such as ozone, lead and toxic hydrocarbons are high as well. The most important sources of widespread ambient air pollution in developing countries appear to be motor vehicles and fuel combustion by industrial, commercial and residential sources. Localized areas of high pollution may be found close to industrial sources.

One of the most important air pollution problems from a health standpoint in developing countries is the combustion of fossil and biomass fuels for domestic cooking and heating. Both indoor and outdoor air may be severely impacted by such activities, with exposure levels capable of exceeding WHO guidelines by up to ten-fold. Data suggest that such pollution may contribute to the high prevalence of respiratory disease that exists in many of these countries.

The requirement that environmental improvement in developing countries must be compatible with economic growth is a well-known axiom. This is particularly applicable to strategies for reducing air pollution, since the problem is so closely related to the growing energy and transportation needs of the developing world.

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TABLE 1
AIR POLLUTANTS, SOURCES AND HEALTH EFFECTS

POLLUTANT	MAJOR SOURCES	HEALTH EFFECTS
Particulate Matter	Combustion of fossil and biomass fuels Industrial processes Motor vehicles Smoking Natural sources	Respiratory effects (e.g., asthma, bronchitis), particularly in children, elderly, sick Short-term and long-term reduction in lung function Fatalities observed in severe episodes Cancer
Sulfur dioxide (SO_2)	Combustion of sulfur-containing fuels - Utility and industrial boilers - Numerous smaller coal and oil combustors Nonferrous smelters Natural sources	Aggravation of asthma and other respiratory diseases in sensitive individuals Bronchoconstriction Increased risk of mortality at high concentrations, in combination with particles
Carbon monoxide (CO)	Motor vehicles Industrial processes Gas stoves and heaters Combustion of biomass fuels Smoking Natural sources	Cardiovascular disease, including aggravation of angina pectoris Neurological effects Decrease in lung function Fatigue, nausea Possible fetal effects Death from asphyxiation
Lead (Pb)	Motor vehicles Smelters, battery plants Paint, ceramic glazing Indirect exposures (e.g., deposition and reentrainment of dust)	Especially toxic to children Neurological effects (IQ, behavior) Hematological alterations (anemia, increased blood pressure) Metabolic alterations Probable human carcinogen

TABLE 1 (CONTINUED)

POLLUTANT	MAJOR SOURCES	HEALTH EFFECTS
Nitrogen dioxide (NO_2)	Motor vehicles Utility and industrial boilers Gas stoves and heaters	Acute respiratory effects, particularly in asthmatics Lung function decrements in asthmatics Possible lung structure damage Increased susceptibility to infection
Ozone (O_3)	Photochemical formation involving hydrocarbons and nitrogen oxides Motor vehicles Industrial boilers Toxic waste disposal sites Numerous small sources Natural sources	Acute and chronic lung function impairment, especially in sensitive and healthy exercising individuals Eye and lung irritation, cough, chest pain from short-term exposures Increased susceptibility to infection Possible lung damage from long-term exposures
Toxic air pollutants (>3000 detected in ambient air) e.g., benzene, vinyl chloride, hydrogen sulfide, methyl isocyanate, arsenic, chloroform, asbestos, formaldehyde, products of incomplete combustion	Stationary industrial sources (e.g., chemical users/producers, coal and oil combustion, iron and steel production) Combustion of fossil and biomass fuel Mobile sources	Cancer Respiratory irritation, reproductive toxicity, developmental effects, pulmonary toxicity, neurotoxicity, other systemic effects

TABLE 2
WHO GUIDELINES AND U.S. EPA AIR QUALITY STANDARDS

POLLUTANT	WHO GUIDELINE[1] Level	Averaging Time	EPA STANDARD Level	Averaging Time
Total suspended particulate	60-90 $\mu g/m^3$ 150-230 $\mu g/m^3$	(annual mean) (98 percentile)	N.A.	
Smoke	40-60 $\mu g/m^3$ 100-150 $\mu g/m^3$	(annual mean) (98 percentile)	N.A.	
Particulate Matter (PM_{10})	N.A.		50 $\mu g/m^3$ 150 $\mu g/m^3$	(annual mean) (24-hour)
Sulfur Dioxide	40-60 $\mu g/m^3$ 100-150 $\mu g/m^3$	(annual mean) (98 percentile)	80 $\mu g/m^3$ (0.03 ppm) 365 $\mu g/m^3$ (0.14 ppm)	(annual mean) (24-hour)
Carbon Monoxide	10 mg/m^3 30 mg/m^3	(8-hour) (1-hour)	10 mg/m^3 (9 ppm) 40 mg/m^3 (35 ppm)	(8-hour) (1-hour)
Lead	0.5-1.0 $\mu g/m^3$	(annual mean)	1.5 $\mu g/m^3$	(quarterly avg)
Nitrogen Dioxide	150 $\mu g/m^3$ 400 $\mu g/m^3$	(24-hour) (1-hour)	100 $\mu g/m^3$ (0.053 ppm)	(annual mean)
Phototchemical Oxidants (Ozone)	100-120 $\mu g/m^3$ 150-200 $\mu g/m^3$	(8-hour) (1-hour)	235 $\mu g/m^3$	(1-hour)

N.A. = Not Applicable
[1]SOURCE: WHO, 1979.

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TABLE 3
ESTIMATES OF POPULATIONS RESIDING IN URBAN AREAS OF GIVEN QUALITY

	Number of Persons (Millions)			
	Particulate Matter		Sulfur Dioxide	
Air Quality Conditions	Chronic Guideline	Acute Guideline	Chronic Guideline	Acute Guideline
Acceptable	350	275	625	550
Marginal	200	275	550	275
Unacceptable	**1250**	**1250**	**625**	**975**

SOURCE: Adapted from Akland, 1991.

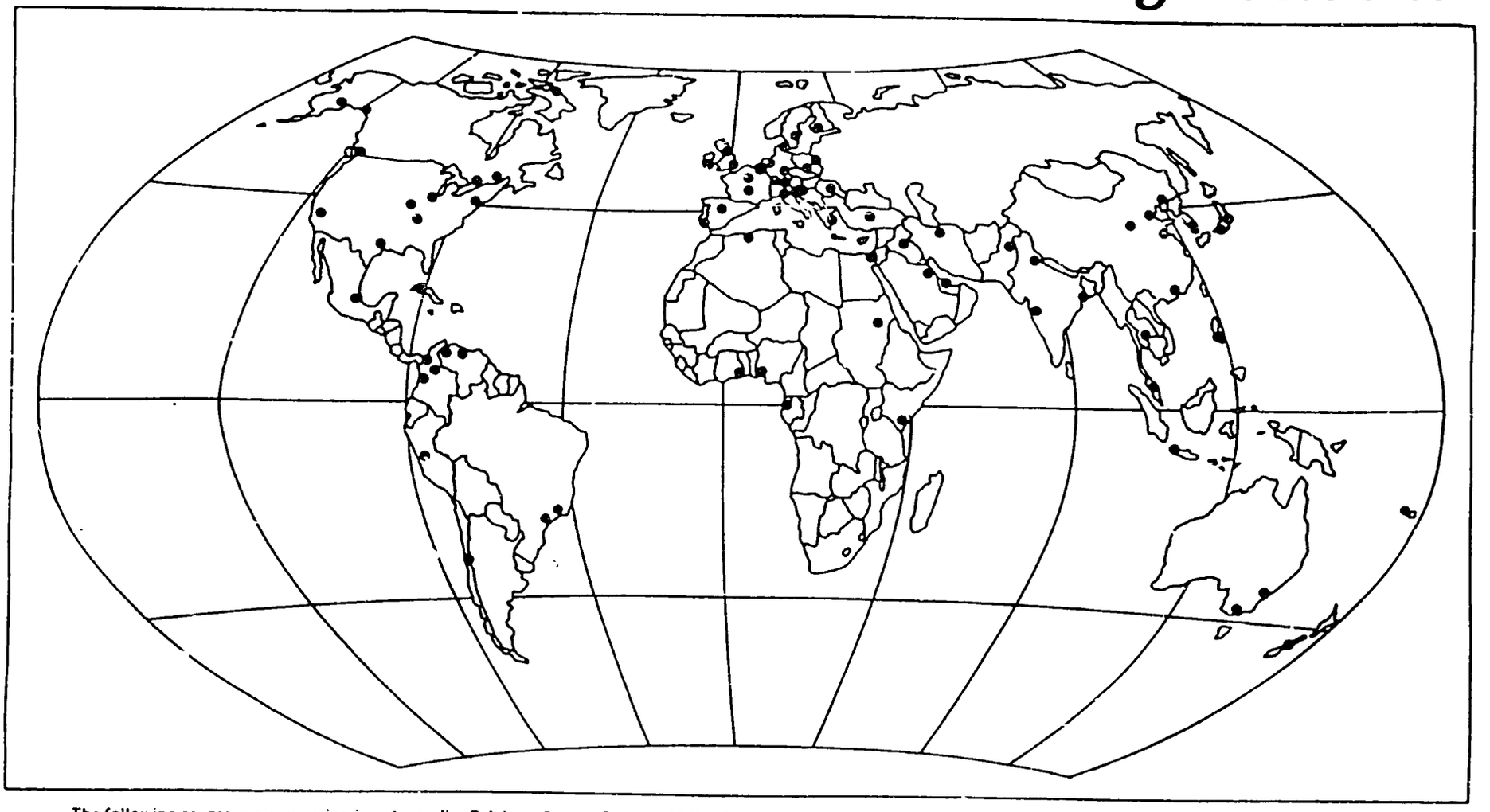
TABLE 4
GEMS DATA FOR PARTICULATE MATTER AND SULFUR DIOXIDE IN DEVELOPING COUNTRIES (1979-85)

	No. Stations Exceeding WHO Guideline/Total No. of Stations (%)			
	Particulate		Sulfur Dioxide	
	Avg	Peak	Avg	Peak
South America	11/20 (55%)	12/20 (60%)	6/18 (33%)	5/18 (28%)
Asia	51/53 (96%)	50/53 (94%)	26/47 (55%)	31/47 (66%)
Totals	**62/73 (85%)**	**62/73 (85%)**	**32/65 (49%)**	**36/65 (55%)**

SOURCE: Adapted from WRI, 1988; data from WHO

FIGURE 1.

Locations of the GEMS air monitoring network

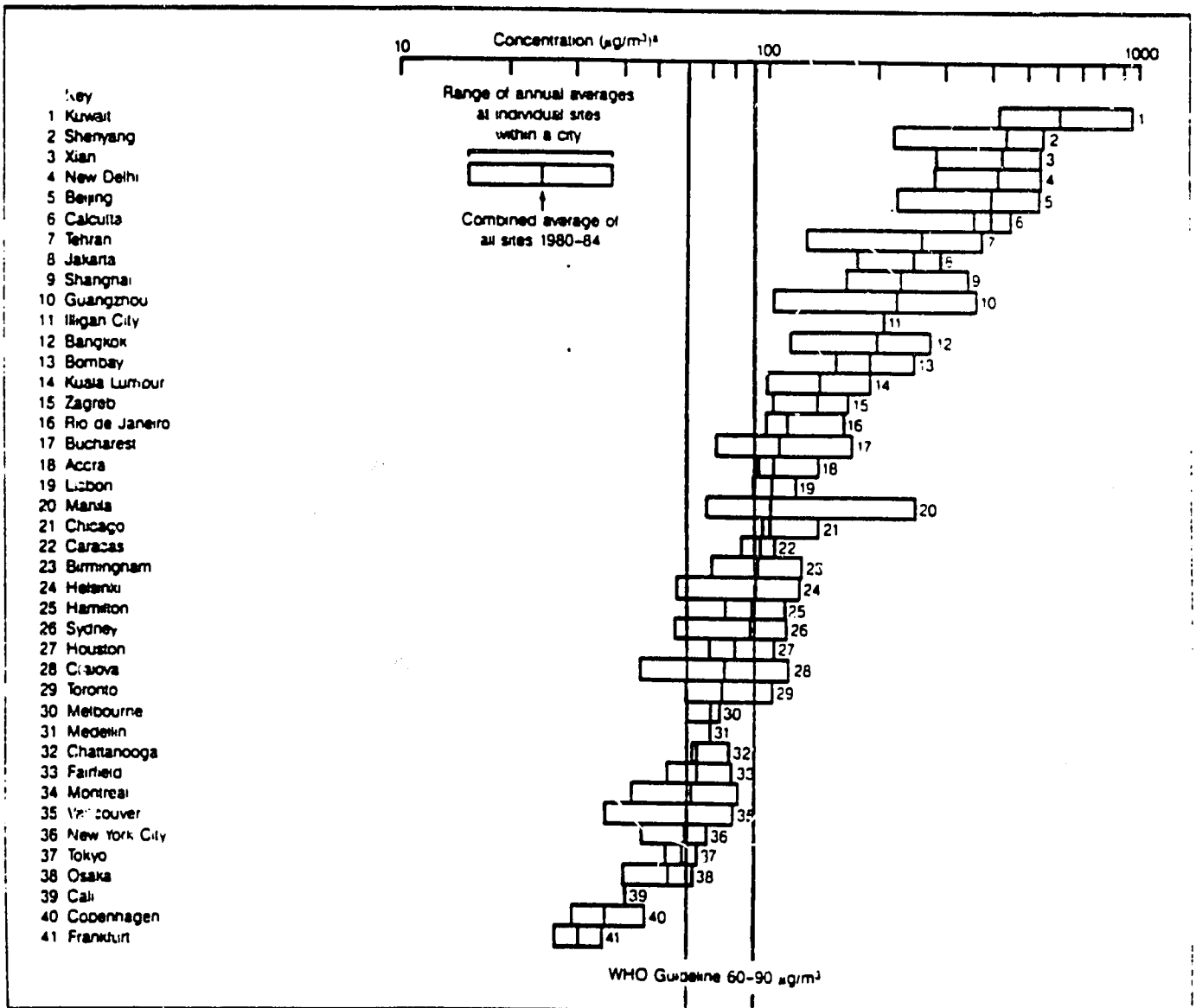


The following countries are participating: Australia, Belgium, Brazil, Canada, Chile, Columbia, Cuba, Denmark, Egypt, Federal Republic of Germany, Finland, France, Gabon, Ghana, Greece, Hong Kong, India, Indonesia, Iraq, Ireland, Islamic Republic of Iran, Israel, Italy, Japan, Kenya, Kuwait, Malaysia, Netherlands, New Zealand, Nigeria, Pakistan, People's Republic of China, Peru, Philippines, Poland, Portugal, Romania, Spain, Sudan, Sweden, Thailand, United Kingdom, United States of America, Yugoslavia.

SOURCE: MARC, 1984.

FIGURE 2.

Figure 10.3 Suspended Particulate Matter Levels in Selected Cities, 1980–84

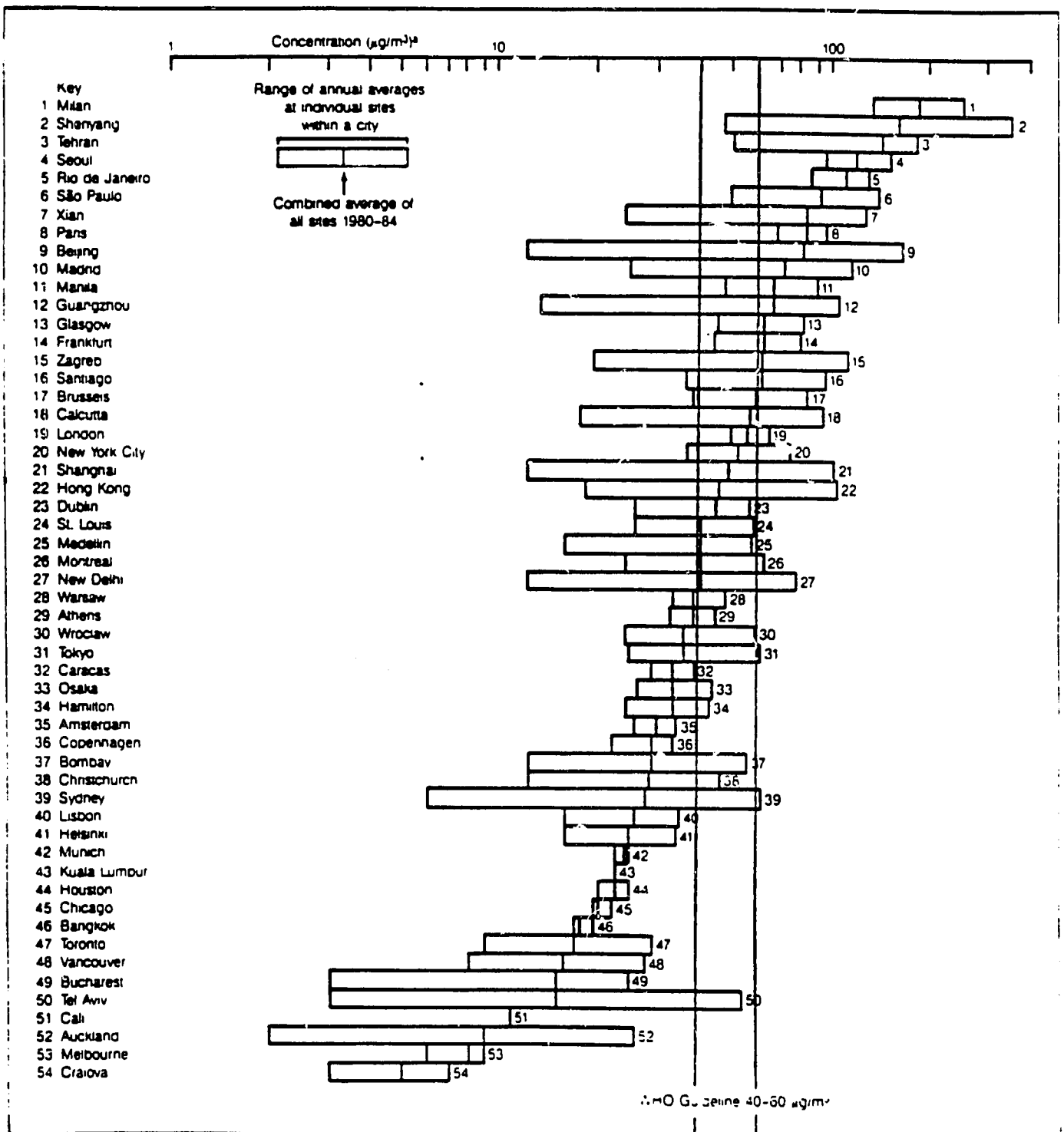


Source: World Health Organization and United Nations Environment Programme. *Global Pollution and Health* (Yale University Press, London, 1987), Figure 3.6.
Note: a. Note logarithmic scale

SOURCE: WRI, 1988.

FIGURE 3.

Figure 10.2 Sulfur Dioxide Levels in Selected Cities, 1980–84



Source: World Health Organization and United Nations Environment Programme *Global Pollution and Health* (Oxford University Press, London, 1987), Figure 2.
Note: a. Note logarithmic scale

SOURCE: WRI, 1988.

Background paper for the USAID
Environmental Health Workshop: Food hygiene

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1. Characteristics of the Environmental Problem and its Impact on Health (High Priority)

1a. brief technical description of the problem (sources, impacts, causes)

Virtually the entire developing world is at risk of ingesting contaminated food as a result of improper food hygiene practices. The study of food hygiene is usually concerned with human behaviours that lead to food contamination, not the problem of industrial or agricultural practices that contaminate food. Thus, for this paper food hygiene will focus on the domestic handling, preparation, and storage practices that lead to the prevention or control of the contamination of food with pathogens that cause illness. Although much is known about the microbiological content of foods, food hygiene has been inadequately studied. Concrete data are lacking on the magnitude of the problem, the health and economic consequences, and intervention strategies. Nevertheless, it is believed that the problem leads to excess morbidity and mortality, and the use of proper food hygiene practices could lead to considerable health and economic benefit.

1b. distribution of the problem (by geography, climate, urban/rural, level of economic development)

The entire developing world is at risk of food contamination as is the developed world. Food contamination exists in urban and rural areas, in homes as well as in public eating establishments (e.g., restaurants and street vendors), and is the result of improper food hygiene practices by all segments of the population. For instance, mothers may prepare food with contaminated equipment and utensils, children may eat with their dirty hands, and grandmothers may refeed the food that has been improperly stored. No strata of the population is immune to ingesting contaminated food as the result of improper food hygiene practices.

1c. number and type of toxins, vectors, infective agents, routes, etc.

For the purposes of this paper, we can consider two types of contaminated food. One type of food contaminants includes harmful chemicals (e.g., pesticides), plant toxicants (e.g., neurotoxins), marine biotoxins

(e.g., ciguatoxins), mycotoxins (e.g., aflatoxin), and certain types of bacteria (e.g., botulism). Harmful chemicals (e.g., pesticides, heavy metals, and fish toxins) are probably more the result of industrial and agricultural practices than food hygiene practices. Plant toxicants are found in the foods as opposed to having them introduced by improper food hygiene practices. Aflatoxins can also occur naturally in foods, although storage of food plays an important role in whether food will become contaminated with aflatoxins. Botulism is well known but a rarity, even in developed countries.

The second type of food contaminants includes the major infectious disease agents of diarrhoea (i.e., bacteria, viruses, and parasites), almost all of which have been found in foods. The remaining discussion focuses on food hygiene as it relates to the infectious disease agents of diarrhoea.

1d. <u>impact on morbidity and mortality (association with major diseases)</u>

It has been estimated recently that a child under the age of 5 will experience 17 episodes of diarrhoea. Based on a recent review of the literature on food hygiene, 15-70% of these episodes are food-borne. Thus, food-borne diarrhoea can account for 2.5 to 12 episodes of all diarrhoea in the child's first five years of life.

Diarrhoeal mortality has also been estimated recently to be 7/1000 cases. Assigning cause (e.g., original infection due to food) to these deaths is not possible. Nevertheless, using the same 15-70% rate of food-borne diarrhoea to all diarrhoea, which may be low, then 1 to 5 of the 7 deaths are due to food-borne illness. One can assume, therefore, that food-borne diarrhoea imposes a significant burden on morbidity and mortality of young children. No relevant data were located on the impact among the elderly, another high risk group.

1e. <u>numbers of people affected</u>

Probably everyone has experienced illness as a result of improper food hygiene practices. The vulnerable groups most likely to become ill from improper food hygiene practices are young children and the elderly. This

does not exclude other segments of the population, but these vulnerable groups are most likely to be severely affected by food contamination. Although estimates have been made in developed countries on the extent of the food contamination problem, little data are available from developing countries.

In developed countries reports of the extent of food-borne illness are available from central institutions (e.g., CDC in the USA). The extent of food-borne contamination varies from country to country. Confirmed etiology is difficult to diagnosis, but usually in less than half of the reported outbreaks is etiology confirmed. Several hundred outbreaks are reported each year in the United States, with well over 10,000 cases identified. Experts concur that even in developed nations, such as the United States, the magnitude of the problem is grossly underestimated, anywhere from 25 to 100 times.

In the developing world, no reliable estimates of food contamination exist. Many countries do not even have reporting procedures, and for those that do, improvements in the reporting procedures are required. For instance, in Thailand where figures are high compared to other Asian countries, there were no reported cases of food-borne diarrhoea prior to 1976 and reported figures increased 7-fold within the next 3 years. Some developing countries reporting food-borne illnesses (i.e., Dominican Republic and El Salvador) reported zero cases of food-borne diarrhoea. Based on estimates of other risk factors for diarrhoea (e.g, water and sanitation, personal hygiene), food-borne diarrhoea may constitute anywhere from 15-70% of all diarrhoea among children under five years of age. This estimate is meaningless, but it reflects the paucity of data in the area of food hygiene.

1f. <u>other relevant epidemiologic information</u>

Very few governments have made a concerted effort to report on the extent of food-borne illnesses. Individual studies in several developing countries have tried to associate food hygiene practices with contaminated food, but the association of either practices or foods to diarrhoea rates is

rarely investigated. The few results that are available have been contradictory.

1g. information on interactions among risk factors

Risk factor interactions fall into two major types. The first are those factors related to the exposure, susceptibility, and treatment of the disease. For instance, breastfed children may be protected from contaminated foods by first decreasing the amount of other foods ingested and by the properties of breastmilk that resist infection once contaminated foods are ingested.

The second type of risk factor interaction deals with the food hygiene practices themselves. Many improper practices exist simultaneously (e.g., using contaminated water and utensils) or are dependent on other food hygiene practices. For instance, inadequate reheating would be much less of a problem if food was properly stored (e.g., refrigerated).

1h. relevance of the issue to developing countries, currently and in the future

Improper food hygiene practices in developing countries are widespread, and will remain so in the foreseeable future. The problem exists at the national, regional, and local level. At the national and regional levels no coherent policies or programs have been established. At the local level, where foods are handled, prepared and stored, traditional practices still pervade.

2. Preventive Measures or Control Strategies Available (High Priority)

2a. available options (assessment, curative/preventive)

Efforts to prevent or control morbidity or mortality by improving food hygiene practices are difficult to assess. First, it is not clear which food hygiene interventions will work. Second, there is a lack of documented experience on food hygiene interventions and legislative efforts, and no evaluations of programs have been found in developing countries.

Education and training, inspection of facilities, and microbiological testing are traditional forms of control. Education and training of those involved in the food hygiene system (virtually everyone) could include food preparers and school children. Inspection of facilities would be less useful, particularly without the requisite education. Microbiological testing would be expensive and of little help initially.

Traditional inspection and quality control procedures have been replaced to some extent by the Hazards Analysis Critical Control Point system (HACCP) as an approach to the control of microbiological hazards in foods. The HACCP system consists of identifying hazards (i.e., risk factors), their point of control, and a system to monitor the points of control (e.g., training, microbiological testing, site visits, sensory evaluation). This system has been successfully implemented in the mushroom canning and low-acid canning industries in the USA, but it has not caught on in other segments of the food industry. The spirit of the system should be considered when investigating intervention strategies in developing countries.

2b. <u>effectiveness of the interventions/strategies</u>

Interventions and strategies were not found in the developing country context, so the effectiveness remains unknown at this time.

2c. <u>alternative or new technologies available</u>

Besides health education to teach better hygiene practices, the effectiveness of environmentally safe refrigerators (e.g., solar) and cooking facilities requiring little or no use of non-renewable fuels should be explored.

2d. <u>cost effectiveness of available interventions</u>

One pilot study included hand washing before preparing food as one component of an intervention. Following the intervention fewer people washed their hands, but the decrease in hand washing in the control group was larger. The association with health was not clear. No other interventions have been found that reported on efforts to specifically control improper food hygiene practices in developing countries. The interventions that are

likely to be most effective are probably health education interventions. Other efforts to change behaviour through education (e.g., ORS, family planning, smoking, breastfeeding) have met with some success. Unfortunately, little data exist on which to design food hygiene interventions. Low-cost, culturally appropriate, technical interventions should also be considered. One technological intervention that could be utilized is solar refrigerators to eliminate improper storage of foods. With the scarcity of fuel becoming more of a problem, better and more efficient cooking facilities may have to be developed or tried in the context of food contamination.

2e. types of economic benefits from effective control or prevention

Economic benefits are impossible to estimate due to the inaccuracy in estimating the magnitude of the problem. If the costs of improper food hygiene practices are large, as believed, then the benefits are also likely to be large if the problem is controlled. The total benefit of controlling food-borne illness would include such factors as gained income due to days not lost from food-borne illness and savings in time and cost of seeking health care stemming from the illness, but the benefits are more far reaching than this. Food for export that is contaminated by improper handling may cost industry and governments millions of dollars when it is rejected by the importing nation. Furthermore, food hygiene interventions, if innovative enough, may improve the nutrient intake of populations, thereby improving their health independent of decreased food contamination.

3. Identification of Data Gaps and Applied Research Needs in the Area (Medium Priority)

3a. types of data and applied research required for assessment of the problem area

There is a need for epidemiologic data associating food hygiene risk factors to food-borne illnesses. Risk factor studies are needed to identify those improper food hygiene practices that are particularly detrimental to health. The factors that are amenable to change should be identified.

During these studies, positive and neutral factors should also be identified and promoted during interventions.

These risk factor studies should associate particular practices not only to the contamination of food, but also to the particular health outcome (e.g., diarrhoea) associated with food contamination. Food contamination, as measured by indicators, has little association with presence or absence of pathogens. Therefore, better methods should be developed to identify pathogen laden food. In developed countries food-borne outbreaks are investigated only after they are reported. This may not be the best model to follow in developing countries because the problem is ubiquitous and recall of events may be subject to bias.

Reporting procedures will only be as accurate as the weakest link in the reporting chain. First, many illnesses go undiagnosed by health authorities. Second, many illnesses that are diagnosed are not investigated and therefore go unreported. Third, the definition of food borne disease should be standardized.

The problem of food hygiene should be established as a priority in developing countries. The lack of attention paid to food hygiene issues is due in large part to inadequate data and lack of understanding about the issue. First, if we rely on the best available figures, the problem appears minor. Second, the problem of food hygiene in the past has been largely the domain of food microbiologists. Thus, diarrhoeal disease control programs have focused efforts on providing pure water and excreta disposal facilities, educating people about personal hygiene (i.e, bathing and hand washing), and promoting breastfeeding. Inclusion of food hygiene measures may have significant impacts on morbidity and mortality rates.

3b. <u>general availability of data in LDCs or elsewhere</u>

Available data come from small samples of individual studies, and little data are available at the national level. Data are lacking on the epidemiologic association between food hygiene practices and health outcomes. Data substantiate the belief that foods are contaminated (as measured by

indicator organisms, but not pathogens) and that improper food hygiene practices are associated with contaminated food. The link between food hygiene practices, [illegible] ed food, and [illegible]ness is [illegible]ely investigated.

3c. constraints on improved data collection and assessment

First, food hygiene is not adequately recognized as a problem area by donors, national governments, and research funding agencies. Second, the problem in the past has been left to microbiologists, who adequately dealt with the contamination of food, but not the epidemiologic or educational issues. Third, inadequate definitions of food hygiene practices and food-borne illnesses have led to a lack of systematic reporting procedures to estimate the magnitude of the problem. In many countries, food-borne illnesses are considered a gastrointestinal illness, without regard to the source of the illness. Fourth, funds are lacking for the investigation of food hygiene practices (i,e., risk factors, possible interventions, and economic cost and potential benefits).

4. Information on U.S. Capabilities and Advantages (Lower Priority)

4a. special experience and expertise we can bring to bear

The United States has all of the capabilities and advantages necessary to launch a major research effort and eventually implement programs to control improper food hygiene practices. Together, universities (e.g., researchers), public health programs (e.g., CDC), and health education communication experts (e.g., Washington area contractors) have the capability to investigate food hygiene issues, develop interventions, implement projects, and evaluate programs. At present no institution has taken the lead in this area.

4b. research and methodological expertise

All of the research expertise exists within the United States, and an interdisciplinary effort should be launched. Epidemiologists, medical anthropologists, economists, microbiologists, and nutritionists are experienced enough to undertake the research needed to develop, implement,

and evaluate intervention programs. Other countries also possess this expertise.

4c. training and technology transfer capabilities

Few programs have been developed that are applicable to the developing country context. Communications experts know how to design and implement health education interventions. Without the requisite knowledge base to design the proper messages, interventions at this time are premature. The HACCP system could be implemented within the context of the food industry (e.g., centrally processed food products), but would do little at the domestic level, at least initially. Domestic food hygiene problems need further investigation before training and technology transfer programs are utilized.

5. Information on Current Activities in Developing Countries (Lower Priority)

5a. major agencies, countries, and programs working in the problem area

Some countries and regions have made some effort to quantify the problem of food contamination by instituting reporting procedures. For example, in Asia (e.g., Fiji, Malaysia, Philippines, Singapore, Thailand, Tonga, and Western Samoa) and the Americas, including the Caribbean region, (Argentina, Dominican Republic, El Salvador, Martinique, and Panama) reporting of food-borne illness occurs. No national data were found from sub-Saharan Africa on reports of food-borne illness. The magnitude of under reporting is still enormous. Because of such under reporting, the extent of the problem may be underestimated.

5b. levels of funding, and types of work being done

Funding in this area is very low.

5c. source and types of coordination, joint planning, etc.

Some institutions are concerned with food hygiene issues, either directly or indirectly, and the nature of their activity is either investigative or legislative. In the United States these include the Centers

for Disease Control (CDC), the United States Food and Drug Administration, and occasionally research funders (e.g., ADDR or CDD of WHO). CDC investigates outbreaks (mostly in the US), the USFDA imposes standards on and rejects imported foods, many of which come from developing countries, and the occasional funding sources are concerned with risk factor studies, but only on an ad hoc basis.

6. Synthesis: Advisory Comments on the Need, the Priority, and Relevance of Interventions in the Problem Area in an AID funded project (High Priority)

There is need for intervention studies to examine the effectiveness of food hygiene interventions. However, before such interventions are implemented, a rigorous research program should be instituted. This research program should have strong central planning and leadership. The program would require a multi-disciplinary team comprised of epidemiologists, nutritionists, microbiologists, social scientists (e.g., medical anthropologists and economists), and communication experts.

The centralized research program should focus on several issues, many of which could be investigated concurrently. The program should focus initially on risk factor studies, then develop and evaluate interventions to improve food hygiene practices, and finally, develop a program for dissemination to areas that were not researched.

IMPACT OF SOLID WASTE ON HEALTH AND THE ENVIRONMENT

By

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A. IMPACT OF MUNICIPAL SOLID WASTE

1. Public Health and Environmental Impacts

Public Health Impact: The characteristics of a municipal solid waste (MSW) have a public health significance only when it includes one or more of the following wastes:

1) Wastes of biological origin — food waste, diseased animal cadavers or scraps thereof, manure, and contaminated clinic or hospital wastes. The danger arises from the likely presence of a wide variety of pathogens (including zoonotic) in such wastes.

2) Wastes of non-biological origin — discarded containers that had contained toxic (pesticides) or hazardous (flammable, explosive) substances.

In the absence of any representative of the preceding two groups of wastes, municipal solid waste has little direct impact on public health at the time it is generated. Table 1, which lists the components of MSW generated in various communities reveals no particular component that of itself would pose a health hazard.

Nevertheless, in the absence of proper management (storage and disposal), even MSW acquires an objectionable health significance. The wastes can provide shelter or habitat, and even sustenance, for disease carrying vectors and rodents. Their breakdown products (intermediates) may lead to the chelation of heavy metals, thereby allowing the metals to enter the food chain. The products may also lead to the conversion of the metals into soluble salts, and thus render them mobile.

Environmental Impact: The concern here is deterioration of the quality of the environment. Two principal direct adverse impacts are unsightliness and the generation of objectionable odors. If the wastes are allowed to accumulate, the space covered cannot be put to more productive use. This applies not only to the land area occupied by the MSW, but also to surrounding areas. More importantly, is the potential of the breakdown products to lead to contamination of the air and water resources.

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2. Widespread Nature of the Problem

The problems associated with management and disposal of municipal solid waste are as widely distributed as is the generation of solid waste. The rate of solid waste generation per person and the composition of the waste generated depend upon several factors, such as levels of economic development and industrialization; climate (presence or absence of seasons, temperate vs. subtropical and tropical); degree of urbanization; and population density. Examples of rates are given in Table 1.

The problems take on added seriousness when the MSW is improperly managed and disposed of. As recently as two decades ago, improper management and disposal was the rule rather than the exception in industrialized as well as in developing countries. Since then, the situation has been largely reversed in industrialized nations, and now is receiving serious attention in developing countries. Not surprisingly, in developing countries, economic and technological problems can pose substantial obstacles to the implementation of even remedial measures.

3. Types and Numbers of Pathogens, Vectors, and Toxins

The number of scientific studies designed to identify and quantify the presence of pathogens, toxic wastes, etc. in MSW has been very limited. Interestingly, a study made of the incidence of enteric microorganisms present in residential solid waste in the U.S.A. indicated concentrations of coliforms comparable to those in raw sewage sludge. The explanation provided was that the high concentration was due to the pet droppings that were disposed with the household waste. The greater the amount of contamination of the municipal solid waste with human body wastes, animal wastes, and diseased animal scraps, the larger is the concentration of pathogens. In addition to the likelihood of contaminating the remainder of the waste through direct contact, pathogens in MSW can be transferred to humans by flies or similar vectors, or by involuntary ingestion or breathing of dust from the contaminated waste. A less likely route is transmittal by a rodent.

Concentrations of toxins (e.g., heavy metals, toxic organics, pesticides) reflect the degree of industrialization of an area, as well as the levels of pesticide usage (both residential and agricultural). The concentrations of toxins probably is greater in developing nations, because of less restrictive legislation on usage and disposal of the materials. However, this latitude is gradually being lessened as decisionmakers in developing countries become increasingly aware of the magnitude and long-term consequences of neglect in this respect.

4. Relevant Epidemiological Information

Studies have been undertaken to assess the effect of contact with solid waste on the incidence of diseases and on morbidity rates. The information in Tables 2 and 3 provides an indication of the impact of such contact on morbidity from diseases associated with dumpsites and the number of those people afflicted with the diseases. The data in Table 4 indicate the diarrheal morbidity associated with contact or ingestion of human waste by way

Table 1

Quantity and composition of municipal solid waste[a] (% wet weight)

Material	India urban	Olongapo City, Philippines	Manila, Philippines	Yemen, Adén	Asuncion, Paraguay	Lima, Peru	Rio de Janeiro, Brazil	Mexico City, Mexico	Caracas, Venezuela	Oshsha Settlement Ibadan, Nigeria
Putrescibles	75.0	44.4	49.8[b]	57.0	60.8[b]	34.3	47.7[b]	56.4[b]	40.4[b]	76.0
Paper	2.0	17.5	12.9	15.5	12.2	24.3	31.5	16.7	34.9	6.6
Metals	0.1	3.1	5.8	13.2	2.3	3.4	5.9	5.7	6.0	2.5
Glass	0.2	2.0	3.5	2.6	4.6	1.7	4.7	3.7	6.6	0.6
Plastics, rubber, leather	1.0	8.7	1.6	2.9	4.4	2.9	3.9	5.8	7.8	4.0
Textiles	3.0	2.9	1.8	6.8	2.5	1.7	4.1	6.0	2.0	1.4
Ceramics, dust, stones	19.0	21.4	17.7	2.0	13.2	31.7	2.1	5.7	2.3	8.9
Weight/capita/day (lb)	0.91	0.68	0.93	1.01	1.41	2.12	1.19	1.50	2.07	0.37

a) Based on actual measurements.
b) Includes small amounts of wood.

Table 2. Prevailing Diseases Among People at Dumpsites

Percent		Disease
70	-	Upper respiratory ailment - pneumonitis, pneumonia, bronchitis and hemophysis
50	-	Extremities wound (hand and feet)
40	-	Parasitism (all forms: ascaris, hookworm, seatworm, pinworm, etc.)
40	-	Gastroenteritis
25	-	Sore eyes
40	-	Undernutrition, anemia, vitamin deficiencies
30	-	Hyperacidity
20	-	Scabies infestation
40	-	Skin diseases: Infected insect bites, tenea flava, exzema, ringworm funal infection
40	-	Influenza
30	-	Anemia
75	-	Low back pain syndrome: backache
10	-	Hypertension
8	-	Asthma, allergies
7	-	Infectious hepatitis
	-	Urinary tract infection (female)
	-	Expistaxis
	-	Low appetite
	-	Dysentery
	-	Diarrhea
	-	Hemorrhoid

Note: 750 individuals interviewed.

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Table 3. Summary of Responses on Disease-Symptons by the Scavengers Interviewed

	Symptoms	ADULT Female Total	ADULT Female Percent	ADULT Male Total	ADULT Male Percent	YOUTH Total	YOUTH Percent
1	Cough	65	31.6	54	26.2	42.	20.4
2	Cold	52	25.4	42	20.4	28	13.6
3	Fever	48	23.3	44	21.4	33	16
4	Sore throat	14	6.8	7	3.4	5	2.4
5	Asthma	10	4.9	5	2.4	3	1.5
6	Dizziness	34	16.5	26	12.6	20	9.7
7	Diarrhea	14	6.8	11	5.3	8	3.9
8	Blood in feces	-	-	2	1.0	-	-
9	Worms in feces	4	2.0	2	1.0	2	1.0
10	Blood in phlegm while coughing	1	.5	1	0.5	1	0.5
11	Blood in urine	-	-	1	0.5	-	-
12	Stomach ache	21	10.2	16	7.8	16	7.8
13	Gas pains	20	9.7	14	6.8	14	6.8
14	Difficulty in urinating	4	2.0	4	2.0	2	1.0
15	Eye strain	5	2.4	4	2.0	3	1.5
16	High blood pressure	10	4.9	5	2.4	1	0.5
17	Blood in nostrils	4	1.9	2	0.9	1	0.5
18	Lack of interest	11	5.3	10	4.9	5	2.4
19	Inflamed glands	4	1.9	3	1.5	4	1.9
20	Sore eyes	31	15	27	13.1	18	8.7
21	Wounds in extremetis	36	17.5	42	20.0	20	9.7
22	Scabies	12	5.4	13	4.9	20	9.7
23	Ringworm	8	3.9	13	4.9	3	1.5

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Table 4. Diarrheal Morbidity by Study Area and Year

	1984	1985	1986	1987
Child-months of observation				
Intervention	6,922	8,301	8,450	8,527
Control	6,603	8,210	8,111	8,165
Overall incidence				
Intervention	3.85	2.71	2.18	2.34
Control	3.75	3.59	2.98	3.12
IDR[a]	1.02	0.75**	0.73*	0.75*
95% confidence interval	.96,1.09	.70,.80	.68,.78	.70,.80
Incidence of persistent diarrhea				
Intervention	0.60	0.62	0.56	0.63
Control	0.58	0.91	0.94	1.10
IDR	1.02	0.68**	0.59**	0.58**
95% confidence interval	.87,1.2	.60,.77	.52,.67	.52,.65
Proportion of episodes > 14 days duration				
Intervention	0.15	0.23	0.26	0.27
Control	0.16	0.25	0.32**	0.35**
Incidence of dysentery				
Intervention	0.62	0.34	0.24	0.27
Control	0.54	0.37	0.34	0.36
IDR	1.16	0.92	0.70**	0.73**
95% confidence interval	1.0,1.34	.77,1.09	.57,.84	.61,.88
% of days with diarrhea				
Intervention	8.8	9.7	9.1	9.5
Control	8.9	14.1**	16.8**	17.5**
% of rectal swabs positive for *Shigella* spp.				
Intervention	7.3 (1,398)[b]	9.9 (933)	17.0 (865)	17.5 (961)
Control	8.0 (14,637)	11.2 (1,323)	17.2 (1,206)	17.2 (1,351)
% of days with shigellosis[c]				
Intervention	0.64	0.96	1.55	1.66
Control	0.71	1.58	2.89	3.01

Note: Chi-squared test for significance of difference between areas: * $p < 0.01$; ** $p < 0.001$.

[a] Incidence density ratio.
[b] Number of rectal swabs taken.
[c] Calculated by multiplying the percentage of rectal swabs positive for *Shigella* spp. by the percentage of days with diarrhea.

Source: Aziz, K.M.A., et al, Water Supply, Sanitation and Hygiene Education - Report of a Health Impact Study in Mirzapur, Bangladesh, UNDP - World Bank Water and Sanitation Program, The World Bank, Washington, D.C., 1990.

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of contaminated water. The number of people afflicted with diseases associated with contact with solid waste is larger in developing countries than in developed countries because the practice of scavenging is much more prevalent. Scavenging involves a much closer contact with the solid wastes than is experienced by workers employed to operate a landfill.

5. Relevance to Developing Countries

The nature of the data in Tables 2 and 3 confirm the effect and relevance of unsatisfactory management and disposal of solid waste presently experienced in developing countries. The growing realization of this relevance is spawning an increased activity towards remedying the situation. Unfortunately, willingness often is not sufficiently accompanied by economic and technological capability.

B. PREVENTIVE MEASURES

From the preceding sections it is evident that the underlying objective with regard to the management and disposal of solid waste is to isolate the material from the people and the environment during storage, transport, and disposal or treatment. However, this isolation is limited by technological availability and economic feasibility. It should be to the extent that not only is possible but also is practical at the time and place of generation. The rationale is that even under the least favorable of economic and technological conditions, it is better to make even a minimal attempt than to do nothing.

The remedial approaches described in the following paragraphs are sufficiently flexible to be adapted to the entire spectrum of technological and economic conditions, i.e., from "low technology" to "high technology" and from the very limited technological and economic resources of developing countries to the more abundant technological and economic resources of industrialized countries. However, the focus is on developing countries.

1. Scavenging

There is considerable debate about the pros and cons of eliminating scavenging by private individuals at all points in the solid waste management process, i.e., from storage through disposal. Strong hygienic and environmental arguments can be made in favor of complete elimination. However, very practical arguments can be made against elimination. These arguments are based on important considerations, namely, political, economic, life-style, and fairness to the scavengers. Probably, the best compromise would be to permit, but carefully regulate, scavenging, in terms of the scavenger, the practice of scavenging, and handling and disposition of the scavenged items. Moreover, the practice probably should be restricted to a specific area in the disposal site and not be permitted while the wastes are in transit.

2. Storage

The storage of MSW should be carefully managed in order to avoid

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concerns associated with public health, as well as environmental problems. Management of solid wastes during storage takes place at two points in the process: at the point of generation, and at the recycling and disposal site.

Point of generation (residences, markets, offices, etc.) — Containers should be fabricated of durable materials, yet be light enough to be manipulated by the collectors. They should have tight covers, and be easily emptied by the collectors. Filled containers should be readily accessible to the collectors. These measures must be adapted to the local conditions, especially with respect to practical limitations in terms of space, availability of containers, etc.

Recycling and disposal site — To ensure the isolation requirement, the material should be sheltered from the elements. Ideally it would be stored in some type of structure. Other options are to store the solid waste under a roof, or to shield the materials from unlimited access by people and animals. If it is not possible to isolate the MSW, then the material should be processed promptly so that each day's input is processed the same day. Residues left after recycling should be disposed immediately.

3. Collection and Transport

Regardless of whether the collection vehicle is a pushcart or a sophisticated packer truck ("garbage truck"), it should be constructed and operated such that no waste is dropped during transport to the disposal site. The collection procedure and the collection vehicle should ensure that only the collectors have contact with the waste and that access by vectors be prevented.

4. Disposal

Strictly speaking, all disposal efforts are remedial by their very nature. The "offending" material is isolated from the public and the environment, although only crudely in some cases. In this presentation, we restrict ourselves to a brief discussion of two methods of disposal — landfill and composting.

Landfill: The landfill is second only to the open dump in terms of simplicity. The wastes are deposited in a depression and are covered, either immediately or later. The depression may be an excavated one or a natural one (valley, ravine, etc.)

Types of landfills are numerous. The ideal type of landfill is the sanitary landfill. A simplified definition of a sanitary landfill is:

> "A landfill in which the waste is: 1) deposited in some type of depression lined with a soil (e.g., clay) layer that is relatively impermeable to water and leachate or with an impermeable plastic or other membrane; 2) thoroughly compacted; and 3) covered each day with a layer of soil sufficiently deep to discourage access by rodents and fly larvae."

According to this definition, the sanitary landfill is an excellent way of disposing of solid waste. However, even in industrialized countries, the sanitary landfill is not without its drawbacks and does not necessarily provide a complete isolation of the wastes from the environment. Problems encountered include the elimination or control of emissions (liquid and gaseous), and land acquisition or siting.

In some developing nations, even primitive versions of sanitary landfill are unattainable. However, since the sanitary landfill is the only truly environmentally and hygienically acceptable version of the landfill, rather than rule it out entirely, the aim should be to approach sanitary landfill fundamentals as closely as possible. For example, clay or plastic liners may be infeasible. In such a case, the fill should be sited such that leachate and runoff from the solid waste are not likely to reach ground and surface waters. If covering can not be done each day, it should be done as often as feasible. The primary concern in landfill disposal is to collect and dispose the waste as effectively as possible.

Composting: Composting has a dual role — it serves as a means of disposal and also of recycling. Much has been written about the subject. As is true with the sanitary landfill option, the technology of composting covers a wide range — from the very simple ("low technology") to the very sophisticated ("high technology"). Fortunately, with respect to effectiveness, low technology is as suitable as high technology. In fact, high technology is not a guarantee of satisfactory composting.

5. Other Technologies

Prominent among the other technologies is incineration. Incineration is not a suitable alternative for most developing countries for a number of reasons. These include: high cost, lack of the necessary technological resources; and hazards to health and environment of all but the more sophisticated and expensive types of incineration operations. At the present time, there are no other options available for disposal of solid waste in developing countries.

6. Cost Effectiveness

The cost effectiveness of the available options was discussed in the preceding sections. The alternatives presented must be developed such that the various tasks are carried out efficiently. Storage, collection, and treatment methods must be implemented such that the country's ability to repay is not exceeded.

7. Economic Benefits from Effective Control or Prevention

Discussing this subject borders on stressing the obvious. It is hard to gainsay the economic advantage of a healthy work force and of a healthy population. Health maintenance and medical costs in general are minimized. For countries dependent on tourism, the economic benefits spell the difference between a strong tourism industry and one that is lagging.

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Vector Biology
and Control Project

Environmental Aspects of Vector-Borne Diseases

February 1991

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Table 1. Estimated Size of the Vector-Borne Disease Problem
Table 2. Relative Costs of Pesticides for Indoor House Spraying

The environmental nature of vector-borne disease was understood long before the etiology was discovered: hence the name malaria was derived from the Italian for "bad air," and *paludisme*, the French name for malaria, refers to a "marsh." Cultivation of rice near human settlements was forbidden in 16th century Spain because of the associated illness. Onchocerciasis is known as "river blindness" because transmission is most severe near the rivers in which the black fly vectors breed. Cutaneous leishmaniasis in the Americas is known as "chiclero" because it is very common in workers who collect "chicle," or gum, in the forest areas where sandflies are abundant.

These diseases have evolved over a very long period and are naturally associated with environmental features -- water, vegetation, altitude and climatic seasonality. More recently, however, we see their patterns changing because of human modifications of the environment, population growth and shifts, and economic conditions resulting in substandard housing and malnutrition.

1. Characteristics of the Environmental Problem and its Impact on Health

Several hundreds of diseases are transmitted by vectors. Some are rarely encountered or occur in limited geographic areas. The most common include:

- malaria (4 human types)
- schistosomiasis (6 types)
- filariasis (6 important forms)
- arboviruses (dengue, yellow fever, numerous encephalitides - about 50 cause human illness)
- leishmaniasis (6-8 types, probably more)
- trypanosomiasis (3 forms)
- numerous rickettsial and bacterial illnesses

The vectors of these diseases, which actually deliver the infectious agent to the human host, include mosquitoes, sandflies, black flies, ticks, mites and fleas. Snails and several species of arthropods participate in infection as intermediate hosts of parasites but cannot truly be called vectors because they do not introduce the parasite into the host's body.

In addition to the vectors, hundreds of species, including mammals, crustaceans and reptiles, serve as secondary hosts and reservoirs of infection.

The rules of biological diversity apply to vectors and parasites as they do

to other species. Although vectors can be found well into the Arctic Circle, their numbers and diversity are maximized in the tropics, as the map of malaria's global distribution demonstrates.

The occurrence of vector-borne diseases is not uniformly reported. In most LDCs, diagnostic facilities are poor and the ubiquitousness of the vector-borne illnesses results in underreporting. Infection is extremely common, and not often reported. Estimates for the numbers of cases (i.e. illness) are shown in Table 1.

In the LDCs, vector-borne diseases are a major cause of morbidity and mortality. Some examples of their impact on public health and economic productivity are listed below.

- Malaria is responsible for more than one million childhood deaths per year in Africa, primarily in infants. In Malawi (1988), 19% of deaths among children younger than 5 were attributed to malaria.

- In many African countries, malaria is responsible for 50% or more of hospital and clinic visits, and as much as 40-50% of bed occupancy in children's wards of hospitals.

- In Ghana, malaria was shown to be responsible for more lost years of healthy life than any other illness.

- Yellow fever was recently (1987-88) responsible for an estimated 10,000 deaths in Nigeria during a single epidemic.

- Epidemics of dengue fever (see Table 1) are frequently estimated in the hundreds of thousands.

- Dengue hemorrhagic fever (DHF) in Thailand in 1987 resulted in 170,000 thousand cases. The cost of a DHF epidemic in Thailand in 1980 was about $7-10 million.

- Egypt estimates that it loses $500 million in agricultural productivity per year, primarily in lost work, due to schistosomiasis.

- The direct and indirect costs of a single case of malaria in Rwanda (Figure 2) are greater than the expenditure per capita of the Ministry of Health of that country.

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The case of Brazil is a dramatic illustration of the effect of man-made environmental change on the epidemiology of a vector-borne disease. As recently as 1970, Brazil had reported only 53,000 cases of malaria, but the incidence had risen to 600,000 by 1989. The vast majority of cases came from the Amazon region (Figure 3). Extensive mining and forest exploitation in Amazonia resulted in rapid immigration of non-immune people from malaria-free areas. For example, the population of Rondonia doubled to more than 2 million people between 1975 and 1985. Subsequently, many of the immigrants returned to homes, reintroducing the infection into areas previously cleared of malaria. When these "extra Amazonian" cases were investigated, only 7 percent were found to be due to local transmission. In all, 26 foci of malaria were reestablished in the country (Cruz Marques, 1987).

The Brazilian experience exemplifies the role that changing human ecology has had on the local resurgence of malaria. It also indicates the difficulty of developing the health services required to keep pace with such rapid human changes. The government of Brazil is negotiating a massive loan with the World Bank (in the order of $400 million) to address the malaria problem in Amazonia and its reintroduction into formerly cleared sections of the country.

Some of the most important changing environmental and related factors contributing to localized resurgence of malaria and other vector-borne diseases include the following:

a. changes in human ecology - the shift toward extensive and intensive agricultural development, often replacing subsistence agriculture and resulting in the movement and resettlement of inadequately housed and otherwise unprotected people;

b. development of insecticide resistance, often associated with the use of the same or similar insecticides in agriculture;

c. planned or unplanned settlement due to enterprises, such as prospecting, mining or construction of dams and roads, particularly in forested areas, which may establish new foci of intense transmission;

d. migration of rural populations to unplanned urban slum areas with makeshift housing, which produces population densities that favor transmission and intensify endemicity;

e. deterioration of existing control programs and/or premature incorporation of vector-borne disease control services into rudimentary or ineffective primary health care systems; and

f. increased costs of labor and commodities requiring foreign exchange (e.g. insecticides and vehicles).

2. Preventive Measures or Control Strategies Available

Current means of control are as diverse as the diseases they are intended to address. They can be classified as follows:

	Anti-vector	Anti-parasite
Direct	insecticides and other pesticides biological and genetic control environmental management draining or filling breeding sites urban sanitation	chemotherapy chemoprophylaxis vaccines
Indirect	public education community participation housing improvement bed nets	nutrition health education

During the 1950s and 60s, insecticide spraying and chloroquine treatment helped eradicate malaria in Europe, the United States, many Caribbean islands, the USSR, Australia and parts of Asia. The success was not complete, primarily in tropical countries, because of the development of insecticide and drug resistance, differences in vector behavior that undermined the effectiveness of indoor residual spraying, and the inability of developing countries to maintain intensive interventions for long periods of time.

Insecticide treatment is still the primary intervention used against most vectors of disease. Aerial spraying of larvicides by the Onchocerciasis Control Programme (OCP) has been particularly effective, freeing an estimated 20 million people of the risk of going blind. However, even the OCP has had problems with insecticide resistance. The overuse of agricultural pesticides in

areas of intensive cultivation has contributed to widespread insecticide resistance among mosquitoes and other vectors in Asia and Latin America. Control programs that depend entirely on insecticides are becoming less effective and are not sustainable. As Table 2 demonstrates, the necessity of increasing the number of insecticide applications and shifting to ever more costly alternative compounds as resistance develops has resulted in a 26-fold increase in total insecticide costs in some programs.

Concerns about cost and environmental safety have resulted in a renewed interest in alternatives to chemical control, particularly environmental management. Environmental management includes personal protection and reduction of breeding sources through environmental modification or manipulation. The use of larvivorous fish and other biological control agents can also help reduce vector populations, but cannot provide sufficient control to reduce disease transmission.

The effectiveness of chloroquine and other antimalarial drugs has been compromised by resistance in many parts of the world. Alternative compounds, including mefloquine, quinine, and a combination of sulfadoxine and pyrimethamine (Fansidar^{R}), are more expensive and most have side effects that prevent mass distribution. Some have also been rendered ineffective by drug resistance. Effective drug treatments for other vector-borne diseases include ivermectin for onchocerciasis and praziquantel for schistosomiasis. There is no treatment for dengue and DHF except supportive hospital care. Despite some progress in vaccine research, the only approved vaccines against vector-borne diseases are against yellow fever, Japanese encephalitis, and a few other arboviral infections.

Even when drugs or vaccines are available, there are serious problems in developing economical, effective delivery systems. Misuse may speed up the development of resistance and render a good drug ineffective. Highly effective and relatively inexpensive vaccines have not been applied widely in endemic areas because of lack of infrastructure in the health services and high cost of delivery (e.g. yellow fever vaccine in Africa).

One of the most important lessons learned from past eradication and control efforts is that no single intervention can provide sustainable vector-borne disease control. Integrated strategies that use a combination of complementary interventions, including environmental management, biological control and insecticide spraying of high-risk areas.

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Cost-effectiveness

There are not good measures of the cost-effectiveness of most vector control measures currently in use. Delivery of services has been the emphasis of most LDC programs. Unlike some of the other environmental problems discussed at this workshop, the vector-borne diseases have been a constant threat for a long time. Broad-scale use of insecticides and other control measures have generally been "imported" by donor organizations, although some countries such as India, Brazil and Mexico do produce their own insecticides. Existing cost-effective studies often compare results between two different compounds, and not between diverse strategies of control.

Only recently has there been more emphasis on studying cost and efficiency of delivery systems. This is often thwarted, however, by the rigidity of the existing vertical structures that have isolated vector-control programs from the general health services of most countries.

The lack of clear alternative strategies has not encouraged studies on cost-effectiveness. In general, if funds (national or donated) are available there is some form of control program, generally a traditional one. If there is no money, there is no program.

Benefits of Control

The cost of controlling and preventing vector-borne disease transmission must be weighed against its tremendous public health and economic benefits. Successful control of these diseases reduces treatment costs, increases economic productivity and school atendance, opens up land for cultivation and resettlement, and helps boost tourism. In addition to saving thousands of people from blindness, the OCP has made some 15 million hectares of land tillable. This would be sufficent for producing 2 million tons of sorghum a year. Successful control efforts in seven highly malarious areas of Nepal helped make it possible to increase the land under cultivation by 32 percent between 1967-68 and 1987-88.

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3. Identification of Data Gaps and Applied Research Needs in the Area

In the guidelines for preparation of this paper, this topic was assigned a "medium priority." For vector-borne disease control, it should rank higher. Of course more data are needed from certain areas, particularly from Africa, the most heavily affected area. Most countries, however, lack the ability to collect and analyze data systematically. Scarce resources are often used to collect data that are not useful for planning, stratification, and making program decisions.

Because vector-borne diseases are intimately associated with environmental change, one would hope to see a coordination of data on land and water use patterns, population shifts, general morbidity and mortality data, and use and efficiency of health care services. But these data often are not available and are rarely used to plan vector-borne disease control strategies. Even the development agencies do not coordinate information about activities and their effects in the various sectors.

In preparing an earlier report, we scanned over 100 documents and books in the A.I.D. Library in Washington, D. C. These were documents catalogued in the development field, or obtained through a computer search using key words such as **development assistance**, **environmental change**, **health** and **agriculture**. Only 25% discussed health, usually with morbidity and mortality statistics. The importance of increasing food supplies and nutrition are mentioned as the health component in about one-third of the documents. Only three discussed parasites/microbial disease. This was not a comprehensive review, and the library is a "development" rather than a "health" library, but it does suggest a lack of coordination between the various sectors in foreign assistance.

A major need therefore, is not to produce **more** data, but to develop the infrastructure in developing countries and train personnel to select carefully what types of data will most advance the disease control programs they need to develop. As the need is to develop **integrated** control programs employing the best parts of the existing control strategies for maximum efficiency, we must also be efficient in the collection of data.

4. Information on United States Capabilities and Advantages

Successes in the control of malaria and yellow fever in the United States and Panama were due to U.S. expertise in vector-borne disease control developed at the beginning of this century. Experience gained by U.S. government scientists during World War II and Vietnam added to this base of expertise. In addition, practical experience in control and the development of control agents and equipment has been gained in the private sector during the past 30 years. With this solid base and the rapid scientific advances in cell biology and genetic engineering during the last 10 to 15 years, the U.S. has been in the forefront of developing new technologies that may enhance the world's capabilities to combat vector-borne diseases. The challenge facing us today is to transfer these technologies from the laboratory or the U.S. commercial environment to vector-borne disease programs in lesser-developed countries.

A number of university, commercial and government research laboratories in the United States are developing new reagents and methodologies to be used in controlling vector-borne diseases. The scientists in these laboratories have developed expertise, particularly in malaria, arboviruses, trypanosomiasis and schistosomiasis. Unfortunately, there has not been a concomitant development of expertise in the "field" aspects of these diseases. Consequently, many of our U.S. experts will not be of much help in transferring and tailoring new technologies to LDCs. Also, our emphasis on the transfer of laboratory tools or new drugs is not appropriate for many LDC programs, which are constrained more by lack of resources and managerial capabilities than by the lack of the latest assays or drugs.

The United States has a number of strong training programs in public health, which are attended by many studentsfropm LDCs. Many of these programs, however, are oriented toward public health problems in this country, such as chronic diseases, industrial hygiene and U.S. health care administration principles. Although basic epidemiology, biostatistics and microcomputer applications are essential subjects for all public health students, these training programs are not particularly strong in transfer of technology that relates to vector-borne disease control. In addition to improving our training programs in the U.S. in terms of practical application overseas, there is a need to improve our experts' abilities to train students in vector-borne disease control on-site.

5. Information on Current Activities in Developing Countries

The major donor agencies working in vector-borne disease control worldwide are A.I.D., WHO, PAHO, UNDP, UNICEF, GTZ, ODA and the World Bank. Many U.S. and European universities have collaborative programs with universities in developing countries, such as in Thailand, Indonesia, Cameroon, Kenya, Guatemala and Colombia. Also, certain U.S. and European government agencies are working along with LDC host governments on vector-borne disease control problems. For example, the U.S. Department of Defense has medical research laboratories in Egypt, Kenya, Indonesia, Thailand, Korea, the Philippines, Brazil and Peru. The Centers for Disease Control has active vector-borne disease control program in Guatemala, Puerto Rico and Kenya, and under a PASA from A.I.D., conducts applied research on malaria treatment as part of the CCCD program. ORSTOM works in a number of West African countries, as do the Dutch.

Much of the money spent by the agencies and institutions listed above goes towards research. For the past 14 years, for instance, the WHO's Special Program on Research and Training in Tropical Diseases has invested more than 240 million U.S. dollars in sponsoring research to develop more effective disease control approaches. The cost of the U.S. government's search for an effective malaria vaccine has already exceeded $U.S. 100 million. On the other hand, A.I.D., ODA and JICA have donated millions of dollars worth of insecticides to reduce vector populations in various LDCs. In some countries where the need is greatest, however, national control program expenditures have not exceeded $U.S. 100,000 per year.

The WHO plays a major role in coordinating vector-borne disease control activities. WHO staff provide periodic reports on the status of various diseases by country and hold numerous conferences in Geneva and elsewhere in the world. The WHO/FAO/UNEP Panel of Experts on Environmental Management (PEEM) program is the most prominent voice for coordination of issues related to vector-borne diseases and the environment. International societies also are important in forming collaborations between developing-country scientists/health workers and U.S. or European scientists/health workers. These collaborations are usually formed during annual meetings or periodic international congresses. A.I.D. participation has greatly facilitated these exchanges. Organization of meetings specifically focused on vector-borne disease control issues could help expand such collaboration.

6. Synthesis: Advisory Comments on the Need, Priority, and Relevance of Intervention in the Problem Area in an A.I.D.-funded project

Concern about the public health impact of vector-borne diseases has always been high in the countries of the developing world. Their continuing perception of the need to control these diseases is evident in the high priority given to vector-borne diseases in the majority of national health plans. In recent years, there has been a growing awareness that vector-borne diseases are not only the cause of inestimable levels of human suffering, but major impediments to development as well. In fact, malaria, schistosomiasis, dengue fever, river blindness and other vector-borne disease have some degree of impact on the majority of development objectives, including agricultural productivity, environmental preservation, child survival, education and private sector investment.

Since its inception, A.I.D. has devoted a significant portion of its resources to vector-borne disease control, with concern for humanitarian issues as well as protecting its development investments. The greatest challenge has been and will continue to be developing control strategies that are sustainable with the resources of the disease-endemic countries.

A.I.D. has used several approaches to meet this challenge during the past 40 years. Initially, the Agency was a major participant in malaria eradication efforts, investing hundreds of millions of dollars in comprehensive programs. In the 1960s and 70s, comprehensive assistance was offered to selected countries that adopted a control rather than an eradication strategy. Today, A.I.D.'s investments are in tropical disease research, malaria control through primary health care, and support for the control efforts of the OCP in West Africa. Assistance in improving the
efficacy and efficiency of national control programs is available through the Office of Health's VBC Project.

Abandoning large, comprehensive, insecticide-dependent national control programs in favor of malaria treatment through primary health care decreased costs and placed intervention within the means of national budgets. Increased morbidity and mortality statistics, however, do not argue well for the efficacy of this strategic shift. A strategy based entirely on case finding and treatment of vector-borne diseases is incomplete and should be expected to yield less satisfactory results than one that integrates several interventions.

The inclusion of vector-borne diseases into a comprehensive

environmental health strategy gives strength to the components of control programs that are currently neglected. This emphasis shifts priorities from cure to prevention and opens up new opportunities for cross-sectoral collaboration and sustainability. Some of these opportunities include:

When applicable, linking the costs of vector-borne disease control to the development rather than the health budget.

Development activities such as irrigated agriculture, rice cultivation and resettlement have predictable and significant effects on some vector-borne diseases. The mechanisms for disease control, as well as their costs, can be included in the design of development efforts, effectively reducing the financial burden on the often under-funded Ministry of Health.

Integrating vector-borne disease control efforts into other sector initiatives.

Vector-borne diseases do not exist in isolation. In many cases, significant control can be achieved through the improvement of water and sanitation, agricultural planning and community development. In some instances, such as the growing threat of dengue hemorrhagic fever in rapidly urbanizing countries, or in the control of urban filariasis, community action in environmental sanitation may be the only effective intervention.

Documenting and verifying cost information associated with the impact of vector-borne disease as well as the cost effectiveness of control options.

State-of-the-art understanding of socioeconomic factors associated with vector-borne diseases and their control should permit more quantitative documentation than currently exists. Cost analyses and simulations of control options hold promise for helping host-country specialists make wiser decisions and promote advocacy for control.

Increasing coordination between the international donors.

Donor coordination is often lacking, even within individual agencies. The environmental approach presents opportunities for donor coordination on a number of levels and among donors that are working in complementary sectors.

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Figures

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Figure 1. Global Distribution of Malaria, 1988

Prepared by the Vector Biology and Control Project
Source map: World Health Organization, 1990

Figure 2

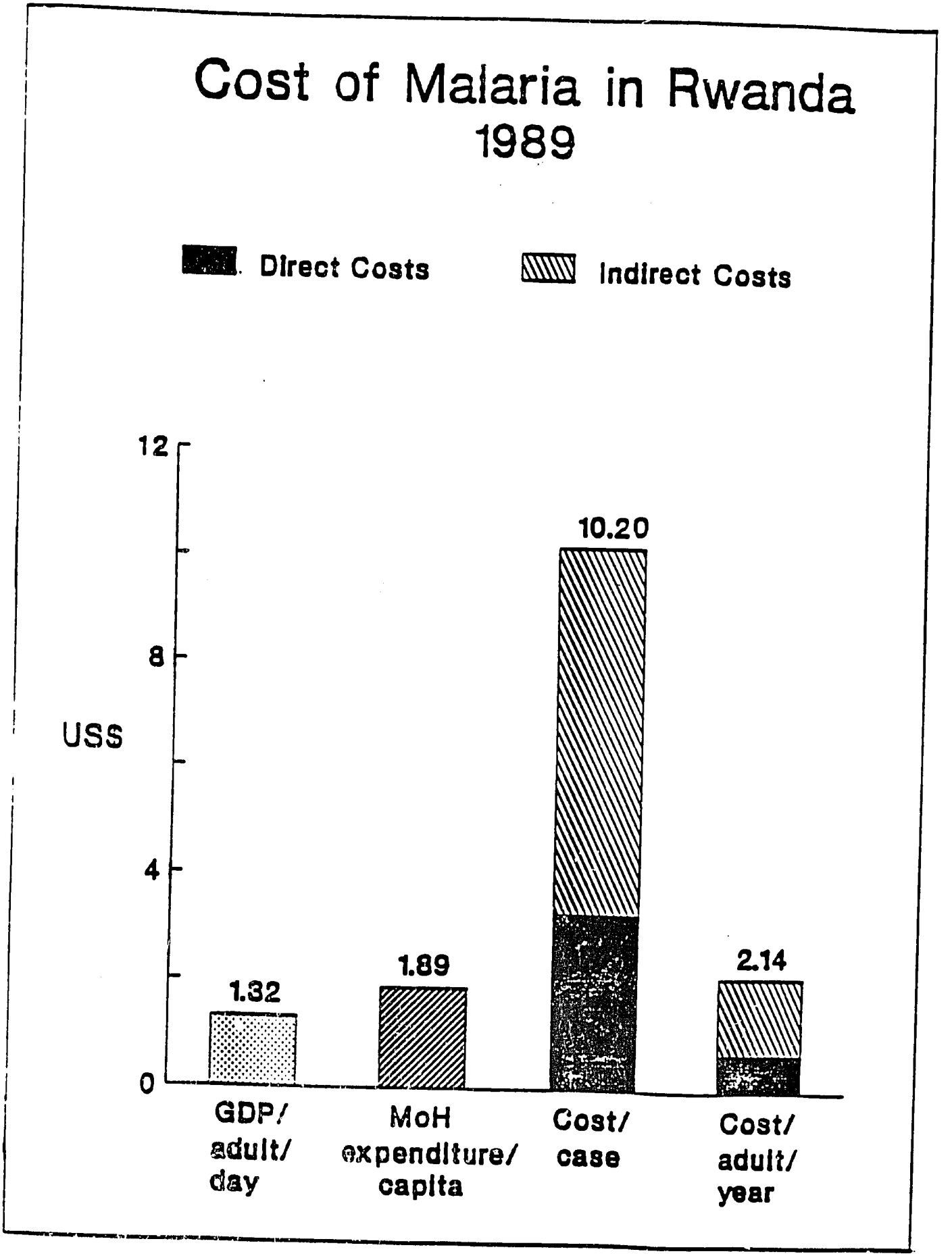
Cost of Malaria in Rwanda
1989
Direct Costs
Indirect Costs
12
8
4
0
US$
1.32
1.89
10.20
2.14
GDP/ adult/ day
MoH expenditure/ capita
Cost/ case
Cost/ adult/ year

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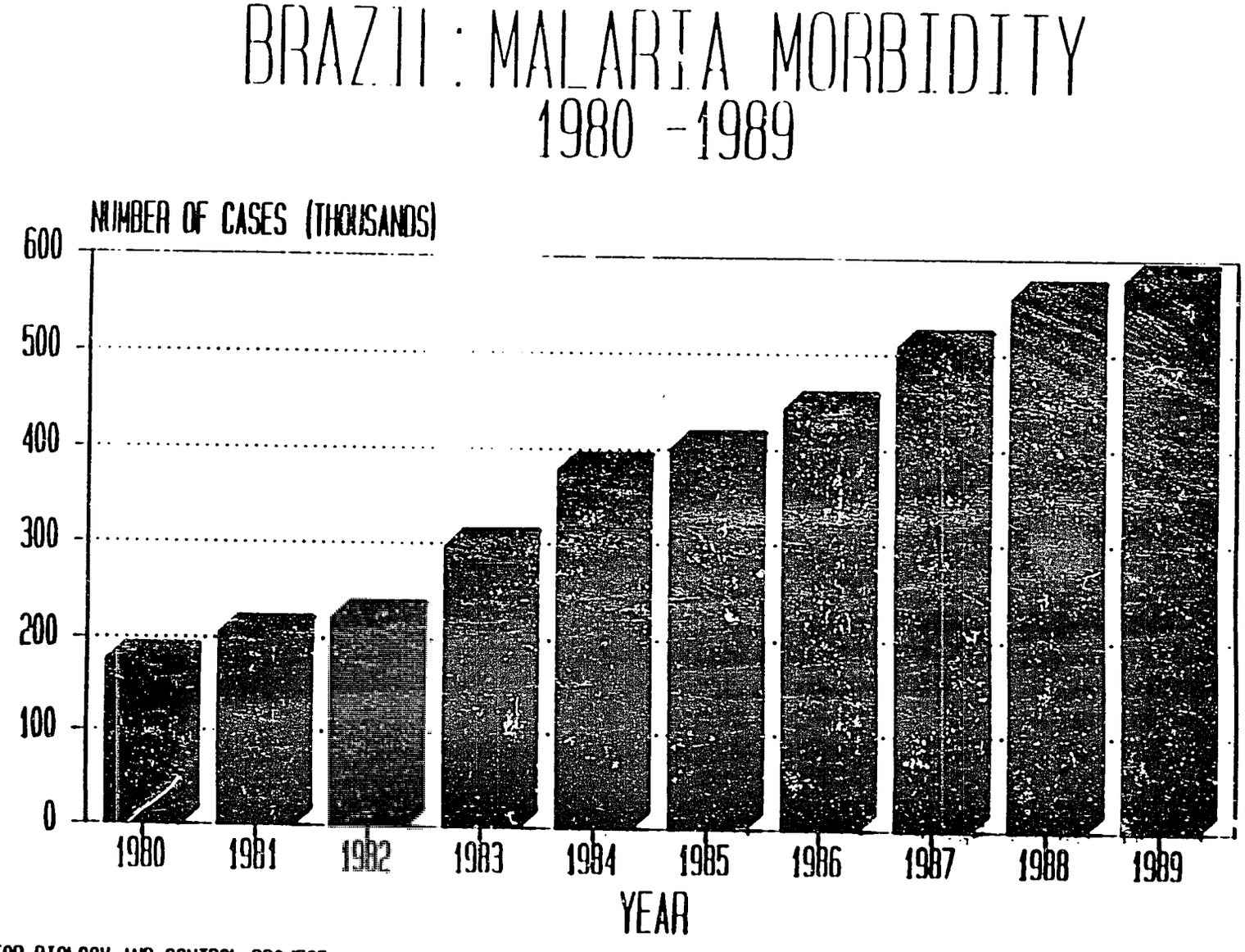
Figure 3



VECTOR BIOLOGY AND CONTROL PROJECT

Tables

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TABLE 1. Estimated Size of the Vector-Borne Disease Problem

Disease	Number of Countries	Population At Risk	Estimated Cases
Malaria	102	> 2 billion	200 million/year 2 million deaths
Schistosomiasis	79	699 million	250 million total
Onchocerciasis	35	250 million	20 million total 500,000 blind
Guinea worm	19	150 million	15 million/year
Chagas' Disease	20	65 million	16-20 million infected
Dengue (epidemic)	50	350,000 cases in Havana 1981 400,000 cases in Guayaquil 1988 500,000 cases in Rio de Janeiro 1987 160,000 cases in Santa Cruz, Bol 1987 170,000 hemorrhagic cases annually in Thailand	
Yellow Fever (epidemic)	20	30,000 cases 10,000 deaths Nigeria (1987-88)	
African Trypanosomiasis	36	50 million	
Leishmaniases	50		12 million 500,000/year (low estimate)
Filariases	50		91 million

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Table 2

RELATIVE COSTS OF PESTICIDES USED FOR INDOOR HOUSE SPRAYING: INCREASED LABOR COSTS (2X) FOR OP AND C COMPOUNDS NOT INCLUDED

Insecticide (Type)	Dosage[1] a.i. g/m²	Applications[1] per year	Cost US $/kg	Relative Costs of Insecticides (DDT=1)
DDT (OC)	2.0	2	1.50	1.0
Malathion (OP)	1-2.0	4	3.50	4.6
Fenitrothion (OP)	1-2.0	4	5.50	7.3
Propoxur (C)	1-2.0	4	16.00	21.0
Bendiocarb (C)	0.4	4	50.00	26.6

[1] World Health Organization/Vector Biology and Control/82.841

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SHELTER AND HUMAN SETTLEMENTS AND ITS RELATION TO ENVIRONMENTAL HEALTH

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Office of Housing and Urban Programs, USAID
Presented at Environmental Health Workshop
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Preface

Shelter and human settlements are not physical developments that can be discussed in isolation from the locational factors which influence their adequacy. As Hardoy and Satterthwaite rightly point out, "In looking at health problems associated with the home, it is important to look beyond the house's structure. It is the environment provided for people by the house, the services and facilities it should contain, and the neighbourhood within which each house is located which should act as a defence against injury and disease."[1] My paper, therefore, will discuss shelter and human settlements in the physical and locational contexts which exist in the cities of the developing world and how those characteristics influence environmental health.

Outline of Paper

I. Introduction
   A. Office of Housing and Urban Programs (APRE/H)
   B. Summary of APRE/H Urban Environmental Activities

II. Relation of Shelter and Human Settlements to Environmental Health Issues
   A. Locational Factors
   B. Environmental Health Problems
   C. Disproportionate Effect on the Poor
   D. Urban Management Solutions to Environmental Health Problems

III. Summary

I. Introduction to the Office of Housing and Urban Programs

Many of you may be wondering why AID's Office of Housing and Urban Programs is now emphasizing urban environmental issues. In order to address this issue, I would like to take a moment to briefly describe the evolution of our programs to provide you with an idea of our approach to environmental problems and how that relates to our projects.

A. Expansion of APRE/H Programs

Until the late 1970's, the Office of Housing and Urban Programs primarily designed and financed housing projects which were implemented by National Public Housing Authorities or private host country Savings and Loan Associations. These projects principally benefitted middle and lower middle class families. The Basic Human Needs Legislation, promulgated in the late 1970's, mandated that AID redirect its' efforts towards improving the quality of life for the poor. As a result, the Office of Housing and Urban Programs shifted it's focus from designing housing projects of completed units to more modest solutions that were affordable to low income families. Consequently, our portfolio gradually expanded to include core housing, sanitary core units, sites and services and neighborhood upgrading projects. As our project portfolio expanded, so did our client base. National and municipal water and sewer authorities, land development agencies and municipalities also became key implementing agencies as a result of this transition. Our involvement in neighborhood upgrading programs served to strengthen and solidify our ties with municipalities who were the principal implementing agencies of these programs.

Issues of cost recovery and municipal project design and management drew us into the broader fields of municipal finance and management. It was principally through our experience, first with site specific housing projects and later with broader municipal management programs, that our involvement in urban environmental issues broadened.

B. Summary of the Office of Housing and Urban Programs Urban Environmental Program

As the Office moved from development of site specific

projects to a broader policy approach to municipal management, the need to more directly address urban environmental issues became increasingly evident. Based on our experience in development of both project and policy programs to improve municipal management, the Office last year adopted an urban environmental strategy and action plan. It has three objectives: (1) to explicitly integrate urban environmental issues into the design of our programs, (2) to test new private sector approaches to providing municipally financed environmental services and (3) to contribute to the improved analytical capability of donors and host countries.

As to the latter point, our understanding of urban environmental problems is woefully inadequate. Very little systematic study has been done to date of the various repercussions of urban environmental problems on human health, ecology or economic development. For this reason, the research component of our urban environmental program is experimenting, through applied studies, with systematic analysis of urban environmental problems. Although the methodologies we are currently testing encompass all three dimensions of urban environmental problems - ecological, economic, and health - I will limit my remarks today to the work we have done to analyze the health effects of urban environmental problems.

In a study of Bangkok, Thailand (Ranking Environmental Health Problems In Bangkok, Thailand, December, 1990) we tested the appropriateness of the comparative risk analysis to rank urban environmental problems, using human health as the filter. The comparative risk analysis has historically been the approach used by USEPA to rank environmental problems in the US. The application of this methodology to Bangkok is the first time the approach has been used outside the US.

The methodology utilized two factors to determine rankings; the overall number of people affected by adverse health effects and the severity of those effects. Thus, severe, irreversible effects, such as learning disabilities due to lead exposure, were more heavily weighted than curable diseases. In the same vein, problems which were more geographically widespread and affected many people were ranked higher than

localized problems which affected a smaller number of people, even if the effect was severe. By developing a common analytical basis for all environmental health risks, the methodology allows different risk reduction policies to be systematically compared.

The results of applying the comparative risk analysis to Bangkok were illuminating. In a city with no sewage treatment, inadequate sewage collection and annual flooding, we had anticipated, and the study confirmed, that one of the principal environmental health risks is microbiological diseases. According to the study, 1.5 million persons per year contract microbiological diseases in Bangkok accounting for 6% of annual deaths.

In addition to microbiological diseases, particulate matter in air and exposure to lead were identified as high health risks. With regard to particulate matter, the study estimates that Bangkok residents might suffer over 50 million restricted activity days and up to 1400 excess mortalities per year as a result of respiratory illnesses. Regarding lead, over half a million adults and children may be adversely affected, experiencing cardiovascular ailments and learning disabilities. This may include several hundred thousand cases of hypertension per year resulting in 800 cases of heart attacks and stroke and up to 400 deaths. Among children, the study estimates that the average child through the age of seven loses 3-5 IQ points due to lead exposure.

The results of this study have been incorporated into the Thai Development Research Institute's report to the Prime Minister and are being integrated into the redesign of the AID MANRES Project. We hope that the results of this study will spur other donors and AID Missions to apply this tool to the analysis of urban environmental health problems.

In addition to the methodologies we are testing, the Office is currently financing technical assistance to 10 host countries to improve municipal solid waste management and to investigate the possibilities of contracting with the private sector for provision of this service. Cities and countries currently participating in this pilot project include Guayaquil, Eucador; Gaborone, Botswana; seven secondary cities in Costa Rica; Sfax,

Tunisia; Tegucigalpa, Honduras; Togo, Mali, and Senegal in a regional project; Chiang Mai and Phuket, Thailand and Port-au-Prince, Haiti. The projects cover the gamut of solid waste management issues, from improvement of the existing collection system to sanitary landfill management. We hope to expand the number of countries participating in this program in the coming year and to provide the Agency and other donors with 'lessons learned' based on our first year's experience in implementation.

Finally, the Office and its seven Regional Housing and Urban Development Offices (RHUDOs) are providing technical assistance to Missions to improve AID's capacity to analyze urban environmental problems. In the past year, technical assistance has been provided to India, Nicaragua, Morocco, the Dominican Republic and a regional study of the Caribbean to examine urban development and environmental problems. Washington staff has been assisting our RHUDOs to develop regional urban environmental strategies. The strategy for the RHUDO in Jamaica has already been completed and incorporated into the Mission's environmental Action Plan. RHUDO Asia will complete their urban environmental strategy this fiscal year.

II. Relation of Shelter and Human Settlements to Environmental Health Issues

As I mentioned in my introductory remarks, the provision of housing cannot be considered in isolation to its location. Many of the problems associated with housing and environmental health are not the result of housing per se, but are due to the rate of urban growth, the patterns and density of that growth, and the inability of municipalities and national authorities to adequately address or manage these demographic and locational issues. In this section of my paper, I will briefly summarize the locational factors which contribute to environmental health problems, the types of environmental health problems generated and possible solutions.

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A. Locational Factors

Environmental health problems have, in fact, intensified in urban areas of the developing world since the 1970's. In many countries, despite increased investments, service delivery has actually declined since the 1970's. In the Dominican Republic the percent of all urban households with piped water supply declined from 91% in 1970 to 70% in 1980[2]; in Abidjan water coverage dropped from 57% (1977) to 47% (1983)[3].

The provision of other urban services is just as deplorable. It is estimated that 30-50% of solid wastes generated within urban centers remains uncollected. In Sao Paulo, one-third of the population live in areas without any solid waste collection service.[4] In Bangkok, 20% of the garbage is left uncollected.[5] In Dar es Salaam (1985) 78% of daily solid waste was uncollected.[6] The lack of sewer services is even more striking. Over 50% of urban residents in the LAC region lack sewers. Sewage treatment is virtually nonexistent in the developing world.

The reason for the lack of urban services can be explained in part by the fact that urban growth rates exceed the capacity of municipalities to keep pace with rapid population shifts. In the Caribbean, the average urban growth rate was 4.2% versus 1% for rural areas.[7] In Africa, the average urban growth rate is 6% per year. 100 million people now live in African towns and cities. These high urban growth rates are particularly true for the Dominican Republic and Haiti where urban growth rates are currently 5% and 4.7%, respectively.[8] The UN estimates that by the year 2020, urban areas in the Caribbean will capture 88% of all new growth.[9] In Africa, by the year 2000, 40% of the continent's population will reside in urban areas.

The decline in urban service delivery is only one manifestation of the inability of municipalities to keep pace with urban growth. The inability of municipal authorities to provide adequate and appropriate land for settlement by new urban dwellers is another striking deficiency. The eruption of squatter settlements throughout the developing world is sad testimony to this

incapacity. These squatter settlements often constitute a high percentage of the total urban population and continue to grow at phenomenal rates. An estimated 50% of the population of Tegucigalpa, Honduras, live in squatter settlements; 79% of the population of Addis Ababa live in slums. In St. Lucia, squatter growth in the Vieux Fort area averaged 70% per year in the mid-1980's.[10]

These new settlements are most often located on land that is inexpensive, primarily because it is located some distance from the city center and employment opportunities or on environmentally unsound sites. Most of these squatter settlements are on flood plains, steep hillsides or adjacent to noxious industries or dumps. Dense squatter settlements in the hills above Port-au-Prince have already destroyed virtually all of the watershed around that city. In Mexico City, approximately 1.5 million people live on the drained lake bed of Texcoco, an area plagued by constant flooding, dust storms in the dry season and an almost complete lack of urban services. Yet these colonias populares were built because no more suitable sites were within the economic reach of lower income groups.[11]

Typically, these squatter settlements lack water, sewer, stormwater drains, garbage collection and disposal, and paved roads. They are densely populated and the combination of overcrowding, inadequate housing and lack of services exacerbate the populations' already serious health problems and provide ripe breeding grounds for a variety of additional environmental health problems.

B. Environmental Health Problems

Use of inappropriate housing construction materials or methods are a contributing factor to the high incidence of environmental health problems, especially for the poor. In the Dominican Republic, some two-thirds of the urban population live in substandard housing. Chagas disease, which causes heart damage, enlargement of liver, spleen and lymph glands and which can be fatal, is perpetuated by inadequate housing where protozoan live in mud walls and thatch roofs. It infects an estimated 24 million Latin Americans, but is most prevalent in

Bolivia.[12] The use of asbestos in construction materials, which can cause cancer, is another.

In addition to the environmental health problems which are caused by inadequate housing, there are a wider variety of environmental health problems which are a result of inadequate services. As mentioned earlier, lead poisoning causes cardiovascular ailments and learning disabilities. The sources of lead poisoning are numerous; lead in gasoline and the proximity of housing to congested roads, corroded lead pipes in the water distribution system, contamination of stored water by lead particulates in the air, and lead based paint. Respiratory diseases are caused by several factors; cooking indoors without adequate ventilation and exposure to dust particulates and other airborne particulate matter. Microbiological diseases, such as diarrhea, dengue fever, cholera, and dysentary result from drinking, swimming, bathing, and washing clothes in contaminated water. Flooding is positively correlated to the increased incidence of microbiological diseases. In Chile, where there is no sewage treatment, in the central region of the country, contamination of irrigation water with urban waste has led to outbreaks of typhoid and hepatitis.[13] Vector borne diseases result from the location of breeding grounds, such as pools of stagnant water and uncollected garbage adjacent to residences.

C. Disproportionate Effect on the Poor

The poor of the developing world, already weakened by malnutrition, are disproportionately affected by environmental health problems. They lack the resources to pay for adequate water and sewer services. They live in areas inaccessible to solid waste collection trucks. They risk greater exposure to vector borne diseases because it is the poor who scavenge the garbage or live adjacent to industrial and municipal dumps, and because of the location of these settlements on steep hillsides and flood plains, the municipality faces higher engineering costs to extend services to these areas. In Kinshasa, 100% of high income areas had piped water while outlying squatter settlements have no piped water system.[14] In Mexico City, the highest concentration of dust particles were in the Southeast and Northeast where low income groups live.[15]

A second characteristic shared by most kinds of housing used by poorer groups is crowded, cramped conditions which mean that diseases such as tuberculosis, influenza and meningitis are easily transmitted from one person to another. For example, in Kanpur, India, the development authority estimates that 60% of the children in slums have tuberculosis.[16] In San Martin, a squatter community which rings Buenos Aires, more than half of the inhabitants sampled has intestinal worms. 15% of the children had respiratory inflammations, and 25% of the men had bronchial problems.[17]

D. Urban Management Solutions to These Environmental Health Problems

There are a number of approaches to address the environmental health problems of the developing world. Improved nutrition, income, and hygiene education are important contributions to the solution. Provision of affordable, accessible and preventative health care is another. However, I would like to focus upon the contribution that improved municipal management can make to alleviating the environmental health problems for people, especially the poor, who live in the cities of the developing world.

1. Improved land use planning is an important factor that can eliminate many environmental health problems. Providing affordable sites for new developments away from dumps, toxic fumes and dust from industries, and not in flood plains or on steep hillsides would reduce the incidence of vector borne and respiratory diseases. Providing adequate roads and pathways which provide access for solid waste collection equipment and minimize dust particulates would reduce the incidence of vector borne and respiratory diseases.

2. Regularizing land tenure, providing land titles to residents, especially the poor, gives them a personal stake in improving their lot and preventing environmental problems in the surrounding neighborhood which might decrease the value of their own property.

3. Reducing water and sewer standards and simplifying solid waste collection methods (using pushcarts instead of trucks) would make the provision of these services more affordable to the poor and accelerate the ability of

the municipality to extend these services more expeditiously. As has been clearly documented, extension of water and sewer services is one of the principal ways to reduce the incidence of microbiological diseases.

4. Closer attention to maintenance of the existing infrastructure system would reduce leakage in the water distribution system, prevent lead contamination of water from corroded pipes, and improve water pressure, thus obviating the need for residents to store water in the home, which can provide breeding grounds for insects and be contaminated from airborne particulates.

III. Summary

In summary, the objective of the Office of Housing and Urban Programs is to ensure that greater attention is focused on the role and contribution improved municipal management can play to alleviate the enviromental health problems which plague urban residents of the developing world.

Footnotes

[1] Squatter Citizen by Jorge E. Hardoy and David Satterthwaite, (London: Earthscan Publications, LTD., 1989), p. 162.

[2] Urbanization in the Caribbean, Prospects and Management Priorities, Report by the Urban Institute for RHUDO/Caribbean, October, 1990, p. ix.

[3] African Cities in Crisis edited by Rodney White and Richard Stren, (Boulder, San Francisco, and London: Westview Press, 1989), p. 41.

[4] Squatter Citizen, p. 160.

[5] Ranking Environmental Health Risks in Bangkok, Thailand, Report for the Office of Housing and Urban Programs by Sobotka and Company and Abt Associates, December, 1990.

[6] African Cities in Crisis, p. 44.

[7] Urbanization in the Caribbean, p. ii.

[8] Urbanization in the Caribbean, p.ii.

[9] Urbanization in the Caribbean, p. iv.

[10] Urbanization in the Caribbean, p. iii.

[11] Squatter Citizen, p. 159.

[12] Bolivia: Current Status and Potential Development of Control Strategies for Chagas' Disease, Report for the Vector Biology and Control Project, February-March, 1990, p. 9.

[13] Chile Environmental and Natural Resource Strategy, Washington, D.C.: World Resources Institute, 1989, p. 18.

[14] African Cities in Crisis, p. 159.

[15] Squatter Citizen, p. 203.

[16] Squatter Citizen, p. 154.

[17] Squatter Citizen, p. 155.

Background Paper

TOXIC, HAZARDOUS AND RADIOLOGICAL WASTE MANAGEMENT

U.S. AID

Office of Health

Environmental Health Workshop

Washington, D.C.

February 14-15, 1991

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EXECUTIVE SUMMARY

Toxic, hazardous and radiological (T/H/R) waste management is one component of AID's Environmental Health Strategy. Unlike most other problem areas, T/H/R waste management is defined on the basis of the hazardousness of materials rather than the medium (air, water, land) through hazards are transmitted. It is further distinguished by certain other attributes: a close correlation with hazardous materials use and level of industrial development; long latency periods of many exposures make risks less visible and less urgent relative to other health hazards; and transportability across international boundaries. The relatively low priority assigned to T/H/R management by AID missions and country-specific risk assessments probably understates its contribution to overall environmental health problems. This is the case because waste materials eventually appear in all environmental media and create multi-pathway exposures at which point the health is reclassified.

U.S. approaches to waste management, based on complex and costly regulatory and enforcement mechanisms as well increasingly capital-intensive technologies, are incompatible with developing country needs and resources. An alternative approach, emphasizing pollution prevention through materials substitution, process changes and waste recycling, is more appropriate and, in the long-term, less costly. U.S. initiatives in pollution prevention may be transferred to developing countries through various private and governmental vehicles, thereby avoiding pitfalls of the U.S. "end-of-pipe" orientation which tends to shift and disperse health risks rather than eliminate them at the source.

AID actions to promote a T/H/R waste reduction program may take the form of training recipient country personnel in waste inventory and forecasting methods, pollution prevention technologies and cost evaluation techniques, and the creation of market incentives to complement improved standard-setting procedures. In addition, specific studies of risk reduction for scavenger populations and secondary materials manufacturers would address more immediate needs. Finally, modification and application of existing comparative risk assessment methodologies, in close collaboration with host country experts, would provide a framework for a more rigorous, comparative assessment of T/H/R waste management relative to other environmental health problem areas. At the same time, such assessments would inform the development of future AID and country-specific environmental health strategies.

1. Introduction

Of the many environmental health challenges facing developing countries and Eastern Europe, toxic, hazardous and radiological (T/H/R) waste management is distinctive in two respects.

First T/H/R is a problem area defined principally by the hazardousness of a class of **materials** which, because of their physical and chemical properties, pose a threat to human health and the environment. In contrast to water supply, and air pollution problems, T/H/R wastes are not confined to a specific environmental medium. They appear in gaseous, liquid or solid form as air, water and land pollutants, and are readily transformed and shifted across media over the course of their lifecycle. Nor are T/H/R wastes defined by receptor characteristics, as in the case of occupational health and safety, where workers and the workplace--agricultural, industrial and service--bound the problem area.

Second, the term "wastes" itself contains a temporal dimension. Virgin chemical or manufactured products may be transformed into waste products simply by disuse, e.g. extended storage of pesticides which renders them ineffective and in need of disposal, or unused, leaking solvents mismanaged in a metal-working factory. This temporal dimension may also come into play in the context of a product lifecycle, as in the case of scrap metals or lead acid batteries imported by developing countries to displace virgin materials or the importation of finished products. These are potentially hazardous wastes in the sense (a) the exporting nation would otherwise discard them and (b) the materials present health risks to both worker and community populations during processing and refabrication. At present, however, neither international nor national regulations provide adequate protection against the health and safety hazards of such recycling activities.

As these dimensions of T/H/R waste management are more fully recognized, its significance as an environmental health problem grows in both absolute and relative terms. Notwithstanding the tendency of policy-makers and program designers to fit environmental problems, T/H/R waste management does not lend itself to easy classification into a convenient, self-contained program area with respect to achieving risk assessment or risk management objectives.

These definitional and boundary issues in scoping the T/H/R waste management problem are reinforced by four additional characteristics of the problem:

The T/H/R wastes are closely correlated with T/H/R materials use. Waste generation and hazardous materials use are closely coupled. T/H/R waste management as conventionally practiced in Western countries is typically an "end-of-pipe" approach intended to minimize health and safety risks from materials already deemed economically unusable. Diminished reliance on T/H/R materials to begin with, under the rubric of "toxics use reduction" and "pollution prevention," is an emerging new paradigm among Western countries. Developing countries and Eastern Europe need not follow the same evolution as the West in this respect. Opportunities for technological "leapfrogging" are possible.

T/H/R waste generation and associated health risks are closely linked to levels of industrial development. Modern industry depends on the constant replenishment of new

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materials, processes and products. In the post-WW II period, such replenishment has meant the development of new chemicals by the tens of thousands, although only a small fraction--probably 1-2%--account for 99 percent of all the manufactured tonnage. Similarly, radioactive materials are a post-War phenomenon whose uses extend from energy production to medical research. With each increment in the inventory of chemical materials, new opportunities for waste generation emerge. It is not surprising to see T/H/R waste management receive a low ranking overall by AID recipient countries, but a higher than average priority among those which are relatively more industrialized, e.g. Thailand, Morocco, and Botswana.

Many health outcomes associated with exposures to T/H/R wastes have long gestation periods, thereby slowing community and official response times in identifying and reacting to hazards. Exposures typically associated with T/H/R wastes are chronic, low dose rather than acute, high dose. Whether through liquid wastes in lagoons, streams or groundwater, or solid materials in landfills, carcinogenic and non-carcinogenic diseases may occur 20 or more years after initial exposure. When, as in poorer countries, life expectancy is the range of 50 years, and other diarrhoeal, gastrointestinal and infectious/parasitic diseases and pesticide poisoning are life-threatening, long-term exposures to T/H/R wastes is unlikely to generate either a sense of urgency or a quick response.

T/H/R wastes are readily imported. Whether defined to include recyclable secondary materials, T/H/R wastes move across national frontiers in large volumes. Such materials may be more, equally or less hazardous than virgin materials which are equally mobile. Without adequate protections and management practices on the part of recipient countries, such hazards may translate into substantial risks to both workers and communities.

With this background, we proceed with an initial exploration of some key issues surrounding the T/H/R waste management component of AID/Office of Health environmental health initiative. Our discussion is organized into six sections. In Section 2, we discuss the sources, pathways and magnitude of health risks in developing country settings. Here, as in subsequent sections, we refer in passing to Eastern Europe, but maintain a focus on conditions typical of those found in AID's traditional recipient countries. Section 3 describes preventative and control strategies, with an emphasis on pollution prevention as an alternative to post-generation responses. Section 4 identifies data gaps and research needs to enhance T/H/R waste management in developing countries, giving special weight to the establishment of waste generation and tracking information systems. Section 5 describes the strengths and limitations of applying U.S. management practices to developing countries, and Section 6 presents a few observations on current AID country activities. Finally, Section 7 summarizes the needs and priorities of T/H/R waste management in AID's Environmental Health Strategy, including specific actions the agency might consider in the near-term.

2. Problem Characterization

T/H/R materials pose dangers to human health when materials are released into the environment, and inhaled, ingested or absorbed through the skin. At any stage in the flow cycle of hazardous chemicals, a release may occur and human populations may become exposed.

This cycle is depicted in Exhibit 1 (Smith 1988). In the first step, hazardous chemicals may enter a developing country as either a raw material imported from abroad, or as a product (or byproduct) of an extractive activity based on local resources (e.g. asbestos or copper mining). Next a material may be refined, synthesized, processed and recycled, and later used as, for example, a solvent or intermediate material in the manufacturing process. Product manufacturing follows, in which compounding, mixing, assembling other process transforms a material into a usable good. In the uses stage, consumers and business apply the product to meet an end use service (e.g. pest control, medical treatment, dry cleaning) and, finally, discard the material in the post-use stage.

At any point in the process, solid, liquid, gaseous or liquid waste products may be generated, setting the stage for exposure. Releases occurring in the immediate work environment represent occupational hazards. Releases which move beyond the property line (of the mine, factory or farm) become an environmental hazard. Some releases are expected, that is, anticipated and integral to the technology to which hazardous materials are subjected. Others are unanticipated and/or in excess of some minimum expected level, the result of poor housekeeping, faulty equipment, human error, or a combination of these. Either may contribute to the regulated T/H/R waste stream.

What is the magnitude of these wastes in developing countries? A compilation of recent figures from selected countries appears in Exhibit 2. Data on developing countries are especially scant, and subject to a high degree of uncertainty and non-comparability, mirroring but far more limited than data available from industrial countries. Of particular note is the absence of African data, save a few figures for waste imports. This, of course, reflects the substantial attention focused on the international waste trade while domestic generation goes largely undocumented. In the industrial countries, differences in U.S. and European definitions make cross-national comparisons of limited value. Municipal, industrial and hazardous/special waste are mixed in various forms for accounting purposes, based on both generation sector (residential, commercial/institutional, industrial) and the hazardousness of the material (chemical versus non-chemical). As of the mid-1980's, a decade after enactment of the Resource Recovery and Construction Act (RCRA) (which set the stage for cradle-to-grave waste tracking), the quality of U.S. data remained uneven and incomplete. In virtually all AID recipients, neither regulatory definitions, much less reliable waste inventories, simply do not exist.

A recent study of relative environmental risks in Bangkok provides at least a glimpse of a waste profile in one newly-industrializing AID country.[1] Exhibit 3 lists the National Environment Board estimates of hazardous waste quantities by type for past, current and future years. Heavy metal sludges and solvents represent the bulk (63.8 percent) of the 1,300,000 tons generated annually. Oils, at 120,000 tons, are a distant second. Growth of 46.2 percent is estimated during the five years between 1986 to 1991, a figure which will almost double to (84.2 percent) during the next five year period, a reflection of Thailand's rapid

[1]This is one of a series of relative risk studies pertinent to setting environmental health priorities in developing countries. See also Goodman 1980; Kates, Hohenemser and Kasperson eds. 1985; U.S. EPA 1987; and Norberg-Bohm et al 1990.

economic growth during the 1990's. In 1989, manufacturing (190,000 tons) and metal smelting (520,000 tons) together accounted for an estimated 86.6 percent of the city's total generation.

In most AID countries, where industrialization is proceeding far more slowly than in Thailand, T/H/R waste generation is undoubtedly far less in total and per capita volume. Nevertheless, the dominance of heavy metals in the Thai waste stream is suggestive of the potential human health risks posed by early industrialization based on modern chemical processes. In assessing the risks in Bangkok, this becomes evident from several perspectives (Abt Associates and Sobotka & Co. 1990) First, hazardous and solid wastes are essentially indiscriminantly delivered to, and mixed in, Bangkok's three operating landfills. From an operational standpoint, they are one in the same. Wastes industry does not discharge to surface waters generally are sent to the landfill for disposal. Thus, any one landfill is a repository of night soil from septic tanks, unrecycled organic material that survives scavenging by waste collectors, and various solid and liquid wastes from industrial processes.

Because waste collection, transport and disposal facilities are uncontrolled from both an environmental or human access standpoint, exposures occur during all phases of waste management. Where generation yields reusable materials (e.g. battery casings burned for fuel), or occurs at distances too far to be transported to operating landfills, local populations are potentially exposed to both metals and volatile organic compounds. Where centralized disposal does occur, waste collectors, residents (at the landfill) and non-residents routinely scavenge for salable material. This phenomenon is documented throughout the Third World, and its positive side cannot be ignored.[2] Nonetheless, such an unregulated system introduces a range of potential human health exposures: pathogens and toxins through inhalation and dermal contact; volatilization of organics linked to open fires and emissions off landfills; contamination of aquifers and surface drinking water sources; ingestion and dermal exposure through bathing in polluted water bodies.

Individuals living on or near the three Bangkok landfills, probably numbering several thousand, represent the extreme range of potential exposures (Abt Associates and Sobotka & Co. 1990) Evidence of respiratory, diarrheal and skin disease have been detected among such populations. High concentrations of particulate matter and stored water with elevated fecal coliform suggest other potential sources of environmental insult. In estimating overall risks, benzene and methylene chloride, both carcinogens, posed moderately high risks of between 1 x 10-4 to 6 x 10-5 for those most exposed populations (Exhibit 4). For the general population, waste management at the landfill may pose a significant risk through groundwater contamination by mercury leaching into wellwater sources, though a similar estimate for chromium suggests EPA's risk-reference dose is not exceeded using conservative estimation assumptions.

While T/H/R wastes generated within developing countries are poorly characterized, the revelation of numerous attempts and some actual waste shipments from industrial nations to developing countries evidence a small but growing trade in hazardous materials (Wynne

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[2]An ongoing Tellus Institute study in Jakarta estimates that 25 percent of all municipal waste is removed from the waste stream before it reaches any transfer point, and 50 percent of earnings from such scavenging is returned to the rural areas as income transfer.

1989). Among those identified have been U.S. proposals or shipments to India, Nigeria, Zimbabwe, Honduras, Panama and Haiti; Italian wastes to Nigeria, Djibouti and Venezuela; and British and Swiss wastes to Guinea-Bisseau (White forthcoming). Transborder shipments all types (including between industrial countries) have been occurring for at least two decades, amounting to perhaps 5-10% of the 350 million tons of annual worldwide volume. Within Europe alone, an estimated 100,000 shipments per year occur, with a strong directional bias from West-to-East. One recent study estimates that since 1989, 22 million tons of waste have been offered to Poland, though only 46,000 has actually been shipped, most notably from West Germany, Austria and Sweden (Bernstorff and Pucket 1990). These include shipments of electronic and cable scrap, solvents, paints, sewage sludge, dredged spoils, and incineration residues.

From a public health perspective, foreign wastes imported by developing countries and Eastern Europe represent different, and likely higher, degrees of risk than domestically generated wastes on a per unit basis. The reason for this is two-fold. First, waste brokers and transporters involved in Third World shipments often operate as phantom corporations with little investment in recipient country welfare. Operating on the margin of legal norms, the tendency has been to choose easy destinations where regulations and enforcement are minimal. Under these circumstances, wastes are likely to be managed with few protections for human health and the environment.

Second, waste from industrial countries tends to be more diverse and less familiar than domestically generated wastes. Whereas relatively few waste types tend to dominate developing country waste streams (as in the case of heavy metal sludges in Thailand), shipments from industrial nations contain a wide array of metals, organic and inorganic compounds. Greater diversity demands more complex monitoring, analytical and disposal capabilities to properly handle waste, all of which are in short supply in developing countries.

In sum, the assessment of the human health risks of T/H/R wastes within and across countries suffers from a lack of data on waste stream volumes, composition, and disposal site conditions and exposure information. These conditions, while limiting our ability to develop a rigorous characterization of the problem, do not stand in the way of certain generalizations. Relative to other environmental health concerns today, T/H/R management is perceived as less urgent by virtually all traditional AID recipient countries; its boundaries are fuzzy, most obviously, but not exclusively, intersecting solid waste management and wastewater management among AID's identified problem areas; its appearance on recipient country agendas is coupled closely with the industrialization process, making it a relatively higher profile issue in newly industrializing countries and in Eastern Europe; and it is the problem area uniquely susceptible to international political repercussions owing to its export-import dimension.

3. Preventative Measures and Control Strategies

In the U.S. and other industrial countries, the management of T/H/R wastes has undergone a gradual but steady evolution during the last decade. This transformation is highly instructive to developing countries, and to AID when weighing alternative intervention strategies in recipient countries.

Land disposal of T/H/R wastes historically has been the principal management option in developing and industrial countries alike. The Thai example depicted above is typical. Those wastes which are not discharged as liquids or semi-liquids into on-site lagoons, ponds or surface impoundments, or discharged into surface water bodies with little or no treatment, are transported to uncontrolled landfill sites. In countries as diverse as Thailand, Venezuela and India, these are essentially the only operational disposal technologies.[3]

In the U.S., land disposal and discharge to water bodies historically have been the principal treatment technologies. Both of these are variants on the same practice--waste dispersal through dilution by water or by transport to other sites. Neither practice reduces risk, but rather shifts it to a different medium, locale or time. This may be compared with two "upstream" alternatives, reduction at the source and treatment, which eliminate or reduce risks by altering the volume and/or character of the wastes themselves.

Exhibit 5 depicts the selected management practices of 70 major industries in 1983, a profile which is changing, albeit very slowly. Land disposal techniques, including injection wells, impoundments, and landfilling, together account for two-thirds of all wastes. Another 30 percent are treated, primarily in sewage treatment plants, and then discharged to surface water bodies. Many pollutants captured during treatment become part of the residuals (sludge) materials which, in turn, may be either landfilled or incinerated. A large fraction of the waste material is thereby shifted from liquid to either solid or gaseous form without undergoing a significant reduction in hazard. Smaller fractions of T/H wastes are used as boiler fuel, directly incinerated, chemically oxidized or land spread. Recycling through distillation and other methods accounts for a small fraction of all managed wastes. A 1984 survey of 700 chemical companies revealed that 99.4 percent of the 278.4 million tons of hazardous waste treated and disposed were handled as wastewaters and discharged into surface water bodies, underground wells or publicly owned treatment facilities. The remaining 1.7 million comprising solid materials were managed in landfills, incinerators and impoundments in approximately equal fractions.

These practices highlight the intimate relationship between T/H waste management and water quality which persists in industrial countries, a lesson of substantial consequence to developing countries seeking to initiate waste management regulatory strategies. Even with abundant capital resources, sophisticated technology, formidable financial penalties for human health and environmental damage claims, and increasingly demanding disposal regulations, the overwhelming fraction of U.S. wastes are destined for land and surface water disposal. For the foreseeable future, developing countries are likely to be in the same position, lacking the capital, financial, and regulatory and/or enforcement resources to implement alternative techniques.

Under these conditions, what strategies make the most sense? In the U.S., pollution prevention--sometimes called waste reduction, source reduction or waste minimization--has slowly emerged as the new paradigm in T/W/R waste management. Exhibit 6 depicts EPA's

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[3]The waste management system is multi-faceted, encompassing transport, storage, treatment and disposal. This discussion focuses on the latter two elements, though transport and storage may pose equal risks to human health as treatment and disposal.

concept of prevention in its various forms, from source reduction through product changes and source control (material changes, technology changes, and operating practices) to on- and off-site recycling through use/reuse and reclamation (U.S. EPA 1988). Driven by the sharply rising disposal costs and liability concerns, pollution prevention increasingly is the option embraced in both official policy circles (EPA 1990) and by some large corporations whose exposure to the adverse financial consequences waste mismanagement is greatest.

From a developing country perspective, this shift toward prevention versus "end-of-pipe" or dispersal treatment strategies holds substantial promise though, at the same time, it faces numerous constraints. The principal constraint is much like that which persisted in the U.S. until the 1970s--cheap and minimally regulated land and water disposal. It was not until a more accurate social costing (health, safety and environmental damages) of uncontrolled land and water disposal was imposed via the legal/regulatory processes of the late 1970s and 1980's that alternatives management options began to achieve economic viability. Developing countries and Eastern Europe face the same conditions, wherein land and water resource damages, and attendant health risks, are not fully incorporated into waste disposal cost calculations. Waste regulations are few and, where they are in place, enforcement is universally lax (White and Emani 1990).

These obstacles to pollution prevention technologies do not diminish their potential benefits in developing countries. There is no compelling rationale to repeat the slow transformation from post-generation to pre-generation waste management strategies which has occurred in industrial countries. The challenge is to accelerate the transfer of preventative technologies now emerging in the U.S. and other industrial countries by choosing technologies containing pollution-avoiding processes, materials and recycling. To some extent, AID has developed assistance programs in this area. Other opportunities exist via purely private initiatives which may be realized if adequate levels of expertise, oversight and incentives are developed in recipient countries to demand waste-minimizing process and product imports. From a technology transfer standpoint, prevention may be the only viable course of action given the reluctance of multinational waste management firms to export advanced T/H/R (versus municipal waste) technologies to developing countries. (Elkington and Shopley 1989).

4. Data Gaps and Applied Research Needs

Identifying cost-effective and workable T/H/R waste management options in developing countries will require major data gathering along three fronts. First, at an aggregate, national waste inventories through systematic sampling of waste generators will provide the requisite profile of waste composition, generation rates and risk implications. This is essential data to provide policy makers and regulators with the foundation for selecting targets based on probable exposures and health risks of different generating activities. As waste composition is characterized, transport and disposal methods may be documented through surveys and tracking of waste shipments. Critical to the success of this national inventory is the assurance to generators that waste characterization will not operate initially as an enforcement tool. Participation by industry trade associations in the design and implementation of survey samples and instruments will assist in this effort.

Second, waste audits within generating firms will assist in identifying opportunities for reducing treatment needs through both source reduction and recycling. EPA (1988) has devised a systematic approach to such audits, though comparable approaches developed by many large industries offer equally effective means for targeting materials substitution, process change and recycling measures which may benefit the firm. With sufficient numbers of such audits, case studies may be used to demonstrate typical waste reduction measures applicable to particular industrial sectors. Many such cases are available through EPA data bases; their relevance to developing country circumstances will vary depending on the similarity in equipment, product line, management systems and capital requirements.

Third, an assessment of typical project investment costs and evaluation methods would assist in determining the economic benefits of different generic improvements (e.g. switching from solvent-based cleaning to aqueous-based cleaning; switching from alkaline chemical bath to mechanical abrasives; establishing routine employee seminars to elicit and reward waste minimization ideas). Once generic cost/benefit calculations are made for different types of common improvements, more detailed project evaluations may proceed using total cost assessment (TCA) methods.[4] These methods account for hidden and longer-term costs and benefits which normally are omitted or underestimated in reviewing environmental investments. Though developed for application in the U.S. context, the concept behind TCA is equally applicable to developing country context with appropriate modifications to reflect economic, liability and regulatory differences.

This three-part data collection and research initiative--a national inventory, firm-specific audits and technology cost assessments--would provide the foundation for rationalizing T/H/R waste management while, at the same time, orienting national priorities toward clean technologies and pollution prevention.

5. U.S. Capabilities and Advantages: Implications for Developing Country Planning

Since enactment of the RCRA in 1976, the U.S. has developed the most elaborate T/H/R waste[5] tracking system and management standards for treatment, storage and disposal (TSD) facilities of any industrial nation. Enactment of the Comprehensive Environmental Response, Compensation, and Liability Act ("Superfund") in 1980 set in motion a multi-billion program to review, prioritize, characterize and clean-up over 30,000 waste disposal sites nationwide. Together, these two pieces of legislation spawned an elaborate data collection infrastructure at both the federal and state government levels, as well as a far-flung environmental remediation industry (engineering, scientific, legal) closely tied to this massive data management and clean-up effort. Concurrently, waste management services (collection,

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[4]TCA methods developed by EPA, General Electric and Precosis are currently being evaluated and field tested by Tellus Institute in research supported by EPA's Office of Pollution Prevention and the New Jersey Department of Environmental Protection.

[5]High-level and low-level radioactive wastes, which are regulated separately under the Nuclear Waste Policy Act and the Low Level Radioactive Waste Policy Act, fall outside the purview of RCRA. The following generalizations apply, however.

transport, storage and disposal), which are increasingly concentrated in a few large firms capable of operating in a highly litigious and politically delicate environment, have become a major growth industry in the U.S.

For developing countries, these capabilities offer lessons in both how and how not to upgrade T/H/R waste management to protect public health. There is little question that the elaborate waste tracking system established under RCRA was essential to characterizing a highly complex waste generation system comprising tens of thousands of large and small generators. At the same time, such an elaborate infrastructure is probably well beyond the needs of most AID countries where waste generation is concentrated in relatively few industries, few firms and few locations. From a policy and planning perspective, the marginal benefits of a universal tracking system probably fall short of the costs of establishing such a system. A focus on the few, large generators which represent the bulk of the waste is likely to be a more cost-effective strategy.

Capabilities developed as a result of Superfund--engineering, scientific and legal skills--need not be replicated in AID countries where sites targeted for remediation may be relatively few and easily identified. In fact, the enormous expenditure of resources on site remediation relative to other threats to environmental health is, by EPA's own assessment, probably a misplaced priority (EPA 1987). It also has tended to preserve a focus on post-generation management, create an enforcement-intensive regulatory regime, and divert attention from waste minimization strategies. This is a key lesson for developing countries where available resources are orders of magnitude less than those available to U.S. environmental agencies.

Notwithstanding these limitations, opportunities for transferring U.S. technologies do exist through appropriate public and private sector initiatives. Section 6 presents some ideas relevant to AID planning. From the private sector, landfill remediation and design capabilities as well as selected applications of incineration, chemical, biological, and recycling processes will be sensible options within developing country contexts (Elkington and Shopley 1989). The opportunities for such technology transfer are more constrained by financial resources than by T/H/R waste problems which would benefit from their application.

6. Current Activities in Developing Countries

T/H/R waste management responsibilities, in those countries where they are assigned at all, fall within the purview of environmental, natural resource, public works and/or industry ministries. As examples, in India responsibility is shared between the State Boards for Pollution Control and the Central Board for Pollution Control. In Venezuela, authority resides in the Ministry of Environment and Renewable Natural Resources. And in Thailand, the National Environment Board and the Department of Industrial Works are the responsible agencies (White and Emani 1990).

For most developing countries, including those who responded to AID's recent survey of program priorities, T/H/R waste management has received scant attention vis a vis other more prominent environmental health issues such as water and sanitation and solid waste management. Even in Thailand, which probably has compiled the most reliable waste inventory among AID recipients, T/H/R waste management is ranked only fifth among eight

environmental health issues by AID mission staff. Attention to this issue tends to be sporadic and short-lived, often triggered by an acute event or publicity over an attempted exportation of waste materials from industrial nations. Similarly, activities of non-governmental organizations, including lending institutions and environmental groups, has tended to focus on large infrastructural issues (e.g. wastewater treatment systems) and resource conservation (e.g. deforestation, biological diversity) rather than on the less visible T/H/R issue.

Since conventional taxonomies places T/H/R waste management as discrete and separable from water and air quality and solid waste management, these results are not surprising. At the same time, the U.S. tendency toward piecemeal legislation, fragmented environmental assessment and post-generation regulation should serve as a lesson and a guidepost for developing countries to do better. Improved management of T/H/R waste through waste minimization, when viewed from an integrated perspective, would have substantial direct benefits to air and water quality which, unfortunately, are typically segregated into separate regulatory regimes.

7. Directions for Future Interventions

Based on our assessment of the T/H/R waste management issue within the AID's Environmental Health Strategy, we recommend consideration of the following interventions:

1. **Development of user-friendly computerized assessment tools, and associated training programs, to structure national and regional waste generation data bases.** These would provide the foundation for implementing systematic data collection to compile and forecast national waste inventories. Periodic follow-up programs to retrain users.

2. **Development of a "train the trainers" short course in pollution prevention technologies.** A course to equip selected technical staff within appropriate ministries to conduct waste audits in industries known to be major waste generators. Preparation of case studies emphasizing waste minimization opportunities.

3. **Preparation, and dissemination through workshops, of a manual on total cost assessment methods for environmental project evaluation in developing countries.** Adapting U.S. methods to the economic and legal conditions typical of AID countries, with opportunities to adjust to specific country circumstances.

4. **Survey, and assess ways to improve, pollution prevention technology transfer by multinational corporations (MNCs).** Investigate current business arrangements between MNCs and host country partners, vehicles for technology transfer, and methods (e.g. incentives, regulations) to accelerate the flow of clean technologies to both partners and to other national firms.

5. **Investigate market incentives to incorporate environment and health risks into economic decision-making.** Examine the range of taxes, fees, permits and other methods to induce waste-minimizing behavior in local firms.

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6. **Conduct environmental risk ranking assessments in a cross-section of AID countries.** Using the Thai study and Norberg-Bohm methodologies as starting points, conduct risk-ranking studies in a selection of AID countries in each region in close collaboration with ministry officials. Follow-up with a symposium to discuss findings and implications for environmental health policy.

7. **Investigate methods for reducing the hazard content of the municipal waste stream to protect the health of collector/scavenger populations.** Conduct waste composition studies in selected countries, identify hazardous materials, and devise prototype methods (e.g. transfer station siting, recycling centers, deposit on hazardous materials) to improve management practices and minimize exposure of collector/scavenger populations.

8. **Examine risks and alternative management strategies to control risks associated with imports of secondary materials.** Assess current trends in trading hazardous secondary materials (e.g. scrap metals, lead batteries) and options to balance economic benefits with occupational and worker health.

9. **Investigate sources and appropriateness of environmental standards.** Determine sources (e.g. EPA, WHO, Britain, Germany, locally developed) and actual standards for T/H/R wastes, and the degree to which they are reasonable and workable within specific country contexts.

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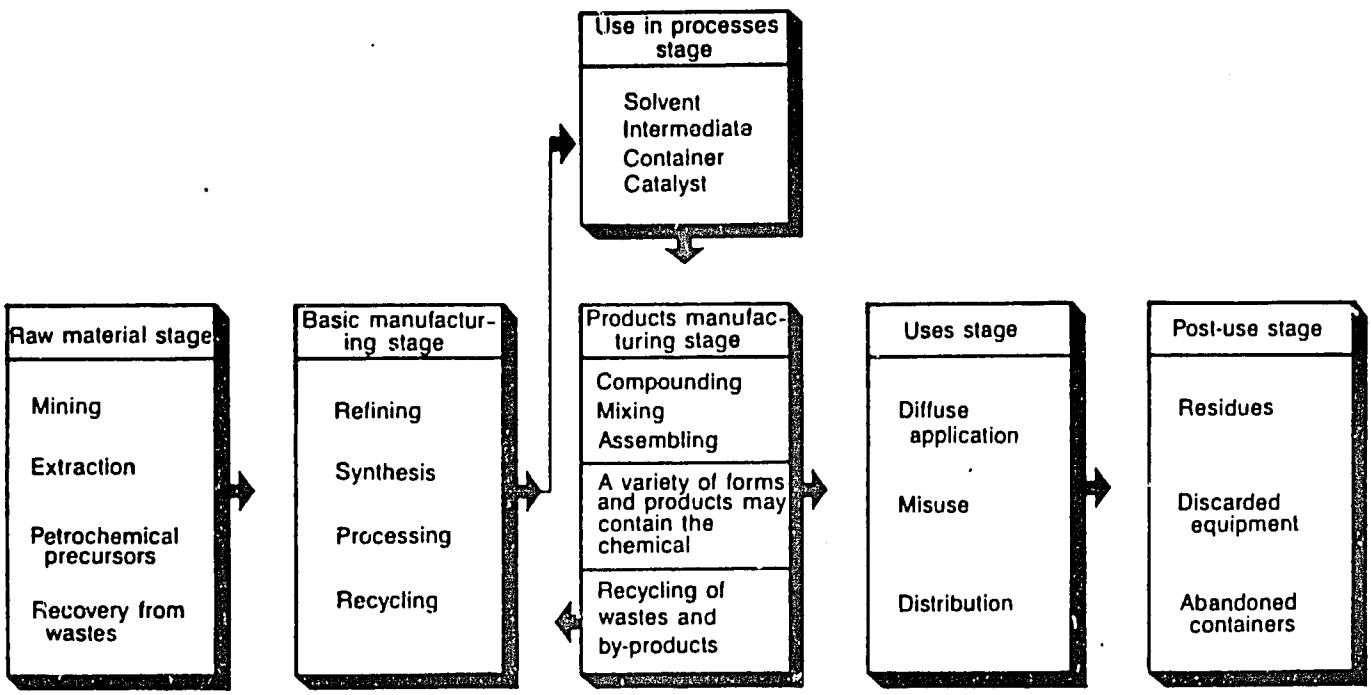
EXHIBIT 1



Flow cycle for hazardous chemicals. Any of the stages may involve suboperations of packaging, storage, or transportation.

Source: Smith 1988

EXHIBIT 2

Waste Generation and Trade in Selected Countries

	Annual Municipal Waste Generation: Total (000 metric tons) 1975	1980	1985	Per Capita (kg) 1985	Per Unit Area (t per km2) 1985	Annual Industrial Waste Generation: Year of Estimate	Total (000 t)	Per Million $US of Industrial Gross Domestic Product (t)	Per Unit Area (t per km2)	Annual Hazardous and Special Waste Generation: Year of Estimate	Total (000 t per year)	Per Unit Area (t per km2)	Imports (000 t)	Exports (000 t)
AFRICA														
Guinea	X	X	X	X	X	X	X	X	X	X	X	X	15.0	X
Nigeria	X	X	X	X	X	X	X	X	X	X	X	X	4.0	X
South Africa	X	X	X	X	X	X	X	X	X	X	X	X	0.0	X
Zimbabwe	X	X	X	X	X	X	X	X	X	X	X	X	6.9 a	X
AMERICAS														
Brazil	X	X	X	X	X	X	X	X	X	X	X	X	40.0	X
Canada	X	12,600	16,000	630	1.7	1980	61,000	730	6.6	1980	3,290	0.4	130.0	65.0
Costa Rica	X	X	534 b	216 b	10.5 b	X	X	X	X	X	X	X	X	X
Haiti	X	X	X	X	X	X	X	X	X	X	X	X	4.5	X
Mexico	X	X	32	0	0.0	1986	192	4	0.1	X	X	X	7.0	X
United States	140,000	160,000	178,000 b	762 b	19.4 b	1985	628,000	513	68.5	1985	265,000	28.9	45.3	203.4
Venezuela	X	X	X	X	X	X	X	X	X	X	X	X	2.0	X
ASIA														
Cyprus	X	X	X	X	X	1985	56	X	6.0	X	X	X	X	X
Hong Kong	X	X	X	X	X	1987	6	1	6.1	X	X	X	X	X
India	X	X	X	X	X	X	X	X	X	1980	35,722	12.0	X	X
Israel	X	X	1,400	331	68.9	X	X	X	X	X	30	1.5	X	X
Japan	38,074	41,511	41,530	344	110.3	1985	312,000	573	828.6	1986	666	1.8	3.0 a	X
Korea, Rep	X	X	15,746 b	396 b	159.5 b	1981	7,030	274	71.2	1981	180	1.8	X	X
Lebanon	X	X	X	X	X	X	X	X	X	X	X	X	2.4	X
Malaysia	X	X	X	X	X	X	X	X	X	1985	419 c	1.3 d	X	X
Singapore	X	1,082	1,498	585	2,455.7	X	X	X	X	X	X	X	X	X
EUROPE														
Austria	1,407 e	1,673 f	1,727 b	231 b	20.9 b	1983	13,258	510	160.3	1983	200	2.4	0.3	3.4
Belgium	2,900	3,082	X	313 g	93.9 g	1980	8,000	186	243.8	1980	915	27.9	914.1 h	13.2
Bulgaria	X	X	6,773	756	61.3	X	X	X	X	X	X	X	X	X
Czechoslovakia	X	X	X	X	X	1982	80,910	X	645.3	X	X	X	X	X
Denmark	X	2,046	2,161	422	51.0	1985	1,317	95	31.1	1985	125	3.0	X	20.0 a
Finland	X	X	2,000	408	6.6	1985	15,000	841	49.2	1985	124	0.4	X	2.8 a
France	X	14,000	15,000	272	27.3	1984	50,000	301	90.9	1984	2,000	3.6	95.9	25.0 h
German Dem Rep	X	X	X	X	X	X	X	X	X	X	X	X	814.3	X
Germany, Fed Rep	20,423 i	21,417	19,387 j	317 j	79.4 j	1984	55,932	198	229.0	1985	5,000	20.5	75.0 h	1,695.6 h
Greece	X	2,500	X	259 g	19.1 g	1980	3,904	378	29.8	X	X	X	X	X
Hungary	X	X	7,000	657	75.8	1985	21,146	2,509	229.0	1984	7,081	76.7	1.5	X
Iceland	X	X	93	386	0.9	1985	105	X	1.0	X	X	X	28.6	X
Ireland	555	640	1,100 j	309 j	16.0 j	1984	1,580	346	22.9	1984	20	0.3	X	20.0 j
Italy	14,095	14,041	15,000	263	51.0	1980	35,000	207	119.0	1980	2,000	6.8	X	22.8
Luxembourg	119	128	131	357	50.7	1985	135	X	52.2	1985	4	1.5	X	4.0 a
Netherlands	X	6,565 k	6,510	449	191.9	1986	3,942	66	116.2	1986	1,500	44.2	320.0 a	250.0 a
Norway	1,700	1,700	1,970	474	6.4	1980	2,186	93	7.1	1980	120	0.4	X	0.3
Poland	X	X	7,900	212	25.9	1985	274,885	X	902.8	X	X	X	X	1.4
Portugal	X	1,948	2,246	221	24.4	1980	11,200	1,110	121.8	1986	1,049	11.4	X	X
Romania	X	X	X	X	X	X	X	X	X	X	X	X	4.0 a	X
Spain	X	8,028 l	10,600	275	21.2	1986	5,108	60	10.2	1987	1,708	3.4	X	2.6
Sweden	2,400	2,510	2,650	317	6.4	1980	4,000	102	9.7	1980	500	1.2	X	15.0 m
Switzerland	1,900	2,240	2,500	386	62.9	X	X	X	X	1987	120	3.0	7.1	68.0 n
United Kingdom	16,036 o	15,816	17,737 p	313 p	73.4 p	1984	50,000	327	207.0	1986	3,900	16.1	82.5	X
Yugoslavia	X	X	X	X	X	X	X	X	X	X	X	X	2.4	X
U.S.S.R.	X	X	X	X	X	1985	306,311	X	13.8	X	X	X	X	X
OCEANIA														
Australia	X	10,000	X	679 g	1.3 g	1980	20,000	386	2.6	1980	300	0.0	X	0.7 a
New Zealand	1,150	2,106 q	X	656 q	7.8 q	1982	300	38	1.1	1982	45	0.2	X	0.1

Sources: Organisation for Economic Co-operation and Development, United Nations Environment Programme, and other sources.

Notes: a. Refers to 1983. b. Refers to 1983. c. Thousand cubic meters per year. d. Cubic meters per year. e. Refers to 1973. f. Refers to 1979. g. Refers to 1980. h. Refers to 1985. i. Refers to 1977. j. Refers to 1984. k. Refers to 1981. l. Refers to 1978. m. Refers to 1980. n. Refers to 1986. o. Refers to 1976. p. Refers to 1987. q. Refers to 1982.

0 = zero or less than half the unit of measure; X = not available; t = metric tons; km2 = square kilometers

For additional information, see Sources and Technical Notes.

Source: World Resources Institute 1990

EXHIBIT 3

Projected Hazardous Waste Quantities by Waste Type

Waste Type	Hazardous Waste Quantities, Thousand Tonnes/Year 1986	1991	1996	2001
Oils	120	220	390	690
Liquid Organic Residues	0.19	0.31	0.52	0.88
Organic Sludges and Solids	3.70	6.70	12	21
Inorganic Sludges and Solids	12	19	32	54
Heavy Metal Sludges and Solids	830	1,500	2,500	4,400
Solvents	20	36	67	120
Acid Wastes	81	120	200	310
Alkaline Wastes	22	34	54	86
Off Spec Products	0.01	0.03	0.05	0.11
PCB	2.50	*	*	*
Aqueous Organic Residues	0.12	0.24	0.50	1
Photo Wastes	8.80	16	30	58
Municipal Wastes	7.20	12	19	31
Infectious Wastes	47	76	120	200
Total	1,300	1,900	3,500	5,900

Source: NEB (1989).
* Figures have been rounded independently.
* Total existing quantity estimated at 2,500 tonnes. It has been assumed that no new PCB-containing materials were imported to Thailand after the mid-1970's.

Source: Abt Associates and Sobotka & Co. 1990

EXHIBIT 4

Concentrations and Estimated Health Risks of Selected Volatile Organic Contaminants Measured at the On-Nuj Dumpsite (1)

Contaminant	Cancer Potency (mg/kg/dy)-1	RfD (mg/kg/day)	Concentration (ug/m3)		Exposure (mg/kg/day)		Cancer Risk Estimates: Individual Risk		Cancer Risk Estimates: Cases Per Year	Comparison to the RfD (3) (Percent)	
			Onsite	Community	Scavengers	Resident	Scavengers	Resident		Scavengers	Resident
Benzene	2.9 x 10-2		13	14	5 x 10-3	5 x 10-3	1 x 10-4	2 x 10-4	2 x 10-2		
Toluene		2	700	31	1 x 10-1	1 x 10-2				6%	1%
Ethylbenzene		0.1	120	6	2 x 10-2	2 x 10-3				20%	2%
m- and p-Xylene		0.3	330	12	5 x 10-2	4 x 10-3				18%	1%
o-Xylene		0.3	110	4	2 x 10-2	1 x 10-3				6%	0%
Methylene Chloride	1.4 x 10-2		26	NR (2)	4 x 10-3	-	6 x 10-5	-	1 x 10-3		

(1) Source: Table 12, Kungskulniti et al., 1989.

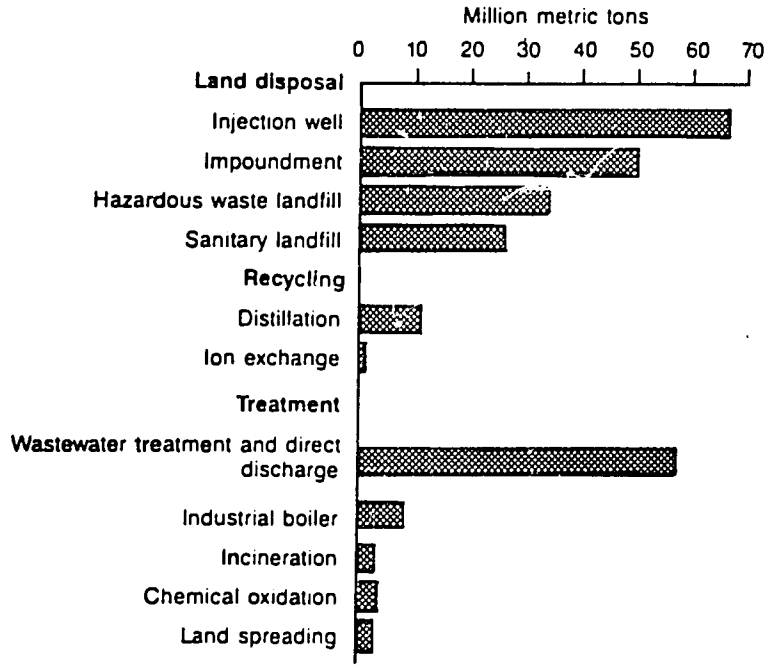
(2) NR = none reported

(3) Calculated as (Exposure/RfD) x 100.

Source: Abt Associates and Sobotka & Co. 1990

EXHIBIT 5

Selected Management Practices Used by Major Industries for Potentially Hazardous Wastes,* 1983

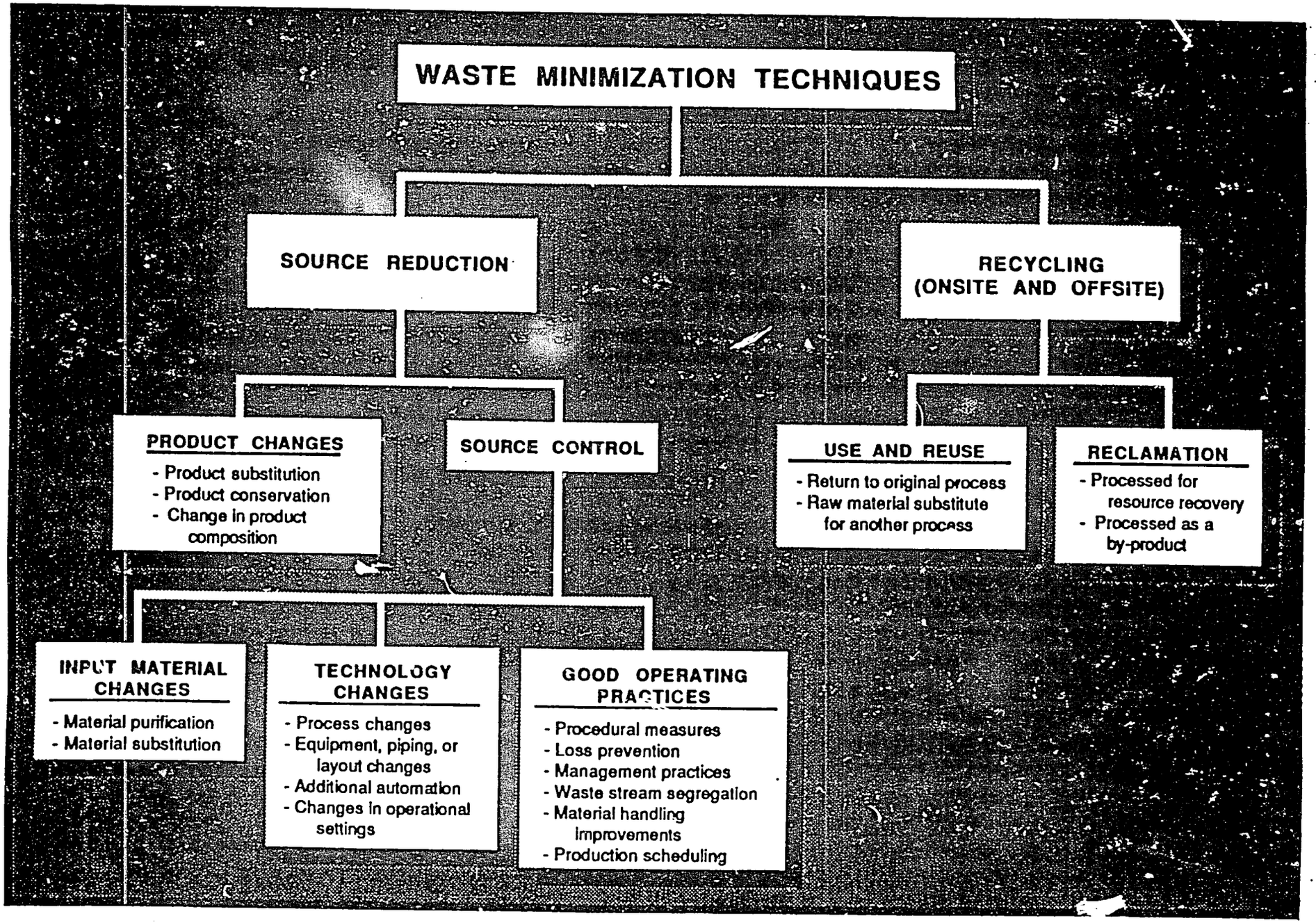


* Includes hazardous wastes defined under Resource Conservation and Recovery Act of 1984 Amendments plus waste oils, PCBs, industrial scrubber sludges, air pollution control dusts, and certain liquid waste streams.

Source: Congressional Budget Office

Source: Conservation Foundation 1987

EXHIBIT 6



Source: EPA 1988

OCCUPATIONAL HEALTH AND INJURY CONTROL:

FOCUS ON DEVELOPING COUNTRIES

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INTRODUCTORY NOTE

This paper covers both Occupational Health and Injury Control, focusing primarily on developing countries. The Occupational Health section covers occupational illnesses and injuries and their control. The Injury Control section covers only non-occupational injuries and their control, with an emphasis on unintentional injuries in developing countries.

OCCUPATIONAL HEALTH

Characteristics of the Problem and Its Impact on Health:

Occupational health and safety hazards cause millions of illnesses and injuries throughout the world each year (1). The toll is especially high in developing countries, where these hazards are often widespread and serious; where few laws restrict the import or use of hazardous materials or processes and few laws mandate worker training in new technologies; where there are insufficient numbers of adequately trained personnel; and where unemployment is often high and workers are unlikely to complain of hazards on the job or refuse to work in imminently dangerous situations (2-8).

Occupational problems include injuries (such as fractures, sprains, minor abrasions, and fatal falls), which account for a substantial amount of work-related morbidity, disability, and mortality in developing countries, and occupational illnesses, which also account for much morbidity, disability, and mortality, but which are more difficult to detect and recognize as associated with work.

The underrecognition and underreporting of occupational illnesses can be visualized as a hippopotamus that is mostly submerged below the surface of the water (9). In this image, few work-related illnesses are identified and reported. Most fall into one of the following four categories: (a) asymptomatic, (b) symptomatic but lacking medical attention, (c) receiving medical attention but incorrectly diagnosed, or (d) correctly diagnosed but not reported to health officials. Occupational illnesses can be divided, by cause, into four categories: chemical, mechanical and physical, biological, and psychosocial.

Chemical: In developing countries, the most common chemically-related illnesses are due to pesticides, heavy metals (including lead, mercury, and cadmium), organic dusts (such as grain dust and wood dust), inorganic dusts (such as asbestos, silica, and coal dust), and organic solvents. According to the World Health Organization, there are an estimated two million cases of unintentional acute pesticide poisoning among workers each year. Lead poisoning affects many workers, damaging the neurologic, hematologic, and reproductive systems. Organic dusts can cause acute respiratory symptoms and chronic respiratory impairment. Asbestos, an inorganic dust, causes both non-malignant chronic respiratory disease and cancer of the lung, larynx, and other sites. Organic solvents, such as trichloroethylene, are increasingly recognized as causing serious neurobehavioral problems that may go unnoticed until they are far advanced.

Mechanical and Physical: Mechanical safety hazards at work can induce acute injuries and also so-called cumulative trauma disorders, or repetitive stress injuries, such as carpal tunnel syndrome, with weakness, pain, and numbness of the affected hands. Physical hazards include

excessive noise leading to hearing impairment and other disorders, vibration that can cause circulatory and other disorders, radiation (both ionizing and non-ionizing) that can cause a variety of ailments and even death, and extremes of temperature, most often manifested in a variety of heat-related disorders.

Biological: Biologic hazards include the microorganisms to which the following groups of workers are exposed: laboratory workers, health care workers, animal care workers, slaughterhouse workers, farm workers, and others. In many developing countries, the high prevalence in the environment -- and in certain work environments -- of certain infectious agents (such as those that cause malaria and schistosomiasis) make occupational biologic hazards important in these countries. (In addition, the presence of a number of endemic infectious diseases, not necessarily related to work exposure, may impair workers' health and productivity, and may even place them at higher than normal risk of occupational injury or illness.)

Psychosocial: Psychosocial stress at work can lead to undue occupational stress and a number of related diseases, such as peptic ulcer disease. In addition, in many developing countries, many people experience psychosocial stresses related to rural-urban migration and to unemployment.

While generally inadequate in number and often in quality, many epidemiologic studies of occupational injuries and illnesses have been performed in developing countries. Although these studies vary greatly in the methodologies employed, definitions used, and populations of workers studied, some patterns emerge:

- In most developing countries, the majority of the workforce works in agriculture and/or in the informal sector of the economy. Studies of agricultural workers show that occupational injuries and pesticide poisoning are by far the most prevalent work-related conditions.

- Certain work-related infectious diseases are prevalent among specific subgroups of workers, such as hepatitis B among clinicians and laboratory workers and schistosomiasis among workers in irrigation projects in areas endemic for Schistosoma organisms.

- Injuries, chemically-induced disorders, and noise-induced hearing impairment are frequent occurrences among workers in manufacturing and mining industries.

Although incomplete, data indicate that the largest employers in developing countries usually have some type of occupational health program working to recognize, treat, and prevent occupational injuries and illnesses. The more frequent and more serious problems are encountered by workers in medium- to small-scale workplaces, where no occupational health program exists and where workers may have no information on the health and safety hazards that they face on the job.

Hazardous workplace exposures are generally worse and more widespread than in developed countries, and for a variety of reasons: (1) inadequate laws, regulations, and other policies pertaining to occupational health and safety; (2) overall, an inadequate awareness of occupational hazards and their prevention, as well as inadequate numbers of appropriately-trained specialists to identify and evaluate hazardous exposures and to try to control them; (3) import from developed countries of hazardous industries or hazardous wastes; (4) national pressures to industrialize and

develop, often without adequate attention to health and safety of workers and others; and (5) the workers themselves, who are not usually inclined to complain about hazardous working conditions, lest they lose their jobs.

The distinctions between the workplace and the general environment, and between occupational health and environmental health, are often blurred, especially in developing countries. In these countries, battery and radiator repair shops, frequently associated with excessive exposure to lead, are often located in the backyards of homes in urban areas. Children in their own homes may therefore experience a "workplace" exposure. In addition, children may be indirectly exposed to lead brought home on a parent's work clothes, hair, or skin. As another example of the blurring of occupational and environmental health, pesticides sprayed on crops may eventually contaminate surface water supplies, exposing many people to these hazardous chemicals. Toxic substances in a factory are an occupational health hazard, but when they go up the factory's smokestack into the ambient air or down a drainpipe and into a river they become an environmental health problem.

Preventive Measures and Control Strategies:

One of the important characteristics of occupational health problems is that they are preventable. Preventive measures fall into two categories: those that focus primarily on the worker, and those that focus primarily on the workplace. The former category includes worker training and labelling of hazards, use of personal protective equipment, medical screening, and administrative measures. While these are important, they are generally less effective than those preventive measures that focus primarily on the workplace. These include engineering measures, such as local exhaust ventilation, changed work practices, and substitution of hazardous materials and hazardous processes with safer ones.

Prevention of occupational injury and illness should be in everyone's interest -- the worker, the employer, the government, although this is often not recognized as being the case. Healthier workers mean lower medical expenses and higher productivity, but this relationship may not be appreciated in an environment where there is high unemployment and where many unemployed workers are ready to replace every worker injured at work, no matter how risky the job.

To deal adequately with occupational health problems, an occupational health program needs to be able to satisfactorily perform the following five functions: (a) anticipate hazards; (b) recognize them as early as possible; (c) investigate hazards that are serious, widespread, or unusual; (d) treat affected individuals; and (e) develop and implement prevention and control measures. These five functions are performed by individuals from several different disciplines, among others: medicine, nursing, industrial hygiene, safety engineering, ergonomics, and epidemiology. These individuals work for government ministries such as ministries of health, labor, mining, agriculture, environment and natural resources, industry, planning, commerce, and economic and trade policy, and for non-governmental organizations in education, health care, public health, business and industry, labor, and insurance and finance, among others. In many developing countries, the policies that impact most on the health and safety of workers are made not in the ministries of health or labor, but rather in the ministries of industry and economic planning.

Inadequacies of Occupational Health in Developing Countries and Strategies to Deal with these Inadequacies:

There are many inadequacies inherent in occupational health in developing countries. These are grouped into five categories below in order to describe the problems as well as possible strategies to address them.

Institutional development: First, there is inadequate institutional development. Organizations, both within and outside of the government, are not adequately developed, financed, or operated to perform the five essential functions that I described before. In fact, some types of organizations, such as a government institute to perform occupational health research that is relevant to a given country's needs, do not exist in most developing countries.

Whenever possible, institutions, both within and outside of government, need to be strengthened, and where necessary, new ones may need to be established. An example is the need for boards at the national level to regulate the import, production, distribution, use, and disposal of pesticides. Pesticide boards exist in most developed countries and some developing countries, often in the Ministry of Agriculture. Where established, they have played a leading role in reviewing, recommending, and regulating pesticide use in a country.

Human resource development: Human resources are insufficient. There are not enough adequately-trained individuals of the types that I mentioned before. In addition, those who have been adequately trained may be handicapped by (a) having had training not made relevant to developing country situations, (b) not being capable of training peers, and (c) not having access to methods or materials for continuing education.

There needs to be development of sustainable education and training programs for workers and managers, for health and safety professionals, for policy makers, and for others. As an example, for 10 years the Finnish Institute of Occupational Health has been presenting training programs, mainly for ministry of labor staff members, in East Africa. This training, in turn, has made a tremendous improvement in the staff capabilities of the Ministry of Labor.

Gaps in data: As a result of both inadequate institutional development and insufficient human resources, there are gaps in important data and needs for applied research. In most developing countries -- and perhaps all of them, there are insufficient basic data on (a) the occurrence, severity, and impact on occupational injuries and illnesses; (b) the nature, frequency, and severity of health and safety hazards in the workplace; and (c) numbers and characteristics of workers and employers.

Community participation: The community of workers and managers does not participate adequately in occupational health. Both groups are often not well informed about hazards in the workplace and what they can do to minimize or eliminate them. In addition, workers often have little input into the decisions that involve health and safety in the workplace. And such mechanisms as worker-management health and safety committees, which are designed to effectively recognize, manage, and prevent occupational health and safety problems, are not implemented as often as they could be.

The development of worker and manager participation is vital in the recognition and prevention of occupational hazards. An important element of this is the establishment and growth of health and safety committees at work. Such committees are mandated by law in Indonesia and may be an important contributor to the decreasing rate of occupational injuries there.

Policy development: There is inadequate development and implementation of policy -- including legislation -- both at the national and at the local levels. Policies that can affect occupational and environmental health include: establishing and enforcing standards of safe workplace exposures and safe working conditions, establishing a worker Right to Know about the hazards of substances that he or she is working with, establishing a worker's right to refuse hazardous work, and establishing a worker's right to be removed from exposures that may be poisoning him or her, without detriment to salary, seniority, or benefits.

There is need to develop policies of many different types on occupational health and safety in developing countries. These range from national legal standards of workplace exposure to specific hazards to company policies on reproductive system hazards. An example is the Right to Know legislation, which in the United States mandates that workers who are exposed to certain hazards are provided with understandable information on the nature of the hazard and what can be done to minimize risk. An example of a policy of economic incentives in setting workers' compensation premiums according to the injury rate in a particular company.

Health and management information systems: Finally, the health and management information systems for programs in occupational health and safety are usually inadequate and often non-existent. Programs generally lack the management and information systems to implement and evaluate programs effectively. Information systems include systems for surveillance of disease, for access to up-to-date information on workplace hazards and their control, for monitoring of worker exposures to hazardous substances, for monitoring and evaluation of services and programs, and for communication with other countries facing similar problems.

It is crucial that occupational health programs have access to health and management information systems, such as surveillance systems for work-related disorders, monitoring systems for hazardous exposures, and systems for responding to problems detected in these ways.

Capabilities of the United States:

Individuals and organizations in the United States have much experience and expertise that can be used to assist individuals and organizations in developing countries to improve their occupational health capabilities. In the United States, there is vast expertise and experience in each of the relevant specialties, including, but not limited to: clinical occupational medicine and occupational health nursing, occupational epidemiology, industrial hygiene (including occupational exposure assessment), occupational safety and occupational ergonomics, and policy development and program management as applied to occupational health.

This expertise and experience is based in many different types of organizations, ranging from governmental agencies to academic institutions, from business and industry organizations to labor organizations, and from professional medical, nursing, industrial hygiene, safety, and legal organizations to community-based non-governmental organizations. Many of the individuals with occupational health expertise have also had experience working in developing countries. In short,

there is much talent and experience in this field in the United States that could be used to assist individuals and organizations in developing countries to deal with occupational health problems more adequately.

Current Activities in Developing Countries:

A variety of occupational health programs and projects are being conducted in developing countries. Most developing countries have a formal occupational health program, usually based in the Ministry of Labor, with varying input and participation by the Ministry of Health. Other ministries, such as the Ministry of Agriculture (with regard to pesticide exposures) may be involved.

Currently, there are at least 500 ongoing research projects in occupational health (and environmental epidemiology) in developing countries, as determined by a recent survey conducted by Management Sciences for Health, with support from the World Health Organization (WHO) and the International Development Research Centre (IDRC), a Canadian aid agency (10). While this is an impressive number, many of these projects and the institutions in which they are based suffer from an inadequate number of well-trained researchers, inadequate data processing, exposure assessment, and other types of equipment, and inadequate financial support. IDRC is one of the relatively few international donor organizations that supports a significant amount of occupational health research in developing countries.

International organizations have major programs in occupational health. The International Labor Organization (ILO) has an important program in occupational health and safety, designed to facilitate the exchange of relevant information, provide training to workers, managers, and government organization representatives, and to provide technical assistance for the recognition, treatment, and especially the prevention of work-related illnesses and injuries. In addition, ILO promotes the incorporation of occupational health services into primary health care activities in developing countries. ILO interacts primarily with ministries of labor, business and industry organizations, and labor organizations, on a tripartite basis. At the World Health Organization (WHO), the Workers' Health Programme provides information, training, and limited technical assistance in occupational health. WHO interacts primarily with ministries of health with regard to occupational health issues, including the provision of health services to workers.

In-country occupational health programs vary significantly among the developing countries. The best-developed programs have generally benefitted from: (a) direct assistance from developed countries or international organizations, as in the case of the Finnish Institute of Occupational Health, which cooperated with the ILO to assist the ministries of labor in some of the East African countries; or (b) indirect assistance, as when occupational health professionals from a developing country take more advanced training at a school of public health or some other program in a developed country. However, despite ILO activities and some WHO activities in occupational health in developing countries, IDRC funding of some research projects, and ongoing in-country programs conducted by government agencies and other organizations, the level and quality of activity (education, research, treatment, and prevention and control) in occupational health in developing countries is woefully inadequate, given the magnitude and severity of occupational health problems.

Synthesis:

Given the frequency and severity of occupational illnesses and injuries and the widespread presence of the factors that cause these problems in developing countries, the preventability of these problems, and the inadequacy of existing occupational health capabilities in developing countries, occupational health deserves a very high priority in A.I.D.-funded projects.

As in other areas of health and well-being, the United States government, governments of both developed and developing countries, international organizations, and non-governmental organizations can play important roles by creating partnerships to improve the capabilities of developing countries in occupational health. An important step in this process is recognizing the nature, magnitude, and severity of work-related illnesses and injuries. When this is done, many countries will begin to appreciate for the first time the widespread incidence, severity, and human and economic impacts of these problems. Many countries and many industries and businesses within the countries will find that it is in their enlightened self-interest to ensure an optimal level of health and safety at work.

A.I.D. can play a vitally important role in strengthening occupational health programs in developing countries through activities that facilitate the development of institutions, human resources, worker and manager participation, policy development and implementation, and health and management information systems. The result of such programs will not only be improved health of workers, but also improved productivity and economic status of their countries.

INJURY CONTROL

This section of the paper will focus primarily on unintentional, non-occupational injuries in developing countries. It will therefore exclude not only occupational injuries, which were covered in the previous section, but also homicide and suicide. It will begin by defining the characteristics of different types of injury and the measures used to prevent them, and will end with brief discussions of current gaps in needed data, injury-control capabilities within the United States, and current activities in the area of injury control.

Characteristics of the Problem and Impact on Health:

Unintentional injuries are a major cause of morbidity, disability, and mortality worldwide (11). Such injuries range from traffic accidents to burns, from animal bites to poisonings. Although the epidemiology of unintentional injuries varies among countries and within countries by degree of industrialization and of urbanization and by age, sex, and other characteristics of the population, the problem is often more serious in developing countries. The rate of injury per motor vehicle in Nigeria, for example, is 250 times greater than it is in the United States (12). Unintentional injuries account for a high number of deaths in developing countries: in Latin America, they represent the leading cause of death among people aged 1 to 44 years; in Mexico alone, they account for 11 percent of all deaths (13). In Thailand, more person-years of life are lost from motor-vehicle injuries than from malaria and tuberculosis combined (14). In developing countries, morbidity and mortality rates due to injuries are aggravated by the lack of institutional infrastructure or policies to deal with injury control, by the small number of trained specialists, and by inadequate and inefficient information systems to track the problem, compile statistical reports, and disseminate relevant information.

Recently, many developing countries have noted several trends with regard to unintentional injuries:

- unintentional injury deaths have become relatively more important in many developing countries as death rates due to infectious diseases have declined
- fatal and non-fatal motor-vehicle injuries, and injury rates, have increased in recent years
- non-motor-vehicle unintentional injury rates, although often at high levels, have generally remained about the same in recent years

This section of the paper will describe injuries related to motor vehicle accidents, burns, drowning, falls, bites and wounds from animals and insects, injuries from instruments and objects that cut or pierce the skin, and poisonings. In addition, natural and man-made disasters will be addressed.

1. Motor-vehicle injuries: Injuries due to motor vehicles are the leading cause of unintentional-injury deaths in developing countries. At present, the rates of such injuries in many developing countries are sharply increasing, a trend often concurrent with urbanization and industrialization. (In Sri Lanka, for example, the rate more than tripled between 1960 and 1983, increasing from 3 to 11 injuries per 100,000 population. In

Mauritius, the rate doubled, rising from 15 to 32 per 100,000 population between the late 1960s and 1976.) Human error, broadly defined, is the leading cause of motor-vehicle injuries, with vehicle deficiencies and environmental problems combined generally accounting for far fewer injuries. Types of motor-vehicle injury vary, although most deaths are due to head injuries.

2. Burns: Burns account for many deaths as well as many cases of disability and disfigurement. High-risk groups include the very young and the elderly. Because in developing countries burns often result from open fires for cooking or lighting, scalds from cooking oil, and ignition of clothing, women (who are usually responsible for cooking) are another high-risk group: in Egypt, burns accounted for nine percent of all deaths among married women aged 15 to 49 who were studied.

3. Drowning: In many developing countries, drowning is the second leading cause of fatal injuries in children and young adults. In Thailand, drowning accounts for 60 percent of injury deaths among children aged 1 to 4 years. Several risk factors have been associated with drowning deaths, including unfenced ponds, wells, and drainage canals, into which young children can fall. Alcohol ingestion and epileptic seizures may be associated with drowning, although more research needs to be done on these possible associations.

4. Falls: Falls account for much morbidity and mortality in developing countries. For example, in Hong Kong, they have accounted for as many as 19,000 hospital admissions a year, more than any other category of injury. In developing countries, where children and young adults often harvest coconuts and other tree-bearing nuts or fruits, falls often occur from trees. In urban areas, many young children take serious falls from windows of tall buildings. The elderly present another group at high risk group for non-occupational falls.

5. Bites and wounds from animals and insects: These are common problems in many developing countries, especially in rural areas. Of particular concern are rabid dogs, certain types of buffalo and other mammals that can gore humans, and snakes whose bites inject venom.

6. Instruments and objects that cut or pierce the skin: Sharp instruments, ranging from the cutting blades of machinery to machetes used to harvest sugar cane, account for a substantial number of injuries: in the Punjab in India, for example, 39 percent of injuries were found to be due to such instruments and objects, although this statistic appears to include occupational injuries. The increasing use of machines without proper safeguards -- both inside and outside the work environment -- aggravates the risk of these injuries.

7. Poisonings: Non-occupational poisonings represent an important category of injuries in many developing countries. Although a substantial percentage of these are intentional (i.e., suicide attempts) and not discussed here, many represent children who ingest pesticides stored in or near the home, kerosene that is easily mistaken for a soft drink, medications from inadequately-labelled or improperly-sealed containers, or other toxic substances. Other important sources of poisonings in developing countries are: (a) the ingestion of fluids or foods from containers in which pesticides or other toxic substances have been stored; and (b) the ingestion of lead from paint, from water passed through

lead-lined pipes, from food or liquid stored in improperly glazed containers, and from inhalation of lead fumes from automobile emissions or industrial sources.

8. Natural and man-made disasters: Thousands of people die and many more are injured each year in developing countries as a result of earthquakes, eruption of volcanoes, floods, and other natural disasters. Many deaths occur because of poorly-constructed homes or homes built in flood plains. In addition, in recent years there have been major technological disasters: in Bhopal, India, the release of methyl isocyanate gas killed almost 3,000 people and injured thousands more; a butane gas explosion in Mexico City killed at least 400 people; and the release of radioactivity at Chernobyl not only killed some people immediately but also exposed thousands to doses of ionizing radiation that place them at high risk of cancer.

Measures to Prevent Injuries and Minimize their Impact:

Most developed countries and some developing countries have injury-control programs that make use of a variety of approaches to the prevention and treatment of injuries. The lessons learned from the experiences of these countries may be adaptable to other developing countries. Although preventive measures and control strategies vary with the specific type of injury, generic measures and strategies include:

- Education about safety hazards and how to avoid or reduce them
- Installation and use of machinery guards and other safety equipment
- Prohibition or restriction of use of unsafe substances or of entry into unsafe areas
- Substitution of unsafe or toxic substances with safer or non-toxic ones
- Appropriate maintenance of vehicles and other equipment
- Redesign of unsafe vehicles and other equipment
- Training in and application of first-aid measures for the injured
- Emergency transport for the injured and emergency medical care
- Development of legislation and other policies to enforce or facilitate the implementation of safety measures
- Improvement of health and management information systems

Examples of preventive measures or control strategies for each category of injuries discussed are listed below. This list is not intended to be comprehensive, but rather illustrative.

1. Motor vehicle injuries:

- Driver training and driver registration programs
- Design of vehicles and roads to minimize the likelihood of crashes
- Availability and use of seatbelts
- Programs that encourage people not to drive after drinking alcohol

2. Burns:

- Substitution of safe stoves for open flames
- Placement of stoves off the floor and on even surfaces
- Teaching of burn-treatment measures

3. Drowning:

- Construction of fences around ponds, wells, and draining canals
- Teaching of resuscitation skills
- Improved supervision of young children near bodies of water

4. Falls:

- Planting of shorter species of trees, to minimize the risk incurred by children and workers who climb trees
- Installation of window guards in tall buildings
- Placement of railings on stairways

5. Bites and wounds from animals and insects:

- Training programs on first-aid measures
- Immunization of dogs against rabies
- Post-exposure immunization for people bitten by possibly rabid animals
- Clearing of grass around pathways to minimize likelihood of snake bites

6. Instruments and objects that cut or pierce the skin:

- Placing guards on machinery, wherever possible
- Teaching of safe cutting techniques for knives and other hand-held tools

7. Poisonings:

- Labelling of pesticides and other hazardous substances
- Storage of pesticides and other hazardous substances away from children
- Mandating of childproof caps on bottles of medicine
- Establishment of poison information centers
- Identification and control of sources of lead in the environment

8. Natural and man-made disasters:

- Better construction of buildings
- Avoiding of construction on land that is likely to be flooded
- Planning of emergency procedures that provide for first-aid, emergency transport, and emergency medical care of the injured

Data Gaps and Applied Research Needs in Developing Countries:

Although statistics for developing countries exist in some of the categories described above, they are often not available, and there is also a lack of useful data in many areas of injury control. Applied research could be undertaken by international organizations (including U.S. institutions) to improve data-collection systems and to gather data for use in problem identification, planning of technical assistance interventions, and policy development.

The major data gaps include:

- Descriptive epidemiologic data on injury morbidity and mortality, where such data are not now available
- Data on people disabled by injuries, extent of disability, and existing and needed rehabilitation services
- Data on the direct and indirect economic impacts of unintentional injuries
- Epidemiologic data on suicides and homicides
- Epidemiologic data on lead poisoning
- Epidemiologic data on non-occupational pesticide poisoning
- Epidemiologic data on bicycle injuries
- Epidemiologic data on fires and burns from cigarettes
- Applied research needs include research to determine the feasibility, impact, and cost-effectiveness of specific preventive measures

The lack of available data is, in part, due to inefficient systems for reporting and analyzing data. Data collection and assessment systems in developing countries often face severe constraints:

- Many injuries occur in rural areas, far from medical care and reporting systems
- Some injuries may have legal or economic implications that are disincentives for reporting
- Most countries have not adopted standard definitions of injury diagnosis and cause of injury
- There is an inadequate number of epidemiologists and biostatisticians
- Data analysis equipment is inadequate

However, existing data should be made more easily available. In addition, more use should be made of "verbal autopsies" (interviews with family members and friends to obtain the lay perspective on cause of death), which can be very accurate for injury deaths, and of existing data from:

- hospitals (including emergency departments)
- health centers
- rehabilitation centers
- insurance and social security
- traffic police records

<u>U.S. Capabilities and Advantages</u>:

Developing-country injury control programs could benefit from outside technical assistance in policy and systems development. In the United States, many types of organizations have expertise in safety: national professional safety organizations, government agencies, private voluntary organizations, university programs, independent research institutions, and others. Such organizations can provide technical assistance in the treatment of injuries so as to minimize disabilities and deaths as well as in the prevention of many types of injury. More specifically, U.S. organizations can offer their expertise and experience in:

- Injury epidemiology
- Design of vehicles and other equipment to minimize injury
- Public health education programs to raise awareness and provide specific education to prevent injuries
- Legislation and other policy approaches to injury control
- Opportunities for more advanced education for epidemiologists, safety specialists, and other professionals who are responsible for injury evaluation and control

Current Activities:

Although clearly there exist great problems in the area of injury control in developing countries and many developed countries are placing a needed emphasis on injury prevention, most international donor organizations have given little attention to injuries. In general, developing countries do not have injury prevention programs, despite the high incidence of serious and fatal injuries and the enormous human and economic impacts of such injuries in these countries.

The World Health Organization (WHO) has an Accident Prevention Programme (which may soon be renamed the Injury Prevention Programme). It has a small budget ($250,000 per year, which supports one professional staff member, one assistant, and $100,000 of projects per year). With its ten WHO Collaborating Centres worldwide, the Programme focuses on the treatment and prevention of injuries, and especially on the roles of the health sector. The Programme fosters the development of methodological tools for the epidemiologic analysis of injuries and focuses particularly on burns, childhood injuries, injuries among the elderly, and head trauma. It is supporting studies in Latin America, Southeast Asia, and the Western Pacific to gather and improve epidemiologic information on these and other injuries. In addition, the Programme is promoting the integration of safety (injury prevention) into primary health care at the district level in such countries as Thailand, Venezuela, Sweden, Denmark, and France, and it hopes to add similar projects in India, Malaysia, and possibly Indonesia. The Programme is also concerned with both pre-hospital and hospital trauma care, and it is promoting the establishment of better surveillance systems for injuries as well as the training of physicians and other health professionals in injury treatment and prevention.

Synthesis:

The rates of morbidity, disability, and mortality due to injuries are significantly higher in developing countries than in developed countries. Many technologically-appropriate measures that are used to anticipate, recognize, evaluate, treat, and prevent and control these injuries in developed countries are adaptable to the developing-world setting, while others can be developed and implemented, thus reducing the substantial costs to affected individuals, their families, and society as a whole.

As with Occupational Health (discussed in the first part of this paper), there are at least five important strategies for injury control. These include: institutional development (both inside and outside the government), human resources development (particularly of safety specialists, injury epidemiologists, and policy makers), development of community participation in injury control, policy development (ranging from legal standards for injury prevention to incentives that encourage responsible driving), and the development of health and management information systems.

In sum, injury control deserves a very high priority in an A.I.D.-funded project. Injuries take a high toll on the populations of developing countries, where high rates of morbidity, disability, and mortality lead to a loss of productivity and have a major economic impact. Although problems related to injuries are serious, they are also often preventable. Injury control can be improved substantially by developing and strengthening capabilities in governmental and non-governmental organizations in developing countries. A.I.D. can play an important role in this effort.

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Urban Management Program

URBAN MANAGEMENT AND THE ENVIRONMENT
(INT/89/052)

While cities continue to make major contributions to the output, employment and incomes of developing countries, rapid population growth and uncontrolled industrial development are seriously degrading urban environments; placing serious strains on the natural resource base; and undermining efficient, equitable and sustainable development. ("Urban Management and the Environment - Project Document," UNDP, 1989)

The neglect of environmental considerations in urban planning and management carries with it not only negative health and social impacts, but, also economic and financial costs which in turn have deleterious impacts on urban productivity. "The Sustainable Cities Programme," UNCHS (Habitat), 1990)

The operational challenge is to formulate policies and actions that address the three central problems of urban growth: reducing the constraints to urban productivity, alleviating poverty, and managing the urban environment in a complementary manner, rather than as trade-offs. (Urban Policy and Economic Development: An Agenda for the 1990s, World Bank, 1991)

In 1990, a new component on "Urban Management and the Environment" was added to the UNDP-funded Urban Management Program, which is jointly executed by the World Bank and the United Nations Centre for Human Settlements (UNCHS - Habitat). Its objectives are to: (a) describe the growing urban environmental crisis; (b) define the nature and extent of specific problems, especially impacts on health and economic development; (c) identify the underlying causes of observed urban environmental degradation; (d) establish criteria for prioritizing needed actions to address the problems and selecting the instruments that can be used; (e) suggest approaches that can yield lasting environmental improvements, including policy options, programmatic responses, and institutional arrangements; and (f) propose strategies for countries and external support agencies to implement the recommended approaches.

How the Program is Set Up

The Environmental Management Component is funded by the United Nations Development Programme. The World Bank's Urban Development Division (INURD) has formed an Urban Environmental Team to carry out the work. A counterpart team has been formed at UNCHS in Nairobi. These core teams are comprised of professionals in the areas of urban planning, environmental engineering, natural resource management, capacity building, waste management, health, land management, environmental planning and economics. In addition, the teams draw on expertise and inputs from other activities at the World Bank (e.g., the Metropolitan Environmental Improvement Program), UNCHS (e.g., the Sustainable Cities Programme), UNEP (e.g., the GEMS/AIR Programme), other external support agencies (e.g., WHO's Healthy Cities Program), non-governmental organizations (e.g., the Stockholm Environment Institute) and local consultants/institutions in developing countries.

The Course of Action

A work program has been developed for the first two years of activity which cuts across several sectors and geographic regions. The component involves preliminary work to define broad environmental management strategies for dealing with critical urban problems in developing countries. The chief product of this work will be a report entitled Strategic Options for Managing the Urban Environment. It will be an important input to the UN Conference on Environment and Development in 1992. It will also lead to a World Bank policy paper on the urban environment in 1993, and to UNDP's forthcoming advisory note on the urban environment.

The report, Strategic Options for Managing the Urban Environment, will be based on research and policy work, several background papers, and a number of city case studies. In order to guide the development of these inputs in an orderly manner and ensure their successful integration into the final output, an annotated outline of the report has been prepared. This paper, along with other intermediate outputs, is available upon request.

The following intermediate outputs are being prepared in the form of Urban Management Program working papers:

Research

"The Relative Health Impacts of Environmental Conditions in Developing Cities"

"The Economic Spillover Effects of Urban Environmental Problems"

"A Framework for Urban Environmental Data Collection"

"The Application of Remote Sensing and Geographic Information Systems to Urban Environmental Planning"

Background Studies

"Priorities for Urban Waste Management and Pollution Control"

"Regulatory and Economic Instruments for Pollution Control"

"Local Management of Wastes from Small-scale and Cottage Industries"

"Energy-Environment Linkages in the Urban Sector"

"Urban Environment: Degradation of Land, Ecosystems and Cultural Property"

"Options for Planning and Managing the Urban Environment"

City-based Activities

(These activities will take place in the following cities: Sao Paulo, Jakarta, Tianjin, Chittagong, Katowice, Tunis, Accra and the Singrauli region of India)

* Preparation of urban environmental profiles

* Workshops to further analyze priority environmental concerns

* Review of institutional and jurisdictional arrangements for environmental management

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OUTLINE OF REPORT ON
STRATEGIC OPTIONS FOR MANAGING THE URBAN ENVIRONMENT

I. THE GROWING URBAN ENVIRONMENTAL CRISIS

1. Urbanization, development and environment - the neglected locus

2. Environmental conditions in and around cities

3. Impacts on health and urban productivity

II. THE NATURE AND EXTENT OF URBAN ENVIRONMENTAL DECAY

1. Specific problem manifestations

   a. Pollution from urban wastes
   b. Urban and household air pollution
   c. Water resource problems
   d. Urban energy issues
   e. Degradation of land and ecosystems
   f. Occupation of hazard-prone areas
   g. Loss of cultural property

2. Unique features of urban environment

   a. Dynamics of urbanization process
   b. Excessive scale of waste concentration and resource consumption
   c. Cross-media and cross-sectoral issues
   d. Deteriorated living environment and services
   e. Impacts on the urban poor
   f. Spatial and intergenerational impacts

III. THE UNDERLYING CAUSES OF URBAN ENVIRONMENTAL DECAY

1. Lack of environmental awareness and political will

2. Insufficient knowledge and understanding

3. Economic policies

   a. Inadequate pricing of both resources and services
   b. Other sources of economic distortion

4. Environmental planning and management

   a. Deficient legal and regulatory framework
   b. Weak organization and management
   c. Ineffective land use controls and property rights systems

IV. PRIORITIES FOR ACTION

1. Criteria for prioritization

   a. Magnitude of health impacts
   b. Magnitude of urban productivity losses
   c. Weight of impact on the urban poor
   d. Irreversibility of outcome
   e. Unsustainable consumption of resources

2. Instruments

   a. Policy interventions
      - economic policies
      - urban hygiene policies
   b. Environmental management and planning
      - legal and regulatory framework
        land use management
      - urban waste management
      - environmental planning
   c. Institutional improvements
      - enforcement capacity
      - jurisdictional arrangements
      - consultative mechanisms
   d. Investments and financing
   e. Environmental education and public participation

V. FORMULATING AN URBAN ENVIRONMENTAL MANAGEMENT STRATEGY IN DEVELOPING COUNTRIES

1. Immediate Objectives: Safeguarding public health/pollution prevention

   a. Formulating appropriate urban hygiene policies
   b. Institutional improvements including jurisdictional arrangements
   c. Use of regulatory and economic instruments
   d. Infrastructure investment programs
   e. Greater citizen awareness and involvement

2. Long-term Objectives: Avoiding irreversible damage/ensuring sustainable urban growth

   a. Formulating appropriate economic policies
   b. Land management
   c. Natural Resource management

VI. AN INTERNATIONAL ENVIRONMENTAL STRATEGY FOR EXTERNAL SUPPORT AGENCIES

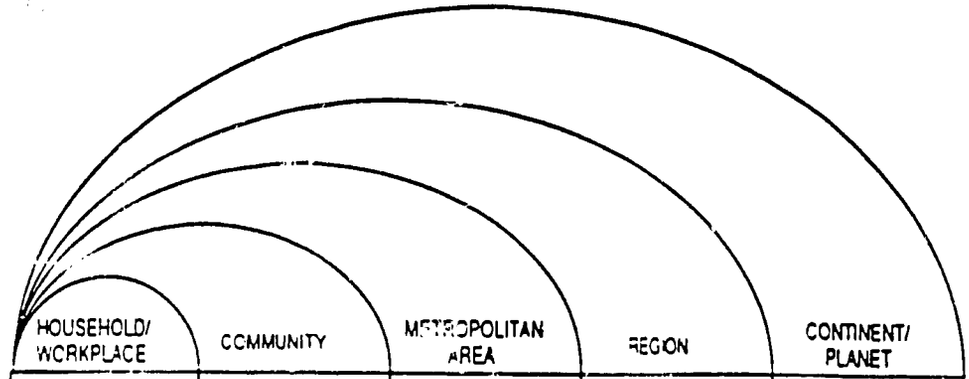
1. Doing a better job through existing urban development lending and dedicated urban environmental management projects

2. Supporting policy reform and domestic resource mobilization

3. Research and policy analysis

4. Advice on policy and institutional issues

VII. OPTIONS FOR OTHER KEY ACTORS



SPATIAL SCALE	HOUSEHOLD/ WORKPLACE	COMMUNITY	METROPOLITAN AREA	REGION	CONTINENT/ PLANET
Key Infrastructure And Services	shelter water storage onsite sanitation garbage storage stove ventilation	piped water sewerage garbage collection drainage streets/lanes	industrial parks roads interceptors treatment plants outfalls landfills	highways water sources power plants	
Characteristic Problems	substandard housing lack of water no sanitation disease vectors indoor air pollution	excreta laden water/soils trash dumping flooding noise/stress natural disasters	traffic congestion accidents ambient air pollution toxic dumps	water pollution ecological areas lost	acid rain global warming ozone layer

Figure 1 SPATIAL SCALE OF URBAN ENVIRONMENTAL PROBLEMS

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ANALYTICAL FRAMEWORK FOR URBAN ENVIRONMENTAL PROBLEMS

Manifestations	Impacts	Causes	Cures
Deteriorated living environment and services	Health impacts - infectious and parasitic diseases - malnutrition - accidents - stress, drugs, violence - acute and chronic toxicity - genetic effects - cancer Lost urban productivity Degradation of the natural environment - resource loss - amenity loss	Substandard housing Lack of water and sanitation Disease-carrying insects and rodents Indoor air pollution Excreta laden water/soils Trash dumping Noise/stress Traffic congestion Natural disasters	Appropriate housing and land development regulations Housing finance Provision of affordable infrastructure and plots Provision of affordable water sanitation, solid waste services at cost Targeted subsidies Improved efficiency and effectiveness of infrastructure and service provision Pollution control Community participation
Ambient air pollution	Localized primarily in large cities - health problems - lost aesthetic, cultural, recreational values - property damage (including historical monuments) At present more of metropolitan area problem than regional/global problem	Urbanization/industrialization Fuel/energy pricing and urban energy demand Vehicle ownership Space heating Use of highly polluting fuels: - leaded gas - high-sulphur lignite	Pricing of industrial and energy inputs Regulations and standards Emission charges Monitoring and enforcement Energy conservation Technological interventions - scrubbers, baghouse filters - vehicle emissions control - fuel substitution
Indoor air pollution	Chronic obstructive lung disease Acute respriatory infections Low birth weight and associated problems Cancer	Biofuel use for domestic cooking and heating Passive smoking Cottage industry exposure	Pricing of commercial fuel and energy Targeted fuel subsidies Improved housing and ventilation Public awareness
Solid waste pollution	Health hazards Amenity impacts Blocked drainage and flooding Water pollution (leachates)	Inefficient management (collection and disposal) Impacts not recognized or external to community	Improved collection - expanded coverage (e.g. to low-income areas via community based approaches) - efficient operations (e.g. create contestable markets to encourage private sector entry) - financial strengthening (budgeting, accounting, cost recovery) Disposal technology and management Resource recovery/recycling
Fecal contamination	Diarrheal diseases Parasitosis Malnutrition High infant mortality	Lack of basic sanitation services Excreta laden water/soils Proliferation of garbage/insects	Provision of affordable sanitation options at cost Community-based approaches Hygiene education

ANALYTICAL FRAMEWORK FOR URBAN ENVIRONMENTAL PROBLEMS (Continued)

Manifestations	Impacts	Causes	Cures
Hazardous waste pollution	Acutely affects groundwater, but often multimedia impacts Damage at low concentrations - Health damages (e.g. acute and chronic toxicity) - Foodchain accumulation "Timebombs" (hidden dumps that build up over time)	Insufficient regulations/ management Pricing of inputs into industries producing waste Impacts removed in space and time	Regulations, standards and charges Monitoring and enforcement capacity Licensing Waste minimization - process modification - resource recovery/ recycling Treatment and disposal technology and management
Fresh water resource [illegible] (surface and ground water)	Sources running out Increasing marginal costs Land subsidence	Pricing policies Cultural (perception of free good) Over pumping of groundwater Irrigation policies and practices (inefficiency)	Improved pricing Integrated watershed management Improved technologies (e.g. wastewater reuse) Regulation of groundwater extraction
Fresh water resource quality degradation (surface and ground water)	Poor quality surface and ground water Health impacts Increasing marginal cost - of potable supply - of industrial supply - of individual treatment Waterlogging and salinization Saline intrusion	Municipal & industrial waste disposal practices - Sewerage (water pricing, poor O&M) - Industrial wastes (input pricing, poor regulations enforcement) Urban runoff Irrigation policies and practices Overpumping of groundwater Impacts not recognized or external to the community	Pricing policies Regulations, standards, charges Monitoring and enforcement Solid and hazardous waste management Treatment technology and operations Integrated watershed management Regulation of groundwater extraction Public Education
Lake, coastal and marine water pollution (including fisheries depletion)	Mainly occurs locally: - closed beaches and lost tourism revenues - lost aesthetics - health consequences - eutrophication - fish and shellfish contamination	Municipal and industrial waste disposal (see above) Agricultural runoff (+ related policies) Detergents Shipping/oil Litter/plastics	Water pollution regulations (municipal and industrial) Solid waste management Improved technologies (e.g. outfall design) Shipping facilities and regulations Special areas designation (e.g. marine sanctuary) Coastal zone management
Degradation of land and ecosystems	Loss of wetlands/wildlands (rich genetic diversity, migratory birds, hydrological aspects) Coastal zone degradation Loss of recreational areas (e.g. beach fronts) Deforestation (urban firewood/charcoal demand) Increased erosion	Shadow value of land much higher than prices Absence of land taxation and enforcement Uncontrolled urban growth - absence of planning control - lack of legal alternative to squatter developments Water pollution Solid waste disposal practices Occupation of steep zones	Appropriate incentives (prices and taxes) Affordable planning regulations; enforcement Pollution control regulations Special areas designation (e.g. nature preserves, parks, seashores) NGO-type activity in support of environmental initiatives

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ANALYTICAL FRAMEWORK FOR URBAN ENVIRONMENTAL PROBLEMS (Continued)

Manifestations	Impacts	Causes	Cures
Occupation of high-risk land (generally squatter and low-income groups) - low-lying land - floodplains - steep zones	Flooding Landslides, mudslides Erosion Health risks, accidents Property damage and building collapse	Land tenure systems Failed land markets Lack of developed lands Land regulation/enforcement	Apropriate incentives (prices, taxes, tenure, access to housing finance) Less regulation of land markets Provision of affordable infrastructure and plots Targeted subsidies Community participation programs
Degradation of cultural property: - historical monuments - living monuments	Loss of cultural heritage Loss of tourism revenue	Local value less than international value Air pollution Solid waste management practices Lack of enforcement	Dead monuments: - pollution control - preservation/enforcement Living monuments: - historical districts - tax incentives - public education

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