AN ASSESSMENT OF URBAN ENVIRONMENTAL PROBLEMS IN ECUADOR

by

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CONTENTS

ACRONYMS

BEDE
Banco Ecuatoriano de Desarrollo

BOD
Biological oxygen demand

CAAM
Commision Asesora Ambiental de la Presidencia

CDC
Centers for Disease Control

COD
Chemical oxygen demand

DIGMER
Direccion General de la Marina Mercante

EMAAP-Q
Empresa Municipal de Agua Potable y Alcantarillado de Quito

EMA-G
Empresa Municipal de Alcantarillado de Guayaquil

EMAP-Q
Municipal de Agua Potable de Quito

EPAP-Guayas
Empresa Provincial de Agua Potable del Guayas

EMASEO
Empresa Municipal de Aseo

EP3
Environmental Pollution Prevention Project

EPAT
Environmental and Natural Resources Policy and Training

IDB
Inter-American Development Bank

IEOS
Instituto Ecuatoriano de Obras Sanitarias

INEC
Instituto Nacional de Estadisticas y Censos

INERHI
Instituto Ecuatoriano de Recursos Hidraulicos

LAC
Latin American and Caribbean Bureau of the U.S. Agency for International
Development

LPG
Liquified petroleum gas

MINDUVI
Ministerio de Desarrollo Urbano y Vivienda

MRF
Materials recovery facility

MSP
Ministerio de Salud Publica

P2
Pollution prevention

PAHO
Pan-American Health Organization

PECIS
Programa de Evaluacion de la Contaminacion Industrial en el Sur

RHUDO/SA
Regional Housing and Urban Development Office for South America of the
U.S. Agency for International Development

TSP
Total suspended particulates

USEPA
U.S. Environmental Protection Agency

WHO
World Health Organization

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INTRODUCTION: POTABLE WATER SUPPLIES AND SEWAGE MANAGEMENT

by

Douglas Southgate, John Kellenberg, and Patricia Kelly

1. Urbanization and Pollution in Latin America

1.01 When the topic of environmental degradation in Latin America is raised outside of the region, most people think immediately of the destruction of topical rainforests and other natural habitats. This response is understandable. Those ecosystems

harbor a wealth of biodiversity. Furthermore, tropical deforestation is an important cause of increasing atmospheric concentrations of carbon dioxide and other greenhouse gases.

1.02 Within the region, however, environmental concerns are much different. To be sure, many Latin Americans worry about the loss and degradation of ecosystems. But for most, deteriorating air and water quality in urban areas and the mishandling of industrial and household wastes are more immediate problems.

1.03 The attention devoted to environmental issues in Latin America's cities is bound to grow with time. The region, it should be remembered, is more urbanized than any other part of the developing world. In the middle 1980s, two-thirds of all Latin Americans lived in localities officially designated as urban; by contrast, 70 percent of the population of Africa and 76 percent of South Asia's population were rural (Merrick, 1991, p. 23). During the last ten years, growth of cities has exceeded general demographic increase throughout the region. The day is fast approaching when Latin America will be as urbanized as Europe and North America, if not more so.

1.04. Rapid urbanization has been accompanied by severe pollution and a general lack of municipal services. At best, emissions controls on vehicles and industrial facilities have been lax. Also, provision of potable water and solid waste services has failed to keep pace with demand. As a result, millions of Latin Americans now suffer respiratory ailments from breathing dirty air, gastrointestinal diseases from drinking dirty water, or both. The costs are enormous, in terms of lost employment, increased expenditures on medical services, diminished intellectual capacity among children, as well as reduced life expectancy.

1.05 Dixon (1993) contends that an opportunity now exists to pursue environmentally sound urban development in Latin America. The economic folly of "growing first and cleaning up later" is becoming obvious. In city after city and industry after industry, emissions must now be brought down to acceptable levels at a cost far above what would have been paid had more efficient and less polluting technologies been adopted earlier. In light of this experience, governments and the citizens they represent are much more receptive than they used to be to investments and policy reforms that have a demonstrable impact on environmental quality. Such is the case in Ecuador, where urban pollution has become acute.

2. The Environmental Challenge Facing Ecuador's Cities

2.01 The country that is the geographic focus of this study is about the size of the United Kingdom or the state of Colorado. In just two generations, it has been transformed from a lightly populated, rural county to a semi-urban one with the highest ratio of people to land area in South America. At the time of the first comprehensive census in 1950, the national population stood at 3.3 million, of whom 28 percent lived in cities. Forty years later, census workers counted 9.7 million Ecuadorians, 55

percent of whom resided in incorporated urban areas.

2.02 Southgate and Whitaker (1994, pp. 13-15) point out that rural population density in the western two-thirds of the country ("i.e.", outside of the Amazonian lowlands east of the Andes) has not changed significantly since the early 1970s. Indeed, five highland and coastal provinces actually experienced a decline in rural population between 1974 and 1990. The impact associated with a large gap between birth and death rates, then, was felt in Ecuador's cities, which grew by 4.5 percent a year during the 1980s.

2.03. Rural-to-urban migration has been affected in various ways by government policy. Alarmed by the large number of campesinos crowding into Quito (the national capital), Guayaquil (the principal port and most populous urban area), and a half-dozen or so medium-sized cities, municipal governments have tried to stem the tide by providing nothing more than minimal services to the slums where migrants tend to settle. But at the same time, emigration from the countryside has been accelerated by a set of macroeconomic and sectoral policies that discriminated against agriculture and other parts of the rural economy (Scobie, Jardine, and Greene).

2.04. The impacts of public policy on migration should not be exaggerated. Had a bias-free policy framework been in place, large numbers of people still would have been drawn away from farming since economic progress, as measured by GDP growth, is almost always accompanied by a progressive reduction in the portion of the labor force engaged in crop and livestock production. Thus, much of the urbanization that Ecuador has experienced in recent years can be regarded as inevitable.

2.05. Although this report addresses the environmental problems that have arisen as Ecuador's cities have grown, it is important to note that urbanization can result in major environmental benefits by lessening pressures on fragile rural ecosystems. Southgate and Whitaker (1994, p. 29) argue that the rural poor encroach on biologically diverse tropical forests, erodible Andean hillsides, and other unique or fragile environments when they cannot get remunerative work outside of farming, because of inadequate human capital formation, labor market rigidities, or both. In a similar vein, Foster (1992) has drawn on cross-country comparisons to show that urbanization is negatively correlated with deforestation rates, population growth, and per capital energy consumption.

2.06 The environmental challenge facing urban centers in Ecuador and around the world is largely a management and policy challenge. In the face of escalating demand for municipal services associated with increases in population and living standards, public agencies and private firms that provide those services must do their job as efficiently as they can. By the same token, firms and households must avoid wasting and misallocating water, energy, and other resources if environmental quality is to be maintained or improved. Peak performance at all levels requires that an appropriate set of policies be in place.

2.07 Management by governmental agencies, private businesses, and individual households has been extremely inefficient in Quito,

Guayaquil, and other Ecuadorian cities. Since potable water and solid waste services have not been delivered at minimal cost, large numbers of urban households rely on alternatives that are more expensive and of inferior quality. Many neighborhoods go without garbage collection altogether. At the same time, manufacturing enterprises in Ecuador waste large amounts of water and energy.

2.08. A disproportionate share of the burden of inefficiency has been shouldered by the poor. As a rule, marginal neighborhoods have been the last to be served by municipal potable water and sanitation systems. At the same time, pollution has been especially heavy in places where the urban poor are obliged to live and work. Breihl "et al." (1983) reported that, whereas infant mortality rates in upper class districts of Quito were approximately 5 per 1,000 during the early 1980s, rates in poor neighborhoods were considerably higher -- 129 per 1,000 -- in part because of poor ambient quality.

2.09 More often than not, mismanagement has been a consequence of misguided or inappropriate public policies. In the 1970s, when Ecuador became one of Latin America's leading petroleum exporters and oil revenues accounted for as much as three-quarters of the national budget (Marshall-Silva, 1988), the central government assumed more responsibility for functions like planning and budgeting. Local governments, which saw their role diminish, no longer had as strong an incentive to design and operate potable water and sanitation systems as economically as possible. At the same time, heavy subsidies for energy, water, and other natural resource inputs were introduced. This resulted in enormous waste and misallocation (Southgate and Whitaker, 1994).

3. USAID's Contribution to Improved Urban Management in Ecuador

3.01 The 1994-1995 USAID Mission Statement places considerable emphasis on environmental protection. The fourth strategic objective aims to "promote the sustainable use of natural resources, the conservation of biological diversity, and the control of pollution." Pursuit of this long-term goal follows the Latin American and Caribbean (LAC) Bureau's strategy to control, reduce, and prevent urban and industrial pollution, thereby addressing the environmental impacts of urbanization and industrialization.

3.02 Goals set by USAID/Ecuador are complemented by activities of USAID's Regional Housing and Urban Development Office for South America (RHUDO/SA), which is based in Quito. The Mission and RHUDO/SA have designed and funded programs aimed at mitigating urban and industrial pollution. Specific activities include (a) the promotion of policies, economic incentives, and institutional capacity as well as the adoption of industrial technologies that reduce pollution through increased efficiency achieved by prevention, reuse, recycling and by-product recovery, (b) promotion of low-cost, low-maintenance solutions to municipal solid and liquid waste problems; and (c) promotion of best practices in urban environmental management.

3.03 USAID/Ecuador activities in industrial pollution mitigation contribute to the goal of diminished industrial contamination by stimulating the adoption of cleaner production techniques. With technical assistance provided by the centrally-funded Environmental Pollution Prevention Project (EP3), local foundations, and manufacturers' associations, USAID/Ecuador has introduced approaches to decrease waste generation in a number of industries and has mobilized cooperation among communities, industries, and municipalities to support and replicate pollution prevention measures. EP3 activities also focus on improving the ability of municipal governments to manage services that directly affect environmental quality and human health.

3.04 USAID/Ecuador goals are being advanced by targeted funding by other bilateral development agencies, the World Bank, and the Inter-American Development Bank (IDB). EP3's technical assistance from USAID/Ecuador was used to develop terms of reference for a $2 million, IDB-financed clean-up of the Guayas River Estuary. Implementation of this project will reduce household and industrial contamination and improve health and protect coastal ecosystems in and around Ecuador's largest urban area, Guayaquil.

3.05 USAID/Ecuador activities also support institutional capabilities in local non-governmental organizations, like Corporacion OIKOS, that seek to address urban and peri-urban environmental needs and to promote sustainable natural resource development. OIKOS has received support from USAID/Ecuador and RHUDO/SA to promote the adoption of improved technologies to reduce industrial pollution. Similarly, the mission co- financed a workshop held by the Ecuadorian-American Chamber of Commerce to identify the major pollution sources in Quito and to develop an action plan to abate environmental contamination.

4. International Interests

4.01 USAID/Ecuador activities aimed at improving environmental quality in Ecuador proceed hand in hand with efforts to promote economic growth and increased trade throughout the region. The Declaration of Principles at the December 1994 Summit of the Americas stresses the importance of environmental quality.

"Social progress and economic prosperity can be sustained only if our people live in a healthy environment and our ecosystems and natural resources are managed carefully and responsibly."

The Summit reflected commitments made at the 1992 United Nations Conference on Environment and Development, held in Rio de Janeiro, to create cooperative partnerships to strengthen institutional capacities aimed at preventing and controlling pollution, protecting ecosystems, using biological resources on a sustainable basis, and encouraging clean, efficient and sustainable energy production and use.

4.02 Aware that trade and investment serve as the main engines for growth in the Americas, it is imperative that nations work together to increase technological, financial, and other forms of

cooperation, as well as facilitate information exchange in areas such as affordable and environmentally sound technologies. Nations participating in the Summit of the Americas were urged to strengthen and build technical and institutional capacity to address environmental priorities such as pesticides, lead contamination, pollution prevention, risk reduction, waste and sanitation issues, improved water and air quality, access to safe drinking water, urban environmental problems, and to promote public participation and awareness. Similarly, participants were encouraged to promote cooperative activities for developing environmental policies, laws, and institutions, as well as establishing mechanisms for cooperation among governmental agencies, particularly in the legal and enforcement areas.

5. Outline of this Assessment

5.01 This assessment of urban and industrial environmental problems, commissioned by USAID/Ecuador and RHUDO/SA, comprises four reports. The first focuses on potable water supply and sewage management and the second on air pollution. The third report is about the prevention and regulation of emissions from industrial sources and the fourth has to do with the management of municipal solid wastes. A summary of key findings follows.

5.02 Potable Water Supply and Sewage Management. Ecuador is blessed with abundant water resources and hydroelectric power potential. Large sums have been spent on the dams, canals, and related infrastructure needed to exploit this endowment. By and large, however, the return on this investment has been disappointing. As a rule, payments from agricultural, industrial, and household beneficiaries of governmental water resource development projects have amounted to a small fraction of those projects' financial costs and the environmental and inter-sectoral impacts of development have been neglected. Because of poor cost recovery, municipal water systems find it difficult to serve poor neighborhoods, the residents of which have no choice other than to depend on sources of water that are expensive, dirty, or both.

5.03 The public health gains of putting municipal water systems on a sounder financial footing would be enormous. Money that is currently used to subsidize water consumption by relatively affluent households would instead be available to extend and upgrade service. This would, in turn, diminish the incidence of waterborne disease. But improved cost recovery, which Quito is starting to achieve, is only a first, albeit necessary, step toward efficient water development. The downstream costs created when untreated sewage is dumped into rivers must be taken into account when decisions are being made about wastewater treatment, which is practically unheard of in Ecuador. Likewise, watershed management requirements and opportunity costs associated with forgoing alternative water uses must be considered when expansion of any given use is being proposed.

5.05 Air Pollution. During the past quarter century, industrial output, vehicle numbers, and fuel consumption have increased dramatically in Ecuador. As a result, serious air pollution

problems have arisen in the country's major cities. This is especially true in Quito, where traffic has become severely congested and temperature inversions occur frequently.

5.06 Monitoring of air quality is rudimentary in the national capital and practically non-existent in other cities. Likewise, incidence of respiratory disease traced to pollution and other factors, like the incidence of intestinal maladies resulting from inadequate access to clean water, is difficult to determine with a high degree of precision. Nevertheless, it seems to be the case that air pollution is costing Ecuador tens of millions of dollars a year in terms of medical treatment expenses, time lost from work, and excess mortality.

5.07 Quito's municipal government is targeting its pollution control efforts on industrial sources, which account for most total suspended particulates (TSPs) and sulfur dioxide in the air, as well as buses and trucks. Early this year, for example, stiff fines began to be assessed on the owners of diesel-fueled vehicles that spew out especially noxious exhausts.

5.08 Industrial Pollution. Historically an agricultural nation, Ecuador has experienced rapid industrial development in recent decades. Since water and energy prices have been subsidized, manufacturing enterprises that use those inputs intensively, such as food processing, textiles, and chemicals, are prominent in Quito and Guayaquil, where most of the country's factories are located. The toxic intensity of Ecuadorian industry is high as well.

5.09 A legal framework for controlling industrial pollution began to be put in place nearly a quarter century ago. That framework has been subject to periodic revision and, by and large, the specific regulations needed to effect general policy goals have not been adopted. Neither has the institutional capacity needed for effective regulation been developed. As a result, public policy for controlling pollution from industrial sources has been a hit-or-miss enterprise, at best.

5.10 Energy and water subsidies are being reduced sharply. As a result, individuals firms' interest in adopting more efficient technology, which tends to create less pollution, has increased substantially. Responding to this interest, USAID and other development agencies, working through the Ecuadorian public sector as well as local nongovernmental organizations, have provided technical assistance and related services. This sort of approach needs to be complemented by policies, like emissions charges, that strengthen incentives to adopt cleaner production methods.

5.11 Solid Waste Management. The local institutions responsible for collecting and disposing of the garbage generated by households and businesses in Ecuador's major cities are in flux. Guayaquil has begun to contract out solid waste services and a new municipal enterprise has been created in the national capital. Other cities are investigating various alternatives to having those services provided by local government, as has been the norm.

5.12 Regardless of how institutional issues are settled, providing adequate solid waste services in Ecuador is a considerable challenge and how it is met carries major consequences for human health. At this point, it seems to make a great deal to maintain current financing arrangements ("i.e.", a surcharge on electricity tariffs). Also, choices regarding standards to be applied in new landfills must be decided and recycling and waste reduction have to be encouraged. In general, innovative techniques must be applied so that garbage can be collected and disposed of cheaply and with minimal threat to the environment and human health.

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POTABLE WATER SUPPLIES AND SEWAGE MANAGEMENT

by

Kenneth D. Frederick, with Douglas Southgate, and Lori Lach

1. Water Institutions in Ecuador

1.01 Ecuador is blessed with relatively abundant water resources and hydroelectric power potential. Per capita renewable supplies exceed 28,000 m3 per annum. However, this natural endowment could be harnessed much more effectively to satisfy human demands. Moreover, current uses and abuses are creating enormous environmental damage, to the detriment of current as well as future consumers.

1.02 All water resources were nationalized by Ecuador's 1972 Water Law. Existing users were granted nontransferable usufructuary rights that are subject to forfeiture for inefficient use. The Instituto Ecuatoriano de Recursos Hidraulicos (INERHI) was created to plan, administer, and regulate water use for all purposes. In addition, it was supposed to supervise all irrigation, drainage, and flood control activities and was charged with designing, constructing, and operating irrigation systems.

1.03 INERHI never had either the political support or the technical and financial capacity needed to fulfill these mandates (Southgate and Whitaker, 1994). As a result, water resource development proceeded in a largely ad hoc manner, often in response to local political interests. Responsibility for water resource planning and management is being transferred to seven regional agencies, which are still being established, as well as the newly created Consejo Nacional de Recursos Hidricos. So far, institutional reform has focused on irrigation, which accounts for 90 percent of water consumption in the country (ECLAC, 1994) and is woefully inefficient (Southgate and Whitaker, 1994).

1.04 Until 1994, the Instituto Ecuatoriano de Obras Sanitarias (IEOS) was formally "responsible for the planning of the drinking water supply and sanitation sector, setting standards, preparing drinking water supply, sewage and storm drainage projects, securing funding for projects, and managing the construction and maintenance of drinking water supply systems in both urban and rural areas of the country" (ECLAC, 1994). However, that agency concentrated on supplying potable water to rural areas. Larger cities established separate public companies to deliver water supplies and also to provide for sewerage and stormwater drainage services to their citizens. IEOS was dissolved in 1994 and its responsibilities and part of its staff were transferred to the Ministerio de Desarrollo Urbano y Vivienda (MINDUVI).

1.05 MINDUVI's capacity to test potable water quality and to enforce existing standards, which were set in 1976 and need updating, is very limited. For example, the maximum fine it can impose for violating standards is just US$25. It is very much involved in a current initiative to formulate a new national water and sanitation policy. So is the Inter-American Development Bank (IDB), which is helping to design a national regulatory framework that will include provisions relating to the installation, operation, financing, and control of water supply and sewerage services (IDB, 1994). However, municipal companies retain primary responsibility for potable water supply in urban areas. The national institution with which they are in closest contact is the Banco Ecuatoriano de Desarrollo (BEDE), which provides technical and financial assistance for the development of water supply and wastewater infrastructure.

1.06 Although municipal water companies have autonomy over administration and assets and supposedly operate on a commercial basis, the prices they charge for various services are usually controlled by the local city council (ECLAC, 1994). Historically, water rates have been set too low to cover operation and maintenance costs. Consequently, public sector deficits have widened, maintenance of existing infrastructure has been poor, and construction of new facilities has depended on access to government financing.

1.07 Under the circumstances, it is hardly surprising that performance of urban water and sewage systems has been poor. In general, water supplies have been unreliable, with large numbers of citizens, especially in poor neighborhoods, receiving no service whatsoever from local water companies and many more receiving water that is of low quality or subject to interruption. Moreover, water supplies have been developed and wastewater disposed of with little concern for the impacts on other water users or the environment.

1.08 An immediate priority for water policy reform in Ecuador is to introduce and enforce tariffs that cover the full cost of providing water and sewerage services and also to reduce the dependence on subsidies that have proven to be inadequate and unreliable. Beyond this, local, regional, and national institutions involved in the delivery of potable water and sewage services will be called on to help resolve a set of issues that, up to now, have been largely ignored in Ecuador. Competition for water is increasing among irrigators, hydroelectricity producers, and household and industrial consumers. This means that prices should reflect more closely the full costs, including opportunity costs, associated with any particular use. When an upstream source is being developed for household and industrial consumption, for example, the economic sacrifices associated with diminished irrigation or hydroelectricity production need to be built into tariffs. Likewise, water consumers should pay for the damages that result when untreated sewage is discharged.

1.09 In the reviews of potable water development in Quito, Guayaquil, and Machala that follow, attention is given to the full range of pricing issues that each city must now face.

2. Water Supply and Sanitation in Quito

2.01 Until very recently, performance of the municipal water company serving Ecuador's capital city left much to be desired. In 1988, the Empresa Municipal de Agua Potable de Quito (EMAP-Q) lacked the basic information on inventories and costs required for adequate planning, budgeting, and pricing. Tariff revenues amounted to just 54 percent of expenses. Because of low cost recovery, the company was unable to raise private capital for expanding or improving service and it needed government subsidies just to operate. Only 55 percent of the municipal population received acceptable service, 10 percent had deficient service, and 35 percent were without any service.

2.02 Management of EMAP-Q has improved dramatically in the 1990s.

With technical assistance from USAID, the company developed accurate cost accounting systems, introduced a scheme for controlling water losses, and started charging customers higher tariffs. To reduce the costs of extending service, the company lowered capacity norms from 250 liters per person per day (the standard for established neighborhoods) to 100-150 liters per person per day in marginal areas. This adjustment enabled the company to reduce pressure requirements and to use less expensive pipes for secondary connections. Overall, these changes lowered the costs of delivering water to poorer neighborhoods by 20 to 25 percent without reducing the quality of service (Carrion, 1993).

2.03 The consequences of improved management and the introduction of better cost accounting systems are indicated in Table 2.1. Between 1991 and 1993, the number of connections increased by 21 percent and average revenues nearly doubled with very little change in the volume of water sold. As far as can be determined, 1993 was the first time when total revenues covered all operation and maintenance costs as well as amortization of deferred costs and depreciation of fixed assets (although the latter were probably underestimated). That same year, 80 percent of the municipal population was judged to be receiving adequate service; established neighborhoods were fully covered, and 60 percent of the households in marginal areas had connections (Carrion, 1993).

Table 2.1 Potable Water Supply and Tariff Revenues in Quito

	1991	1992	1993
average connections	144,152	157,665	174,398
volume of water sold (thousand m3)	84,978	87,823	88,527
amount billed (thousand US$)	9,618	12,189	17,297
average revenues (US$ per m3)	0.11	0.14	0.20

source: IDB, 1994

2.04 By no means has every opportunity to improve the efficiency of potable water delivery in Quito been fully exploited. An evaluation carried out in 1992 (IDB, 1994) revealed that there was no accounting for 45 percent of the city's water supply, either because of physical losses (25 percent) or because there

was no billing (20 percent). Furthermore, there were large differences in the quantities of water used by those with and without meters, which suggests that installing additional meters might produce even greater water savings. For example, metered connections in Quito represented 66 percent of all those connected to the system but accounted for only 27 percent of consumption, which implies a five-fold difference in per capita use. The magnitude of this gap between metered and unmetered water use makes the authors of the study question how unmetered use was measured (Gavin "et al.", 1992). But even if unmetered consumption were only one-third of the reported level, the potential to reduce water use through the installation of meters would still be great.

2.05 Households with connections to the municipal system continue to pay only a small fraction of the rates paid by people dependent on tanker trucks and an even smaller portion of the estimated willingness-to-pay for water and sewerage services. For instance, 60 percent of the water users surveyed in late 1989 and early 1990 were supplied at least partially by tanker trucks and paid an average of US$4.31 per month for 4 cubic meters, or US$1.08 per cubic meter. By contrast, the prices paid for water delivered through the municipal system ranged from US$0.06 to US$0.22 per cubic meter for residential users and from US$0.11 to US$0.37 per cubic meter for industrial users. Another indication of the benefits of being connected to the public water and sewerage systems is that this increased the estimated value of a housing unit by US$1,363. In addition, a contingent valuation study estimated the willingness-to-pay for drinking water at US$0.43 per cubic meter, which is twice the highest price paid by residential users. The estimated average willingness-to- pay for sewerage services was US$0.79 per month (Velasco and Infante, 1990).

2.06 Improving system efficiency and reducing subsidies are essential since the cost of developing new sources of supply is very high. Most of those sources are located on the eastern slopes of the Andes, which is where most of Quito's water is now obtained. Raw water quality is excellent in that region. But getting it to the city's treatment plants and distribution system involves building canals and pipelines in ecological preserves on the eastern slope of the Andes mountains and then pumping the water substantial heights to get it over or through the mountains. Energy expenditures, associated mainly with pumping, already amount to one-fifth of the total cost of supplying water from EMAP-Q's Papallacta project (Mena, 1995).

2.07 System efficiency, subsidy, and service extension issues are now being addressed by the Empresa Municipal de Agua Potable y Alcantarillado de Quito (EMAAP-Q), which was created in 1994 through the merger of the city's water supply and sewage companies. This institutional change is producing cost savings and the pricing structure is being simplified, by reducing the number of rate categories from ten to four. The intent is to establish a uniform price per unit of water regardless of differences in water delivery costs (Mena, 1995).

2.08 Lowering costs and the dependence on subsidies, it should be emphasized, will make it possible to extend service. At present, 200,000 Quitenos lack connection to the municipal system.

Furthermore, 15 to 35 percent of the households with a connection have no sewer service. It should be kept in mind that industrial and other large users might react to higher prices by using more groundwater. This response will need to be monitored, especially in those places where groundwater resources are being depleted.

2.09 There is another benefit of the merger, which is that it ought to be possible to plan and deliver water and sewerage services in a more coordinated fashion. The technical challenges of diminishing pollution are considerable, in large part because Quito has a combined system for carrying away sewage and stormwater. However, with assistance from the IDB, EMAAP-Q is preparing an integrated master plan for medium- and long- term investments. Improvement of sewerage services is an especially high priority since, at present, all wastewater is dumped untreated into the Machangara and Monjas Rivers, which pass through the city. This creates major costs downstream, where contaminated water is used extensively for irrigation. An analysis of the quality of the water in these two rivers shows elevated levels (that frequently exceed acceptable standards for agricultural use) of total dissolved solids, chemical oxygen demand, organics and inorganics, heavy metals, coliform bacteria, and turbidity (Gomez, 1994).

3. Water Supply and Sanitation in Guayaquil

3.01 Quito imposes large costs on downstream water users because of its failure to treat sewage. Similar problems arise in Guayaquil. Wastewater discharged at the city's three outlets either receives limited pretreatment (Castillo, 1995) or no treatment at all. Even the pretreatment amounts to a temporary diversion of pollutants because all sludges and slurries from the plant in question are eventually dumped in rivers flowing past the city (Mayor's Office, 1995). It is possible that water pollution from Guayaquil has combined with pesticide run-off to cause high shrimp mortality in downstream maricultural operations.

3.02 Not all of the costs associated with inadequate sewerage services in Guayaquil are "externalized." The sewage system run by the Empresa Municipal de Alcantarillado de Guayaquil (EMA-G) was designed to serve 0.5 million people ("i.e.", less than one-fourth of the current population of the company's service area) and has been poorly maintained over the years. With the company operating at a substantial financial loss (Gavin "et al.", 1992), many parts of the city have no service and large volumes of wastewater routinely are trapped in stagnant pools. The most spectacular example of this problem is contamination of the Estero Salado, which runs through the center of Guayaquil. Because the estuary is unable to flush out the large quantities of industrial and municipal wastes that it receives, it has become an enormous open sewer. Plans for dealing with this problem are under study.

3.03 Just as Guayaquil's businesses and households are the source of a considerable amount of water pollution, the city incurs major costs due to discharges from upstream farms and urban

areas. The port city is located at the lower end of the Guayas River Basin, which is Ecuador's agricultural heartland. Water withdrawn at the La Toma Water Treatment Plant, which is situated by the Daule River 30 km north of Guayaquil, often contains high concentrations of fertilizers, pesticides, and eroded soil, along with other pollutants. [Salt water intrusion, which used to be a problem at La Toma, has been resolved by construction of the Daule- Peripa Dam, which is located upstream; water can be released from the dam's reservoir during the dry season, which runs from June to December, to prevent salinity problems (Castillo, 1995).]

3.04 Poor water quality in the Daule River and other streams around Guayaquil creates two sorts of costs. The first is treatment expenses. At present, the Empresa Provincial de Agua Potable del Guayas (EPAP-Guayas), a provincial enterprise, uses conventional water treatment processes, consisting of pH adjustment with lime, coagulation with aluminum sulfate, sedimentation, filtration, and disinfection with chlorine gas. The second cost, which has to do with the consumption of inadequately treated water, is incurred because the La Toma facility, with a capacity of 630,000 m3/day, is not large enough to serve Guayaquil adequately. In 1993, only 55 percent of the 2.2 million people living in the city and its suburbs were connected to EPAP-Guayas's distribution system. An additional 25 percent received EPAP-Guayas water from tanker trucks. The other fifth of the population was not served at all (Chudy, Arniella, and Gill, 1993).

3.05 Adding more treatment capacity, then, has been a matter of great urgency in Guayaquil. A new facility, with a planned capacity of 864,000 m3/day, is now being constructed alongside the La Toma plant (Chudy, Arniella, and Gil, 1993). In addition to making it possible to deliver water to that portion of the metropolitan population that currently receives no service from EPAP-Guayas, this investment ought to improve service quality for many households and businesses that are already connected to the system. Because of a lack of system pressure, residents in the southern part of the city receive water for only a few hours during the early morning hours. Even then, pumps are often required to extract water, which is often contaminated because of porous pipes.

3.06 EPAP-Guayas is being transformed into a municipal water company and merged with EMA-G. In addition, there are plans to privatize many water supply and sewerage services. But regardless of institutional arrangements, major improvements in management will be needed if investments in the potable water distribution system, sewers, and related infrastructure are to be financed and maintained. EPAP-Guayas typically bills for less than a third of its production (Subdireccion Ejecutiva de Planificacion de Guayaquil, 1995).

3.07 The authors of an evaluation of EPAP-Guayas that was carried out in the early 1990s concluded that the company was staggeringly inefficient. The population it is meant to serve suffers enormously as a consequence, in terms of water delivery that is sporadic, of low quality, or entirely non-existent.

4. Water Supply and Sanitation in Machala

4.01 If anything, the state of potable water and sewerage services in Machala and the adjacent city of Puerto Bolivar is worse than what it is in Ecuador's largest city. Raw water quality is poor, system capacity is inadequate, a large portion of potable water cannot be accounted for, and wastewater is discharged without treatment into the Gulf of Guayaquil. If these problems are to be resolved, management of the municipal water company will have to improve dramatically.

4.02 Machala's water comes from four deep wells as well as one plant, La Lucha, where surface water is treated. Well flow, which amounts to 242 liters per second (l/s), is delivered to the city without treatment since it is supposedly of high quality. The same cannot be said of the 80 l/s reaching La Lucha. After being diverted from the Jubones River, that water travels 30 km through an open canal that winds through urban areas and banana plantations. When it arrives at the treatment plant, it is turbid and high in coliform bacteria. It also carries pesticides and, on occasion, trace amounts of mercury because of artisanal gold mining and processing in the mountains east of the city. The water leaving La Lucha, which is expensive to operate and was not designed to remove the organic chemicals contained in pesticides, is not fit to drink. That plant is supposed to be closed by 1996 (I. Municipio de Machala, 1994).

4.03 Closure of the treatment plant will widen the gap between demand and supply in Machala. Whereas the former is estimated to be 1,000 l/s, current flow from surface sources and wells is only 322 l/s (see above). Of that supply, 30 l/s is removed at pump stations and delivered by tanker truck. Of the 292 l/s that enters the distribution system, at least half, and perhaps as much as 60 percent (Arniella, 1993), is lost due to leaks. Aside from commercial and industrial establishments, 98.5 thousand people ("i.e.", 62 percent of Machala's total population of 158.9 thousand) are served (I. Municipio of Machala, 1994). Moreover, as is the case in southern Guayaquil (see above), being connected to Machala's distribution system is no guarantee that water will be available when wanted. More than three-fourths of those with connections have reservoir tanks and more than one-fourth use a pump to fill those tanks or to provide pressurized water directly to the house. All but 4 percent of served households have no water pressure at one time or another during a typical day (I. Municipio of Machala, 1994).

4.04 If anything, connected households are getting what they pay for. There are no water meters in Machala and dwellings in the center of the city are assessed an annual fee equivalent to US$1.00. The situation is much different for the customers of tanker trucks, who must pay approximately US$0.50 to get a 55-gallon (208-liter) barrel filled. Since their daily consumption averages 43 liters per person (I. Municipio of Machala, 1994), a family of four can expect to spend a little more than US$300 a year for water, which amounts to a significant portion of household income in the poor neighborhoods not served by the municipal system.

4.05 It is entirely possible that the quality of water delivered by tanker trucks is superior to what connected households and businesses received. Lack of pressure in the pipeline during periods of high demand, 50 percent leakage from potable water pipes, a porous sewage system, and the widespread use of suction pumps all combine to draw sewage into the potable water supply (I. Municipio of Machala, 1994). The city has no functioning water quality laboratory and, at present, the respective contributions of poor quality of surface water sources, substandard operations at La Lucha, and wastewater intrusions are difficult to quantify. Nevertheless, it is clear that levels of coliform bacteria are excessive. It was no accident that, when cholera entered Ecuador in the early 1990s, it did so through Machala.

4.06 There is no reason for potable water supply in Machala to be the disaster that it is. The city is one of the most prosperous in the country, with a per capita income nearly three times the national average. Furthermore, construction of a regional potable water system, comprising reservoirs, a plant capable of treating 740 l/s, and pipelines, was completed in 1988. That system now supplies several communities with filtered and chlorinated water. However, Machala has never benefited, even though it was supposed to do so. The immediate problem has to do with the pipeline that was installed to deliver water to the city. Built with inferior materials, it ruptures when subjected to pressure tests. Replacing the pipeline would cost more than US$10 million (I. Municipio of Machala, 1994).

4.07 If potable water infrastructure in Machala is deficient, the city's public sewer system is practically nonexistent. Nearly half the population receives no service at all, and, at best, rely on substandard septic tanks and latrines that contaminate aquifers. Sewers serving the other half discharge into open canals that empty directly into the Gulf of Guayaquil and adjacent wetlands. Exposure to waterborne disease is high in the neighborhoods that border those canals (I. Municipio of Machala, 1994).

4.08 Unless and until households that are connected to potable water pipes and sewers begin to pay more than a negligible amount for the services they receive, the municipal enterprise that provides those services will never have the financial means needed to improve and expand the system.

5. The Health Impacts of Inadequate Potable Water and Sewerage Services

5.01 When available water is unclean, most consumers choose to employ some sort of remedial measure. The expense involved can be considerable. For example, the residents of Jakarta spend more than US$50 million each year boiling water; that amount is equivalent to 1 percent of the value of all goods and services produced in the city (Briscoe, 1993). No such estimates are available for Ecuador, though no one doubts that the costs are high.

5.02 In spite of the effort firms and households devote to boiling, filtering, or otherwise treating water, remediation often falls short of being perfectly comprehensive. When this occurs, human health suffers, as the recent outbreak of cholera in Machala and other parts of Ecuador demonstrates. Viruses that cause the common cold, hepatitis A, and meningitis, bacteria responsible for diarrhea, dysentery, typhoid fever, and cholera, and protozoa that cause various sorts of intestinal disease can all be carried in poorly treated water. Improper sewage disposal provides a virtually inexhaustible supply of the same biological pathogens. Also, poor hygiene practices, due in part to inadequate access to clean water, leads to exposure to fecally-carried pathogens. Finally, uncovered standing water is a breeding medium for mosquitos and other insects responsible for the transmission of malaria, yellow fever, and dengue (Feacham "et al.", 1983).

5.03 Available data do not indicate the full dimensions of the problem, although it is certain that waterborne diseases are the primary cause of death among children in coastal Ecuador. Numbers of cases for which medical attention is sought, which are the most readily available measure of morbidity, amount to a tiny fraction of total illness. For example, a survey of diarrheal incidence undertaken recently by the Ministerio de Salud Publica (MSP) revealed that there were at least 6 million cases a year in the country (Laspina, 1995). In household interviews carried out in the early 1990s, 19.5 percent of children under five in Guayaquil and 15.9 percent of children from the same age cohort in Quito and El Oro province were reported by their mothers to have had diarrhea during the prior two weeks (CEPAR, 1994). One survey in Guayaquil revealed that half the residents of middle and upper income neighborhoods have a parasitic infection (Martinez, 1995); estimates of prevalence in the marginal neighborhoods of Ecuador's two largest cities range from 90 to 100 percent (Martinez, 1995). Yet morbidity data show that there were fewer than 8,000 hospitalizations for intestinal infections and parasitic diseases in Pichincha province, where more than one-tenth of the national population resides (INEC, 1992).

5.04 Causes of mortality are also under-reported. Sometimes, relatives of a deceased person report the cause of death to authorities according to their own limited knowledge. Alternatively, a doctor must make a determination in the absence of a medical history. Furthermore, synergistic effects are usually difficult to capture in official reports, even though they are often very important. For example, the risk of dying from diarrhea with measles is four times that of dying from measles alone (Rutstein, Fermo, and Crespo, 1987) and parasites, while generally not contributing directly to mortality, steal vitamins and minerals from their hosts, which can lead to anemia and malnutrition (Martinez, 1995).

5.05 Official statistics, then, should only be regarded as indicators of where health risks are particularly severe. As morbidity and mortality rates reported in Table 2.2 show, exposure to fecally-carried pathogens is especially pronounced in Guayaquil, Machala, and other parts of coastal Ecuador. In those places, inadequate quantity and quality of water leads to inadvertent ingestion of sewage and associated pathogens via insect vectors, improper hygiene, and consumption of contaminated

water.

5.06 Comprehensive evaluation of the economic losses associated with impaired health is always a complicated exercise, especially when illness leads to death. Rarely is physical and emotional suffering experienced by the deceased and loved ones easy to express in monetary terms. However, income losses due to premature demise and expenditures on medical treatment can be estimated.

Table 2.2 Hospitalization and Mortality Rates by Province

	1992 Hospitalization Rate (per 10,000 inhabitants)		
	Pichincha	Guayas	El Or
infection and parasitic diseases			
- intestinal	42.02	79.15	111.57
- other bacterial	1.81	1.17	2.20
- viral	2.88	2.88	5.16
- anthropod-transmitted	1.34	3.14	10.06
- other	2.75	2.54	3.68
- nutritional deficiencies	1.93	1.98	2.64

	1993 Urban Mortality Rate (per 10,000 inhabitants)		
	Pichincha	Guayas	El Oro
infection and parasitic diseases			
- intestinal	1.34	1.97	1.96
- other bacterial	0.81	0.76	0.58
- viral	0.23	0.21	0.41
- anthropod-transmitted	0.08	0.08	0.17
- other	0.10	0.07	0.03
- nutritional deficiencies	0.98	0.71	0.89

Source: INEC (1992) for hospitalization numbers; INEC (1993) for mortality data; CEPAR (1993) for population

5.07 An estimate of the present value of income losses for an employed adult is obtained by supposing that, had he or she lived, such an individual would have earned US$6 a day working 5 days a week, 50 weeks a year, for 30 more years. At a discount rate of 10 percent, the present value of income not earned by that person would have been:

$$\sum_{t=1}^{30} (\text{US\$6} \times 5 \times 50) \times (1.08)^{-t} = \text{US\$ } 16{,}887.$$

In 1993, 377 residents of urban areas in Guayas province and 57 people living in Machala and other cities in El Oro province died because of cholera, typhoid fever, and other bacterial infections of the intestinal tract; approximately 23.5 percent of these people were between 15 and 64 years of age (INEC, 1993).

Multiplying all these deaths by the preceding measure of the present value of per capita foregone earnings yields an estimate of one, but only one, of the costs resulting largely from inadequate sewage treatment and limited access to clean water: US$7,328,958.

5.08 Identifying the costs of morbidity that does not lead to death is not much easier than assigning a price tag to premature death. Problems arise in a place like Ecuador because most cases are never reported to public health authorities (see above). Even when a fairly reliable estimate of the number of cases of some particular illness is available, the analyst is still left with the problem of determining associated losses of work effort as well as treatment expenses.

5.09 With respect to intestinal infections, one MSP official suggests that about 10 percent are recorded officially (Laspina, 1995). The total number of cases in 1992 reported in the first line of Table 2.3 are based on this information and recorded incidence for the same year (INEC, 1992). Treatment expenses, which are reported in the second line, amount to US$5 per visit for the 10 percent of all cases that result in a visit to a clinic (La Forgia and Balarezo, 1993) plus US$20 for oral rehydration therapy (ORT) for the 1 percent of all cases that require same (Margulis, 1992). Hospitalization and use of antibiotics are rare (Laspina, 1995), so the costs associated with those remedial measures have not been included in the analysis. Finally, it can be supposed, conservatively, that an average case results in the loss of one day of work, which is valued at US$6. This is the basis of the costs reported in the third line of Table 2.3.

Table 2.3 Selected Costs of Intestinal Morbidity in 1992

	Pichincha	Guayas	El Oro
total number of cases (INEC, 1992)	73,790	199,070	46,030
expense of clinic visits and ORT	US$51,653	US$139,349	US$32,221
value of lost employment	US$442,740	US$1,194,420	US$276,180

5.10 Almost certainly, the cost estimates presented in Table 2.3 under- state the total disutility associated with intestinal illness. In addition, they are probably much smaller than the costs resulting from parasitic infection in Ecuador. MSP officials report that prevalence of the latter among the country's poor is 90 to 100 percent (Martinez, 1995). Along with medical treatment expenses, which are incurred by a minority of those afflicted, school performance of children with parasites is undermined and workers' performance is impaired. To estimate the latter impact, it can be supposed conservatively that 10 percent of any given city's population is infected and that, on average, infection causes a worker to earn 25 percent less than he or she would otherwise. Using CEPAR's (1993) population estimates and assuming average daily earnings of US$6, one arrives at the cost estimates reported in Table 2.4.

Table 2.4 Selected Costs of Parasitic Infection in 1993

	Urban Pichincha	Urban Guayas	Urban El Oro
infected adults of working age	128,000	191,827	29,075
effective working days lost	8,000,000	11,989,188	1,817,188
value of lost work	US$48,000,000	US$71,935,128	US$10,903,128

5.11 It must be stressed that the preceding estimates of mortality and morbidity costs are of the "back-of-the-envelope" variety. Some important consequences of illness have not been evaluated and the respective contributions of dirty water, inadequate sewage treatment, and other causes of infection have not been specified. Nevertheless, even a simple economic analysis reveals that inadequate access to clean water and sewage services is a serious problem in Ecuador. Since provision of safe drinking water and reliable sanitation are known to result in reduced incidence of cholera, typhoid, amebiasis, and several helminthic diseases (Okun, 1988), sizable benefits would result from improving the performance of local water and sewage systems in the three cities that are the geographic focus of this report as well as in the rest of the country.

6. Policy Recommendations

6.01 For potable water supplies to be efficient, five types of costs need to be analyzed. They are:

(1) the opportunity costs of the water, including the environmental impacts on the source;
(2) the costs of storing and transporting water from the source to the treatment plant;
(3) the costs of treating the water for domestic use;
(4) the costs of delivering the treated water to the user; and
(5) the costs of disposing of the wastewater.

6.02 None of the preceding costs is fully reflected in the tariffs paid by household and industrial customers of Ecuador's municipal water companies. As is common throughout the developing world (Anton, 1993), prices have been designed to cover a portion of the second through fourth costs -- that is, the operating expenses involved in storing, transporting, treating, and delivering water. As a result, local water suppliers have come to depend on subsidies from the central government for infrastructure development and maintenance. This has tended to caused maintenance to be deferred until breakdowns in service have occurred. Moreover, the quality of service has been held hostage to political whims, the state of the national treasury, and the availability of international assistance. In a nutshell, subsidization of the second, third, and fourth costs of potable water supply has created a "low level equilibrium" for

most Ecuador's cities. As Briscoe (1993) explains the predicament, poor quality service is provided, for which consumer willingness-to-pay and thus revenues are low; as a rule, service deteriorates over time.

6.03 There is no doubt that many customers of Ecuador's municipal water companies, including the residents of poor neighborhoods, are prepared to break out of low level equilibrium. Where services are unreliable or entirely absent, people pay much more for water, either directly or indirectly, than what connection to a well-functioning municipal system would cost. For example, a family of four living in a poor part of Machala not served by the city water company must now pay about US$300 a year for water delivered by tanker truck (see above). To that cost, which represents a major economic sacrifice for such a family, must be added boiling and other in-house treatment expenses, the lost wages and medical expenditures associated with waterborne disease, or both. By contrast, a study carried out by the U.N. Economic Commission for Latin America and the Caribbean (Lee, undated) revealed that the capital, operating, and maintenance costs of providing potable water as well as sewerage services to a family of six in urban Ecuador would total no more than US$120. In other words, the potential customers of the country's municipal water companies are paying about three times what the most basic of all basic commodities should cost.

6.04 To achieve a high level equilibrium, in which consumers receive good service, are willing to pay for it, and revenues are sufficient to operate, build, and maintain the desired system (Briscoe, 1993), municipal companies have to be technically competent, financially viable, and politically independent. Almost by definition, such companies are in a position to charge and collect from customers enough money to recover capital, operating, and maintenance costs and, at the same time, are responsible for the quality of services they provide. High level equilibrium has not been reached yet in Quito. Water losses remain excessive, more than 200,000 are still not connected to the system, and monumental wastewater problems have not been faced. Nevertheless, there have been major improvements in recent years because EMAAP-Q has identified and controlled its costs, increased its revenues, and extended its service.

6.05 Another pair of prerequisites for achieving high level equilibrium at affordable prices are improved efficiency and demand management. An analysis of the costs of raw water from projects financed by the World Bank indicates that, in most cases, the unit costs of additional water from the next water-supply project is more than double the cost from existing projects (Briscoe, 1993). Forestalling the need for new water supply projects, through efficiency improvements and the reduced consumption that results when price subsidies are eliminated, provides both economic and environment benefits. Machala and Guayaquil, where municipal companies cannot account for 50 percent or more of their water, can reap major benefits from improving their distribution and billing systems.

6.06 Efficient potable water supply requires more than raising tariffs enough to recover storage, transport, treatment, and delivery costs. As is mentioned in the first part of this report, the opportunity costs of developing water for any

particular use, including household and industrial consumption, have been roundly ignored. So have the economic damages associated with the discharge of untreated wastewater. This approach is appropriate where resources are abundant and where sewage emissions do not strain water bodies' assimilative capacities. But water has become economically scarce in Ecuador and the quality of its rivers, lakes, and streams is deteriorating. Hence, the opportunity costs of developing water for any single use, including household and industrial consumption, can no longer be ignored. Neither can the damages resulting from water quality deterioration.

6.07 It appears that initial steps are being taken toward systematic internalization of all upstream and downstream costs involved in water resource development. At the national level, a Consejo Nacional de Recursos Hidricos is beginning to operate and MINDUVI is formulating a new water and sanitation policy. In addition, regional authorities, each with responsibility for a major drainage basin, are being established. For the time being, the latter are focusing on irrigation, which is appropriate in many places since most water is used for crop and livestock production. But over time, regional entities should evolve into institutions capable of analyzing and settling inter-sectoral conflicts. This would be appropriate since most trade-offs among alternative uses of scarce water resources arise and are therefore best resolved within a single watershed.

6.08 Guayaquil and Machala, which are both at the lower end of a drainage basin, could be major beneficiaries of improved basin-wide management. Because of chemical and manure run-off and soil erosion from upstream farms and ranches and wastewater emissions from upstream urban areas, both cities must now incur sizable treatment costs and put up with high incidence of waterborne disease. The case for basin-wide management might seem less compelling in Quito, which obtains its water from relatively pristine high watersheds east of the city. However, its citizens suffer because contamination of the Machangara and Monjas has resulted in the loss of the recreational and scenic values that clean rivers provide. Also, irrigating with polluted water withdrawn from those same two streams poses an indirect health risk for the national capital. Furthermore, protecting watersheds on the eastern slope of the Andes is important for preserving both their ecological values and the quality of the city's water.

6.09 Basin-wide management could impinge somewhat on agricultural water use. In order to insure adequate supplies for higher-valued household and industrial uses, minor reductions in irrigation might be required in some places during the dry season. In addition, controls on the application of pesticides and fertilizers might be put in place. On the other hand, treatment of urban wastewater would be a major boon for many rural areas. Incidence of waterborne disease would increase and there would be reduced risks of shrimp, irrigated crops, and other commodities becoming contaminated.

6.10 Once tariffs have been raised enough to cover storage, transport, treatment, and delivery costs, additional increases to cover the full opportunity costs of potable water development and wastewater disposal must be given serious consideration. The

latter increases, which should reflect the cost of developing alternative supply sources, will be needed to safeguard the environmental wealth being harnessed to provide water to Quito, Guayaquil, and other Ecuadorian municipalities.

6.11 Finally, as the goal of completely recovering all five costs identified at the beginning of this section is approached, equity considerations should be taken into account as tariffs are being set. At present, the distributional consequences of higher prices are of no great concern since improving the finances of municipal companies will make it possible to serve poor neighborhoods, the residents of which are paying a lot for water delivered by tanker trucks. In the future, a low basic tariff could be charged households using small amounts of water and high surcharges could be used where luxury uses, like swimming pools, are involved.

6.12 Education will be needed to inform citizens and the governmental decision-makers who represent them of the full costs associated with the current poor level of service and the potential benefits that would be derived from achieving high level equilibrium in municipal water systems. Such an understanding is probably essential for gaining acceptance for improved cost recovery. It should not be terribly difficult to convince people that access to safe, reliable drinking water at the turn of a tap and reliable wastewater removal and treatment are one of the best bargains any consumer can get. Ecuadorians, like anybody else, should be willing to pay a fair price for these services.

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AIR POLLUTION

by

Douglas Southgate, and Lori Lach

1. Economic Development and Emissions Sources

1.01 Although smog often increases as living standards rise and industrialization occurs, development in many places has been accompanied by the substitution of cleaner fuels, like natural gas and hydroelectricity, for dirtier ones, like wood, charcoal, and coal (Smith, 1988). Exactly this sort of substitution has taken place in Ecuador, largely because prices for electricity and petroleum have been artificially low since 1972, when the country began to export oil. Fossil fuel subsidies peaked at 7 percent of GDP in 1980. But as late as 1988, prices charged for electricity covered less than half the costs of production (Southgate and Whitaker, 1994, p. 71). It is hardly surprising, then, that fuelwood use has become rare in urban areas. Even along agricultural frontiers, where timber is plentiful, canisters containing liquified petroleum gas (LPG) are found in many farm kitchens.

1.02 While energy subsidies might have diminished pollution by stimulating a switch to cleaner forms of energy, they simultaneously affected air quality for the worse by encouraging energy-intensive industry and the use of motor vehicles. As is mentioned in a companion report on industrial air and water pollution (White with Southgate and Lach, 1995), several of the most important manufacturing subsectors in Guayaquil and Quito, such as food processing and textile and chemical production, rank high in terms of ratios of energy consumption over value added.

1.03 Industry has expanded and contracted in concert with the Ecuadorian business cycle. Meanwhile, the number of vehicles registered in the country has increased year in and year out. Growth was rapid even during the 1980s (Table 3.1), when the national economy was racked by rising real interest rates, falling international oil prices, and natural disasters. Consumption of petroleum products increased even faster (Table 3.1), in spite of gradual reductions in subsidies. Evidently, Ecuadorians were seeing fit to drive more, to purchase less fuel-efficient cars, or both.

Table 3.1 Vehicles Registered and Fossil Fuel Consumption in Ecuador during the 1980s

year	vehicles	average growth (% p.a.)	fuel consumption (million gallons)	average growth (% p.a.)
1981	256,668		176	
		3.7		4.9
1985	297,269		214	
		4.2		5.2
1988	336,638		249	

Source: Fundacion Natura (1992), p. 93

1.04 Motor vehicle numbers have continued to rise in the 1990s, in part because economic expansion has resumed and also because tariffs on imported cars and trucks have been cut. During the 1980s, duties reached 200 percent and there were import prohibitions for certain types of vehicles. By 1995, tariffs on private automobiles had fallen to 40 percent and duties on private buses and heavy trucks amounted to just 10 percent. There are no tariffs on vehicles imported from Colombia or Venezuela or on buses used for public transportation. Between 1988 and 1993, the number of vehicles in the country rose by 5.8 percent per annum, reaching a total of 450,000.

2. Exposure to Air Pollution in Guayaquil and Quito

2.01 Air quality data are scarce in Ecuador, even in its largest cities. In Guayaquil, for example, only one station where total suspended particulates (TSPs) are monitored is working, the other two facilities having closed in 1982 and 1986. TSP readings obtained at the operating station in 1990 averaged 54.7 micro g/m3 and ranged from 20.6 to 106 micro g/m3 (Fundacion Natura, 1992). These figures are within the World Health Organization (WHO) standard, 60 to 90 micro g/m3, and also the U.S. norm, 75 micro g/m3. Information for other pollutants is less complete. Jurado (1991), who has estimated that industry's average contribution to ambient TSP concentrations is 25.2 micro g/m3, has identified sulfer dioxide emissions as the most serious form of pollution from industrial sources. His estimate of the ambient concentration traced to manufacturing plants is 246.7 micro g/m3, which is above the WHO norm, 80 micro g/m3. The sector's nitrous oxide emissions, like its TSP discharges, constitute a less serious problem.

2.02 Focused exclusively on the manufacturing sector, Jurado's (1991) study does not address vehicular pollution, which accounts for most carbon monoxide, lead, and uncombusted hydrocarbons in the air. In addition, there are neighborhoods with a lot of industry where levels of sulfur dioxide, TSP, and other pollutants are high. But in general, air quality in Guayaquil is relatively good. For this, its residents can probably thank the city's location on a coastal plain as much as any other factor.

2.03 In terms of air pollution risks, Quito is in a much less

favorable position. The national capital is situated in a narrow mountain valley 2,800 m above sea level and temperature inversions are common events. As manufacturing establishments and motor vehicles have proliferated, air quality has deteriorated.

2.04 There is no doubt that car, truck, and bus numbers in Quito have skyrocketed in recent decades. Between 1962 and 1990, registered vehicles increased by 10 percent a year (Varea, 1994). That growth was approximately double the rate of population increase and exceeded the rate of income growth by a wide margin. In 1994, there were 140,000 vehicles in Quito, 134,000 of which were powered by gasoline and the other 6,000 by diesel (Puga, 1994).

2.05 An important consequence of vehicle growth has been to slow traffic on the capital city's major thoroughfares. It has been determined, for example, that the average speed of buses on "Avenida 10 de Agosto" is only 6 km/hour (Sevilla, 1995). Since those vehicles start and stop frequently and since their engines tend to be poorly maintained, they spew out large volumes of uncombusted hydrocarbons and other pollutants.

2.06 Available data do not allow the air quality impacts of increased emissions from fixed and mobile sources to be described very precisely. In October 1994, the Inter-American Development Bank (IDB) made US$1.8 million available for Quito's Red Metropolitano de Monitoreo Atmosferico, to which the municipal government is contributing US$235,000. Once in place, that system will provide specific information regarding sources of emissions as well as where concentrations of pollutants are especially high. In the meantime, the best information on air pollution is obtained through rapid assessments, such as one carried out in 1993 to justify the IDB-financed monitoring system.

2.07 Since the increase in automobile, bus, and truck numbers has coincided with a decline in the quality of Quito's air, it is widely believed that vehicular exhausts are the principle cause of pollution in the city. The findings of the 1993 assessment (Table 2), in which WHO guidelines were followed, suggest that this view is only partially correct. Cars emit virtually all the carbon monoxide, which in terms of tons per year is by far the largest component of total emissions. Also, they account for all the lead and most of the uncombusted hydrocarbons emitted. However, factories and other fixed sources discharge most of the TSP and sulfur dioxide and nearly half the nitrous oxide. Jurado (1991) has estimated that 44 percent of the sulfur dioxide and 40 percent of the nitrous oxide emitted in Quito come from textile and leather- working factories and that the food and beverage industry discharges 37 percent of total sulfur dioxide and 35 percent of total nitrous oxide.

Table 3.2 Sources of Air Pollution in Quito (tons p.a.)

	TSP	sulfur dioxide	nitrous oxide	carbon monoxide	Lead	uncombusted hydrocarbons	other
vehicles fueled by:							
- gasoline (134,000)	706	191	3,603	132,350	102	5,114	0
- diesel (6,000)	363	468	1,695	6,966	0	385	0
- fixed sources (600+)	7,170	18,707	5,023	915	0	3,233	617
total	8,239	19,366	10,321	140,231	102	8,732	617

Source: WHO-style rapid assessment conducted in 1993 and cited in Puga (1994)

2.08 The rapid assessment also revealed that there are four areas where annual discharges from mobile and fixed sources are especially high: two industrial zones in northern Quito (with combined emissions of 4,179 tons/year), the central historical district (where buses, cars, and trucks discharge 2,511 tons annually), and an industrial zone in southern Quito that accounts for 10 percent of total pollution (18,662 tons/year). These findings are generally consistent with data on TSP concentrations collected at three permanent monitoring stations. In 1991, readings at the central and southern facilities averaged 123.3 and 149.9 micro g/m3, respectively. Only at the northern station did the average reading, 58.8 micro g/m3, not exceed either WHO and U.S. norms (see above). There were seven occasions when TSP concentrations at either the central or southern station rose above 185 micro g/m3 (Arcia "et al"., 1993, pp. 60-61).

2.09 In response to a well-publicized report of elevated blood lead levels among pregnant women, newborns, street vendors, and other Quito residents (see next section), research has been undertaken to identify areas where exposure rates are especially high. In 1992, a study carried out by the Facultad de Geologia y Minas of the Universidad Central del Ecuador and the Instituto Ecuatoriano de Obras Sanitarias (IEOS) revealed that atmospheric lead concentrations in the national capital averaged 0.67 micro g/m3, but that levels in some places ("e.g.", in and around traffic tunnels) were above 7.00 micro g/m3. Concentrations appear to be lower in Guayaquil; in the later 1980s, average readings in the port city were found to be 0.49 micro g/m3 (Fundacion Natura, 1993, p. 94). Ecuador has adopted the U.S. Environmental Protection Agency's (USEPA) ambient standard, 1.50 micro g/m3, which is ten times the European Union's norm, 0.15 micro g/m3.

2.10 As reports of TSP and lead concentrations in different parts of Quito make clear, exposure to pollution varies markedly across neighborhoods and population groups. One-fourth of national

capital's inhabitants lives within 100 m of heavily traveled thoroughfares and 13 percent of the residents of marginal neighborhoods classify themselves as informal vendors, who work mainly on those same thoroughfares (Arcia "et al.", 1993, p. 61).

Without a doubt, these two segments of the population suffer more than others because of dirty air.

3. Air Pollution's Effects on Human Health

3.01 Air pollution creates a number of harmful impacts. Acidic precipitation, which is a product of sulfer dioxide emissions, damages buildings and other infrastructure. If views of snow-capped mountains and other sights are often obscured by a smoky haze, foreign tourists might decide to take their business elsewhere. But in a place like Ecuador, the most damaging consequences of air pollution have to do with impaired human health.

3.02 Inhalation of particulates, sulfur dioxide, and nitrous oxide can create or aggravate respiratory illness. Since the human respiratory system is size-selective, the effects associated with particulates depends in part on their diameter. Material less than 10 micro m in diameter is able to bypass the nasal passages and cilia and continue toward the lungs. Very fine particles, with a diameter less than 3 micro m, can penetrate all the way to the alveoli (John, 1988), thereby causing obstructions and irritations (Lu, 1991).

3.03 Because they are both byproducts of combustion, sulfur dioxide and nitrous oxide are often mixed with particulate emissions. Also, sulfur dioxide is very water-soluble and therefore is easily absorbed by the nose and upper respiratory tract, which can impair various respiratory functions (Lu, 1991). Nitrous oxide is less soluble and therefore passes through the lungs to the terminal bronchioles and alveoli, directly damaging the lung epithelium and cells necessary for gas exchange. Chronic exposure, at work for example, can lead to emphysema and decreased resistance to bacteria and viruses (Lu, 1991; WHO, 1977).

3.04 Even if precise data on human exposure to various airborne pollutants were available for Quito and Guayaquil, it would still be a challenge to quantify the resulting respiratory illness. In addition to actual exposures, synergism among pollutants and varying susceptibilities of different parts of the population would have to be taken into account.

3.05 Evidence concerning the importance of synergism is strong (Jaakkola "et al"., 1991). Ericsson and Camner (1983) have observed impaired respiratory function among children exposed to annual means of 63 to 71 micro g/m3 of sulfur dioxide and 61 to 73 micro g/m3 of particulates (Ericsson and Camner, 1983). Likewise, increased incidence of acute respiratory disease in school children and parents was reported in a community with annual means of 150 to 282 micro g/m3 of nitrite, less than 26 micro g/m3 of sulfur dioxide, and 63 to 96 micro g/m3 of

particulates compared to a control community with 56 to 113 micro g/m3 of nitrite, less than 26 micro g/m3 sulfur dioxide and 62 to 72 micro g/m3 particulates (WHO, 1977). A possible explanation for this finding is that more particulates may be successful in penetrating deep into the lungs if nitrite compromises the mucociliary clearing action of the air passages. It is important to note that many of the concentrations reported by these researchers are below the minimal levels at which exposure to an individual pollutant has been demonstrated to be harmful and also below estimated pollution levels in Ecuador's two largest cities.

3.06 Although more research is needed on the reactions of children, the elderly, asthmatics, and other sensitive populations to various sorts of airborne pollutants, it is clear that many groups are much more susceptible than are healthy adults, who are the subjects of most studies. Investigation of asthmatic individuals, for example, showed that a significant decrease in lung capacity was observed after just 10 minutes' exposure to 70 micro g/m3 of sulfur dioxide (Ericcson and Camner, 1983). That level is well below the minimum short-term exposure level, 250 micro g/m3, at which an adverse response has been reported for adults without asthma (WHO, 1979).

3.07 In Ecuador, various causes of respiratory illness are at work. Crowding, poverty, and malnutrition are common and many people must make do without adequate shelter and clothing. Quite possibly, concentrations of TSP, sulfur dioxide, and nitrous oxide that would not be considered very harmful in an affluent country may be causing significant damage in the poor neighborhoods of Quito, Guayaquil, and other places. Because of chronic under-reporting of morbidity and even mortality to public health agencies (Frederick with Southgate and Lach, 1995), available data do not accurately reflect the true magnitude of ill health. Nevertheless, the large numbers of hospitalizations and deaths officially attributed to respiratory illness, which are reported in Table 3.3, suggest that poor health caused in part by air pollution is taking a serious toll.

Table 3.3 Hospitalization and Mortality Rates by Province

	1992 Hospitalization Rate (per 10,000 inhabitants)			1993 Urban Mortality Rate (per 10,000 inhabitants)		
	Pichincha	Guayas	El Oro	Pichincha	Guayas	El Oro
- upper respiratory illness	7.81	8.03	6.30	0.10	0.04	0.03
- other respiratory illness	17.53	14.89	21.43	5.65	5.05	3.78

Source: INEC (1992) for hospitalization numbers; INEC (1993) for mortality data; CEPAR (1993) for population

3.08 By no means are TSP, sulfur dioxide, and nitrous oxide the only air pollutants that jeopardize human health in Ecuador. Although it is considered less hazardous than other pollutants (Bartone "et al.", 1994), carbon monoxide affects the

cardiovascular system, causing decreased oxygen transport and cardiovascular damage. Also, uncombusted hydrocarbons are a source of concern.

3.09 No pollutant seems to have aroused more alarm in Quito than lead. In 1991, Fundacion Natura, the country's leading environmental organization sponsored a study of 83 women undergoing normal pregnancies, 15 pre-eclamptics ("i.e.", pregnant women with high blood pressure, protein in the urine, and abnormal weight gain), and 31 of their newborn babies. Blood lead levels were found to range from 15 to 23 micro g/dl, which is higher than the 10 micro g/dl U.S. Centers for Disease Control (CDC) criterion for additional testing of children. In addition, levels for 26 children in the center of Quito and 38 children in peripheral areas were found to average 28.7 and 28.9 micro g/dl, respectively. In another component of the same study, 17 male and 59 female street vendors from central Quito, where traffic is especially heavy, were examined. On average, members of this second sample had worked in the area for 9 to 10 hours a day for 15 years and their blood lead levels were found to range from 26 to 30 micro g/dl, which is below the 40 micro g/dl CDC standard for additional testing of adults (Oviedo, 1991).

3.10 These readings are, indeed, disturbing. Lead, it must be emphasized is a potent central nervous system poison and also has adverse impacts on the cardiovascular system. An increase of 1 micro g/m3 in ambient lead concentrations is known to increase blood lead levels by 3 micro g/dl (Margulis, 1992) and levels of just 10 micro g/dl are associated with decreased intelligence, hearing ability, and growth in children. Blood lead levels of as little as 12 micro g/dl may cause hypertension in adults. Higher concentrations lead to decreased vitamin D metabolism, decreased hemoglobin synthesis, infertility, anemia, and even death (Bahr, 1993).

4. Economic Evaluation of the Health Impacts of Air Pollution

4.01 Complicated linkages between morbidity and mortality and their various causes make evaluation of air pollution's health impacts difficult. Romieu, Weitzenfeld, and Finkelman (1990) have used dose- response relationships reported in the literature to estimate excess mortality, chronic coughs in children, respiratory restricted activity days (RAD), and chronic bronchitis among the elderly resulting from the excessive TSP levels to which 81 million Latin American urban dwellers are exposed. Margulis (1992) has carried out a similar sort of analysis in Mexico City and has combined his findings with information on wages and treatment costs to evaluate morbidity and mortality in economic terms.

4.02 Evaluation of the health impacts of poor air quality is particularly important in highland Ecuador, where pneumonia, one manifestation of lower respiratory infection, is the second leading cause of death across all age groups behind cardiovascular illnesses (INEC, 1993). Arcia "et al." (1993, p. 63) have used the three equations that follow to estimate RAD, work days lost (WDL), and excess mortality (MORT) resulting each

year in Quito because TSP levels exceed the U.S. standard of 75 micro g/m3 in most of the city.

RAD = 0.00282 x 26 x [(TSP level - 75) x exposed population]
WDL = 0.00145 x 26 x [(TSP level - 75) x exposed population]
MORT = 0.00002 x [(TSP level - 75) x exposed population]

4.03 Assuming that the city's population, approximately 1,140,000 in 1990, was divided equally among its southern, central, and northern districts, we estimated RAD, WDL, and MORT in southern and central Quito for the average readings in 1991: 149.9 and 123.3 micro g/m3, respectively (see above). The results are reported in Table 3.4. To evaluate time lost from work as well as reduced productivity, WDL and RAD were multiplied by the prevailing wage rate (approximately US$6/day) and half the daily wage, respectively. Expenditures on medical services and pharmaceutical products were also taken into account. It was assumed that a single visit to the doctor, which costs US$12 counting medication expenditures, resulted from every ten WDL or RAD cases (Yamashita, 1995). The costs reported in the second and fourth lines of Table 3.4, then, equal RAD multiplied by US$4.20 (half the daily wage plus 0.10 times the average cost of medical treatment) and WDL multiplied by US$7.2 (the daily wage plus 0.10 times the average cost of medical treatment), respectively.

Table 3.4 Selected Costs of RAD, WDL, and Increased Mortality Associated with Elevated TSP Levels in Central and Southern Quito

	central	southern	total
yearly reduced activity days	1,346,000	2,087,000	3,433,000
yearly RAD costs	US$5,653,200	US$8,765,400	US$14,418,600
yearly work days lost	692,000	1,073,000	1,765,000
yearly WDL costs	US$4,982,400	US$7,725,600	US$12,708,000
yearly excess mortality	37	57	94
yearly MORT costs	US$624,819	US$962,559	US$1,587,378

4.04 Comprehensive evaluation of the economic losses associated with excess mortality, which would require analysis of expenditures on medical treatment and the physical and emotional distress suffered by the deceased and loved ones, was not attempted for this study. However, the present value of income lost due to premature demise was estimated. It was assumed that, on average, mortal victims of excessive TSP concentrations could otherwise have expected to earn US$6 a day working 5 days a week, 50 weeks a year, for 30 more years. At a discount rate of 10 percent, the present value of income not earned by that person would have been:

$$\sum_{t=1}^{30} (US\$6 \times 5 \times 50) \times (1.08)^{-t} = US\$16,887.$$

This figure, which is 23 percent of the per-death cost Margulis (1992) used to evaluate excessive mortality induced by air pollution in Mexico City, was multiplied by MORT to obtained the costs reported in the sixth line of Table 3.4.

4.05 In Guayaquil, available data and studies indicate that TSP concentrations are not excessive relative to international norms, although particulates are undoubtedly contributing to a certain amount of sickness (see preceding section). By contrast, sulfur dioxide levels in the port city are much higher than they should be.

4.06 Ostro (1994) has investigated the morbidity and mortality that result when atmospheric concentrations of sulfur dioxide exceed international norms. Referring to his research and also to Jurado's (1991) estimates of emissions from industrial sources in Guayaquil (see above), we have estimated three health impacts.

increase in premature mortality:
0.048 x (246.7 - 80) = 8.00 percent
increase in respiratory symptoms among children:
0.018 x (246.7 - 80) = 3.00 percent
increase in chest discomfort among adults:
0.010 x (246.7 - 80) = 1.67 percent

4.07 No attempt was made to evaluate the latter two categories of morbidity. In 1993, 975 people were reported to have died because of upper or lower respiratory infections (INEC, 1993). An estimate of the present value of additional income that would have been earned had that number been reduced by 8 percent is US$1,317,186, which equals 78 (8 percent of 975) multiplied by US$16,887.

4.08 Finally, we have estimated the costs of identifying, treating, and educating children exposed to lead in Quito. As Margulis (1992) did in his study of pollution damages in Mexico City, we supposed that one-half the 290,000 children under the age of ten in the Ecuadorian capital would have to be screened, 10 percent of the screened group would require follow-up EDTA testing (which generally involves a hospital stay and three follow-up visits), and that 2 percent of the same group would require chelation therapy and compensatory education. A conservative assumption was made that costs for screening (US$5/case), EDTA testing (US$30/case), and chelation therapy (US$110/case) were equal to approximately one-thirtieth of the costs for the same services in the United States (Yamashita, 1995). The resulting estimate of annual screening, testing, and treatment costs was US$1,479,000. Margulis (1992) found that 3 years of special education, costing US$153/year, would be needed for each child with blood lead levels high enough ("i.e.", 40 micro g/dl or above) to impair intelligence. Assuming that half the children requiring chelation therapy would fell into this category, we estimated that the cost involved would be US$1,331,100.

4.09 Along with the US$2,810,100 needed to helping children with elevated blood lead levels, the costs adults incur because their exposure to the same pollutant results in hypertension and myocardial infarctions should be taken into account. Although Margulis (1992) investigated these impacts in Mexico City, we concluded that currently available data do not allow for similar analysis in Quito.

5. Strategies for Controlling Air Pollution

5.01 The problem facing policy makers intent on improving air quality can be put in the context of a model of the benefits and costs of pollution abatement that is found in any environmental economics textbook.

5.02 In general, the marginal costs of abatement ("i.e.", the economic sacrifices required for a small improvement in environmental quality) increase along with the level of pollution control. It is typical, for example, for marginal costs to be extremely high as complete abatement ("i.e.", zero pollution) is approached. By contrast, initial marginal costs can actually be negative, as is depicted in Figure 3.5. This happens to be the case in Ecuador. As is explained in the companion report on industrial pollution (White with Southgate and Lach, 1995), manufacturing enterprises that adopted energy-intensive technology when energy was highly subsidized are now finding that profits can be enhanced by adopting production technology that saves energy and also reduces emissions.

5.03 Between the extremes of negative marginal costs (corresponding to abatement measures that benefit polluters) and high positive marginal costs (which must be paid in order to rid the air entirely of pollutants), a fairly broad range of positive but low marginal costs is usually encountered. For example, it has been found that poorly maintained motor vehicles account for as much as 50 percent of total emissions in Los Angeles, the United Kingdom, and other places (Anonymous, 1994). Since most of those vehicles are old and of low value, their removal from the scene would not be prohibitively expensive.

Figure 3.5 The Benefits and Costs of Pollution Abatement

(Graphics do not transfer on to the internet. Please contact the author to obtain a copy.)

5.04 The marginal benefits of pollution abatement, which are also depicted in Figure 3.5, tend to fall as environmental quality improves. Starting from the point of zero abatement, even a small reduction in emissions is likely to have a positive impact on human health, which can be worth quite a lot. But as complete abatement is approached, marginal benefits grow small, comprising minor aesthetic values for the most part.

5.05 Finding the efficient abatement level, at which marginal benefits just equal marginal costs, is a challenge since it is

rarely possible to plot out the two functions represented in Figure 3.5 with a great deal of precision. [Estimation of the marginal benefits curve is particularly difficult.] However, the immediate problem in Ecuadorian cities, where little has been done in the past to improve air quality, is more straightforward. The benefits resulting from diminished morbidity, mortality, and treatment are large (see above). As long as there are opportunities to reduce pollution at a marginal cost that is either negative or positive and small, increased abatement, which is represented by a rightward movement along Figure 3.5's horizontal axis, will be efficient.

5.06 Initiatives undertaken by the City of Quito and Corporacion OIKOS, with support from USAID's EP3 Project, represent an attempt to capture the health and other benefits associated with diminished industrial discharges of TSP, sulfur dioxide, and other pollutants at a negative cost. These initiatives are described and evaluated in the industrial pollution report.

5.07 If the owners and operators of factories and motor vehicles are left to their own devices, overall pollution will approach the level at which the marginal costs of abatement equal zero. This privately optimal outcome, which is illustrated in Figure 3.5, is socially efficient only if the marginal benefits of abatement are less than or equal to zero. But if marginal benefits are positive, net social benefits are enhanced by moving to a higher level of pollution control, increasing abatement as long as marginal benefits exceed marginal costs.

5.08 Almost surely, the positive marginal costs of reducing emissions from trucks and buses are outweighed by the marginal benefits of same. This is the implicit economic rationale for Municipal Ordinance 3120, which went into effect on 2 January 1995 and which targets large vehicles. As is reported in Table 3.2, the city's 6,000 diesel-fueled trucks and buses produce a disproportionate share of various pollutants discharged from mobile sources. This means that dealing with that subset of the capital city's motor vehicle fleet is bound to yield disproportionate human health and other benefits.

5.09 The new ordinance stipulates that heavily polluting buses and trucks are to be identified by using a device that measures exhaust opacity. Owners of vehicles with exhausts that do not meet the norm set forth in the ordinance, which is based on Brazilian and Italian standards, are subject to a fine equal to five minimum monthly salaries. Currently, that fine is worth US$160. In addition, violators face a 375,000 sucre fine (equal to US$155 at current exchange rates) and must post a "guarantia" of 1,125,000 sucres (US$465), which is approximately double the cost of making the repairs needed to bring an engine up to standard.

5.10 Quite intense in January, enforcement of the ordinance lapsed somewhat in February due to the disruptions that accompanied a border conflict with Peru. All told, nearly US$100,000 in fines, including those assessed on vehicles with damaged or absent exhaust pipes, were collected between 2 January and 3 March 1995. Future enforcement is expected to be accomplished at least in part through contracts between the municipal government and private entities, which would keep half

the fines they collect (Gomez, 1995; Sevilla, 1995).

5.11 In order to comply with the new norms for exhaust opacity, vehicle owners will have to be much more careful about vehicle maintenance. However, they are not the only parties who will have to change their behavior. Mechanics will have to tune truck and bus engines properly, which might require some training in some cases and the current practice of replacing worn-out engines with used and rebuilt units will have to be reassessed.

5.12 Also, quality control will have to improve at refineries and it might be necessary to switch to the production of a higher grade of diesel fuel. Without a doubt, better management of the multipurpose pipelines that connect the Esmeraldas and Shushufindi refineries with the central fuel distribution center at Santo Domingo will be required. Otherwise, mixing of leaded and unleaded gasolines and diesel fuels will continue to be routine. In addition, vigilance will be needed to prevent fuel haulers and retail dealers from adulterating the final product with kerosene (which is sold at an artificially low price), water, and other materials.

5.13 Once emissions from industrial facilities and diesel-fueled vehicles have been reduced, other measures need to be explored. For example, converting truck and bus engines so that they can run on natural gas merits investigation. One difficulty with conversion is that the long- standing policy of subsidizing LPG would become more difficult to sustain. Changing that policy might involve environmental costs since, all else remaining the same, fuelwood use would increase. These costs would have to be taken into account in a complete economic analysis of engine conversion, which has not yet been undertaken in Ecuador.

5.14 Finally, it should be recognized that some measures to control air pollution are likely to be very expensive. Increasing the production of unleaded gasoline is a case in point. In 1993, ICF Resources, a U.S. consulting firm, completed a detailed study of Ecuador's refinery system. In a public briefing held in Houston in June of that year, the company reported that a major investment would be required to produce unleaded gasoline at the Esmeraldas refinery. To be specific, US$490 million (in 1991 dollars) would have to be invested in a new delayed coker, a fluid cat cracker, and other equipment from 1994 through 2004. In addition, operating costs would increase because octane-enhancers that do not contain lead ("e.g.", methyl-ter-butyl ether) are considerably more expensive than what is currently being used at Esmeraldas.

5.15 Considerably less investment would be required if a partial, as opposed to a full, conversion were made to lead-free gasoline. However, the viability of this alternative depends on improving pipeline management (see above), installing separate tanks at service stations, and related measures for avoiding adulteration of unleaded fuels. Another option would be for Ecuador to export all leaded gasoline produced at Esmeraldas and its other refineries and to import lead-free fuels. However, this is bound to grow more difficult over time as global demand for the former declines. Eventually, production of leaded gasoline might well have to be phased out entirely in the country, both because of health concerns and also because newer cars cannot run on that fuel.

6. The Political Economy of Air Pollution Control in Ecuador

6.01 Improvements in environmental quality, it must be conceded, sometimes have universal support. As is discussed in the companion report on industrial pollution, there is a large number of manufacturing establishments in Ecuador that installed wasteful technology when energy and water were subsidized and that now find it economical to invest in cleaner and more efficient production processes (White with Southgate and Lach, 1995).

6.02 Many more environmental quality improvements, however, involve positive costs, and so are bound to arouse opposition from polluters, taxpayers called upon to subsidize pollution control, or other economic agents. If the marginal costs of pollution abatement exceed the marginal benefits of same, then economic efficiency is served best by the opponents of improvement. [This does not mean, of course, that efficient pollution should not be taxed.] Complete elimination of lead might be a case in point.

6.03 By no means does successful opposition to pollution abatement demonstrate that the benefits involved are less than the costs. Instead, what often happens is that organizing an effective coalition of opponents, each of whom will have to pay a high cost if the abatement measure is adopted, proves easier than organizing a coalition of proponents, comprising a large number of individuals who each stand to capture a small benefit. Current policy initiatives to control emissions from diesel-fueled vehicles in Quito could be undermined because of this skewed distribution of costs and benefits.

6.04 There is little doubt that many of the owners and operators of buses and trucks could suffer sizable financial losses because of those controls. Acting on this interest, they blocked Quito's principal traffic arteries in late 1994 to protest the municipal law that was superseded by Ordinance 3120. Their actions should be regarded as a precursor to the stronger opposition that will greet more stringent measures to reduce emissions from their vehicles.

6.05 If the per capita benefits of improved air quality are so small that few individuals find it worth their while to participate in organized support of pollution controls, then organized opposition to those controls might not be overcome. However, Dixon (1993) suggests a reason why this inefficient outcome might not prevail. He points out that individual avoidance of the damages associated with air pollution is impractical for most households. This means that, where pollution is severe, as it is in central and southern Quito for example, each household suffers significant costs, in terms of increased respiratory diseases, exposure to lead, and so forth. Provided those costs exceed the expense and trouble for a household of participating in a political initiative to implement pollution controls, it is quite possible that the coalition needed to improve environmental quality will be organized.

6.06 Inefficiencies often arise because abatement costs are concentrated and environmental improvement benefits are diffuse.

However, it is also possible for inefficient air pollution controls to be adopted because the benefits of improved air quality are, as Dixon (1993) points out, non- rivalrous. Affluent households tend to insulate themselves, by boiling water and adopting other low-cost measures, from the impacts of contaminated water supplies. By contrast, their options for avoiding airborne pollutants are much more limited, air conditioning being much more expensive and often not very effective. Under these circumstances, reducing air pollution might be more important than improving water quality (or doing something else that tends to benefit less affluent households) as far as they are concerned. If the wealthy choose to exercise their political influence consistent with their interests, there is a chance that air pollution controls might be given higher priority than measures featuring higher net social benefits.

6.07 Once all opportunities for "win-win" pollution abatement, in which polluters themselves find it beneficial to reduce emissions, have been exploited, effective and efficient policy-making will require more than a comparison of aggregate benefits and costs. As the case of emissions from diesel-fueled vehicles makes clear, the likelihood that coalitions of polluters will try to block efficient pollution control merits needs to be taken into account. Likewise, the possibility that abatement measures that create more costs than benefits will be adopted because they are favored by wealthy and influential groups merits investigation.

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INDUSTRIAL POLLUTION

by

Allen White, with Douglas Southgate, and Lori Lach

1. Introduction

1.01 In Ecuador, as in all rapidly urbanizing countries, industrial pollution represents a major threat to environmental quality, one that has to be met through improved management and technological change. Designing and implementing effective policies to diminish emissions from manufacturing plants is essential if the quality of life is not to deteriorate in the country's major cities.

1.02 It is not by chance, of course, that industrial pollution is largely an urban phenomenon. As a rule, manufacturers prefer to locate where skilled labor, dependable transportation, and reliable supplies of water and electricity are most readily available. Also, being in a large urban market hold obvious attractions. So it is that approximately 70 percent of Ecuador's industrial establishments are in Pichincha and Guayas provinces (Hoffman Jurado Sandoval, 1992). Those two provinces account for 83 percent of total value-added in manufacturing outside of petroleum extraction and refining (INEC, 1992).

1.03 Many of the industrial plants in Quito and Guayaquil rank high on the scale used by the World Bank to rate toxic intensity: the Industrial Pollution Projection System, or IPPS (Wheeler "et al.", 1991), which is similar to the International Uniform Industrial Classification System used by Ecuador's Instituto Nacional de Estadisticas y Censos (INEC). The second and third leading industries in Guayas province, chemical and plastic manufacturing and pulp and paper production, fall within the top dozen IPPS sectors. Likewise, two of Quito's leading industries, tanneries and leather-working and textiles, rank among the top seven of 37 for which IPPS ratings have been developed. Industries in the southern part of the national capital are the source of most of the district's sulfur dioxide and particulate emissions as well as 30 percent of total discharges into the Machangara River (I. Municipio de Quito, 1994).

1.04 Other burdens on the urban environment are associated with intensive energy and water use. In terms of energy consumption per dollar of value added (U.S. Department of Energy, 1991; U.S. Department of Commerce, 1991), food processing (which is Guayaquil's leading industrial sector by far), textiles, and chemicals all rank well above the average for manufacturing as a whole. Having enjoyed large energy subsidies since the early 1970s, these same industries sometimes respond to higher fuel and electricity prices with protests and lobbying. Likewise, subsectors that use water intensively, including pulp and paper,

textiles, and chemicals (Gleick, 1993), have complained about diminished water subsidies. Of late, industry is reacting to higher prices by trying to conserve energy and water. For example, tanning and textile enterprises are much more interested than they used to be in the recovery and reuse of process waters. As is discussed later in this report, various policy initiatives aimed at diminishing industrial emissions are being pursued as well. If successful, these initiatives should have a beneficial impact on human health.

2. Health Impacts of Urban Industrial Pollution

2.01 People are exposed to industrial pollutants in various ways. Within a factory, workers are put at risk when equipment maintenance is deficient, obsolete technology is used, or hazardous materials are handled without proper precautions. Surrounding neighborhoods as well as downstream and downwind populations are affected when pollutants are released into the air or water or dumped onto land.

2.02 Exposure can be difficult to characterize and quantify. Similarly, determining the ultimate effects of chemical exposure on human health is usually problematical. This is especially true when there are multiple causes of morbidity and mortality. For example, any estimate of cancer resulting from the release of a hazardous industrial chemical must take into account the impacts of smoking, diet, and other variables.

2.03 That being said, it is undeniable that human exposure to several important pollutants in Quito and Guayaquil can be traced to industrial sources. A companion report on air pollution (Southgate and Lach, 1995) documents that industry is the primary source of sulfur dioxide emissions in both cities. Likewise, concentrations of total suspended particulates (TSP) exceed international standards in Quito, mainly because of manufacturing activity. As a result, the incidence of respiratory disease is high. Industry also contributes 49 percent of nitrous oxide emissions as well as nearly two-fifths of the uncombusted hydrocarbons suspended in the capital city's airshed.

2.04 Manufacturing enterprises also are an important source of heavy metal contamination. Studies carried out in southern Quito under the auspices of the Programa de Evaluacion de la Contaminacion Industrial en el Sur (PECIS) revealed that textile and leather plants accounted for most cobalt, zinc, and nickel discharges and that most chromium and large amounts of cobalt, copper, and zinc are emitted by metal-working establishments and machinery and equipment manufacturers (I. Municipio de Quito, 1994).

2.05 Without a doubt, those industries' employees are most at risk. Inhaling chromium causes lung cancer and occupational exposure to nickel is known to be carcinogenic. In addition, large doses of copper can lead to acute oral poisoning, excessive ingestion can cause gastrointestinal distress, and occupational exposure to cobalt induces respiratory irritation (Lu, 1991). Other people are exposed to dangerous amounts of heavy metals

when there are discharges into streams that are the source of drinking or irrigation water. Estimation of this latter sort exposure tends to be imprecise.

2.06 Organic solvents, commonly used as cleaning and degreasing agents and as inputs in a wide range of industries, are another source of health risk, particularly for industrial employees. Acetone, benzene, toluene, phenol, and chloroform are among the solvents used by Ecuadorian leather and textile manufacturers and the country's chemical industry (Fundacion Natura, 1992). Inhalation of these materials can depress the central nervous system and prolonged exposure can lead to paralysis, convulsion, and even death. Several chlorinated hydrocarbons are known to produce liver tumors and lesions and may also be damaging to kidneys. Benzene, a volatile organic hydrocarbon, causes leukemia as well as decreases in blood cell production and the number of blood cells in circulation (Lu, 1991).

2.07 Data required to evaluate the sickness and death resulting from occupational and environmental exposure to hazardous metal and chemical inputs used in manufacturing and industrial emissions do not exist in Ecuador. The two most common forms of cancer in the country are of the digestive tract and abdominal cavity and genitourinary tract. In 1993, 399 urban residents of Pichincha province and 512 inhabitants of Guayaquil and other cities in Guayas province died of the former; deaths attributed to genitourinary cancer amounted to 183 and 328 the same year in urban Pichincha and urban Guayas, respectively (INEC, 1993). While some of this mortality might relate to exposure to hazardous metals and chemicals, it should be remembered that stomach cancers also result from stress-related ulcers and a diet high in recycled cooking oil; cancers of the genitourinary tract can be caused by poor hygiene and sexual activity. Obviously, lung and other sorts of cancer are linked to smoking.

2.08 The air pollution report mentioned above contains an estimate of the costs incurred in central and southern Quito because elevated TSP concentrations increase the incidence of respiratory illness: US$37.4 million per annum (Southgate and Lach, 1995). Since 87 percent of that pollution is contributed by fixed sources, the annual costs of TSP emissions attributable to industry amount to US$32.5 million. Other sorts of pollution create appreciable costs as well. In all likelihood, control of industrial emissions would create tens of millions of dollars in annual economic benefits for the citizens of Quito, Guayaquil, and other Ecuadorian cities.

3. Regulating Industrial Pollution

3.01 For more than 20 years, regulation has been the principal response of national and local governments in Ecuador to air and water pollution from industrial sources. Establishment of the legal and institutional framework for regulation began with adoption of the Health Code, in 1971. Article 28 of that law obliged factories to seek permission for pretreatment prior to discharge into any sewer system. In 1972, the Water Law was passed, which resulted in the creation of the Instituto

Ecuatoriano de Recursos Hidraulicos (INERHI). In collaboration with the Ministerio de Salud Publica (MSP), the new agency was made responsible for enforcement of Article 28.

3.02 The scope of regulation was broadened in 1976. The Law for the Prevention and Control of Environmental Contamination went into effect with the issue of Supreme Decree Number 374. An inter-ministerial commission was founded to coordinate policy and regulatory development, including the preparation of specific emissions standards. INERHI retained responsibility for setting freshwater quality standards and the Direccion General de la Marina Mercante (DIGMER) was assigned to protect coastal waters and navigable rivers. The Instituto Ecuatoriano de Obras Sanitarias (IEOS) was charged with developing standards for drinking water, wastewater, air, noise, and solid waste, and with training the inspectors needed to enforce those standards.

3.03 From industry's perspective, two features of the 1976 law are particularly noteworthy. First, an environmental impact report must be submitted to the MSP for any project that might result in pollution. Second, violations of emission standards are punishable by up to three years of imprisonment and a fine of up to 50,000 sucres (worth US$2,000 in the middle 1970s, but now less than US$25), depending upon the severity of the violation.

3.04 Despite the establishment of an institutional framework and the assignment of responsibilities for the setting and enforcement of standards, 13 years were to elapse before specific standards would be promulgated. Other than to make possible some sporadic efforts by various local governments to require polluters to characterize wastewaters and to report on treatment (Santana, 1989; Fundacion Natura, 1993), the 1976 law has had little effect.

3.05 In 1989, a new Regulation for the Prevention and Control of Pollution of Water Resources was adopted. A technical commission, in which IEOS, INERHI, and DIGMER were represented, was established and standards were set for industrial, agricultural, and six other water uses. Treatment standards for discharges from industry and public systems were to be enforced by IEOS.

3.06 The 1989 regulation requires each polluter to submit a plan to IEOS comprising three parts: (1) characterization of wastewater, production processes, existing control and treatment, current and anticipated production levels, and receiving water bodies as well as development of a plan for meeting standards; (2) implementation of treatment procedures; and (3) compliance monitoring. The MSP grants a provisional discharge permit upon completion of necessary treatment studies and a final permit once water quality standards have been met. The 1989 regulation also provides for periodic inspections by IEOS, INERHI, and DIGMER as well as sanctions for noncompliance, including plant closure and fines consistent with the 1976 Law. Plants can be relocated if it is impossible to comply with discharge standards. In addition, discharge fees, based on volume, biological oxygen demand (BOD), toxic content, and other factors, can be assessed.

3.07 After six years, this most recent regulatory initiative at the national level has had a minimal impact on industrial

discharges. The Centro de Investigaciones Universitarias de la Universidad Laica reports that, of the nearly 300 industrial plants in Guayaquil, only 27 have bothered to apply for provisional discharge permits and that in no case have standards actually been met (El Puerto, 1994). Poor enforcement is attributed to the limitations of responsible agencies, an unaware citizenry, and even outright bribery. Industry representatives have complained that regulators are biased against certain sectors, like food processing, and in favor of others, like government-owned facilities (Fundacion Natura, 1993).

3.08 Though their impacts have been minimal, water pollution regulations have been more effective than regulatory controls on air pollution. Guayaquil's experience with La Cemento Nacional, Ecuador's leading concrete producer, is a case in point. For half a century, that enterprise has been a major source of TSP in the city. However, the most that has been done to date has been a call by the Mayor to carry out an environmental audit (Hoy, 1994).

3.09 With national regulatory initiatives having failed to yield major improvements in environmental quality, a few local governments have decided to act on their own, as the national Law of Municipalities allows. Cuenca, a medium-sized city in southern Ecuador, is doing so with financial assistance from the Inter-American Development Bank (IDB). In 1992, Quito's municipal government assumed responsibility for water and air pollution within its jurisdiction by passing Ordinance 2910 ("Prevention and Control of Water and Air Pollution").

3.10 Although it parallels the 1989 regulation, the local ordinance is distinctive in several important ways. First, air quality standards are written directly into the latter, with limits established for seven pollutants from fixed and mobile sources: settled particulates (expressed in mg/cm2), TSP, sulfur dioxide, carbon monoxide, ozone, nitrous oxide, and lead. Second, the local ordinance spells out a procedure for registering facilities and submitting compliance plans. [In practice, the maximum time period allowed to bring any given facility into compliance -- one year -- has proven to be too short and is currently under revision.] Third, a literal reading of the ordinance suggests that sanctions for noncompliance are strict and aggressive. For example, a plant can lose its operating permit if it exceeds discharge standards and can be relocated if there is insufficient space for treatment infrastructure. Monetary penalties are not mentioned, but presumably those contained in the 1989 regulation remain applicable. Three years after enactment of Ordinance 2910, business and the municipal government have come to agree that the role of incentives for compliance (including tax allowances and low-cost financing for pollution control infrastructure) as well as penalties for noncompliance merit immediate attention (Lozano, 1995).

3.11 It is fair to say that considerable progress has been made toward establishing the basis for effective regulation of industrial pollution in Quito. In a pilot project, in-depth assessments of 30 enterprises in the city's southern manufacturing district amount to informal materials balance studies that allow the municipal government to determine sources,

volumes, and hazards of pollution for the entire zone. But even in the national capital, which has the most capable city government and many of the most advanced manufacturing plants in Ecuador, implementation of local controls on air and water pollution has been hampered by limited budgets, shortages of qualified personnel, and scarce laboratory capacity. As a result, compliance with Ordinance 2910 has been less than complete. No more than half of the medium-sized industrial facilities and 70 percent of the small plants that should register have actually done so; approximately 10 percent of the city's large factories have failed to register (Gomez, 1995; CAAM, 1995). Noncompliance with allowable emissions standards also is substantial. Based on a sample of industries in the southern industrial district of Quito, noncompliance rates are as follows: 29 percent for metals, 33 percent for sediments, 50 percent for BOD, 92 percent for suspended solids, and 100 percent for chemical oxygen demand (COD). Data for combustion units tell a similar story: 64 percent noncompliance for ovens, 89 percent for diesel boilers, 94 percent for bunker-fueled boilers, and 100 percent for wood- fired boilers and incinerators (I. Municipio de Quito, 1994).

3.12 Disappointing as these noncompliance rates might be, they still compare favorably with what regulators at the national level have been able to accomplish since the 1970s. It is possible that the transfer, in August 1994, of various responsibilities from IEOS, which has been disbanded, to the new Ministerio de Desarrollo Urbano y Vivienda (MINDUVI) might lead to the development and implementation of effective and viable policies for the control of industrial pollution. Certainly, this is desirable, if for no other reason than to prevent a few local governments from competing for private investment on the basis of lax environmental standards.

4. Beyond Regulation: Accelerating the Adoption of Cleaner Technologies

4.01 Although there is some degree of confusion on the subject, there seem to be at least 30 national laws governing the management of water resources (CAAM, 1995). The number of laws that potentially apply to air pollution and other environmental problems also is high. As has been recognized at the highest levels in Ecuador (CAAM, 1993) and in other countries (White, 1991), the mere existence and lack of codification of so many legal arrangements, none of which comes close to being fully enforced, gives rise to both confusion and, more importantly, a loss of credibility in government's ability to consistently and fairly manage Ecuador's industrial pollution.

4.02 There is an alternative to the "command and control" approach that has become entrenched in the United States and other countries but has failed to take root so far in Ecuador. The alternative consists of working closely with private industry through voluntary partnerships and programs to identify cost-effective pollution prevention (P2) measures. This approach, which involves assessments of the use of energy and chemicals to identify waste prevention opportunities, has been

applied successfully by Quito's municipal government in a pilot program carried out in an industrial district, El Inca.

4.03 What P2 involves is illustrated by the case of an enterprise in Guayaquil that manufactures non-ferrous metal products and ceramics. During the last two years, it has invested approximately US$1.5 million to upgrade burners, replace pumps, recover salable byproducts from tile cuttings, and switch to chemical additives that are environmentally preferable according to the U.S. vendor. These innovations, which reduced energy consumption as well as the volume and toxicity of process wastewaters, had nothing to do environmental regulations, subsidies, or tax breaks. Neither were they motivated primarily by the environmental consciousness shared by some members of the professional and managerial staff. Instead, reengineering and yield enhancement was undertaken to improve the firm's competitiveness in a marketplace that is moving, slowly perhaps, toward free trade. For this company and many others in Ecuador, the need to avoid waste of energy, water, chemicals, and other inputs is blurring the distinction between technological change aimed at reducing pollution and innovation aimed at containing costs.

4.04 Identifying P2 measures that are profitable for polluting firms to adopt is the central thrust of USAID's Environmental Pollution Prevention Project (EP3). More than thirty pre-assessments have been carried out in Ecuador with EP3 support. Of that number, eight have been selected for more thorough assessment based on a high likelihood that ways will be turned up to prevent pollution at a negative cost for the participating firms. For example, a complete audit of an Ambato tannery has uncovered eleven P2 measures that resulted in significant short term cost savings.

4.05 Hirschorn and Associates (1994) have investigated opportunities for the adoption of profitable P2 technology in developing countries where USAID is active. Many of the industries where such opportunities were found to be present are prominent in Quito and Guayaquil. These include textiles, leather tanning, metal finishing, paper, and vehicle repair and maintenance. One electroplating firm cited in the study realized annual cost savings of US$20,000 by adopting eighteen P2 measures that cost approximately US$6,000. Application of eleven such measures at a sheep tannery cost US$22,000 and yielded savings of US$95,000 per annum.

4.06 Adoption of profitable P2 technology is never instantaneous and automatic. Right now in Ecuador, high capital costs can be a hinderance since nominal interest rates, which have approached 60 percent in recent months, exceed annual inflation (25 to 35 percent) by a wide margin. It is significant that the Guayaquil company mentioned above was able to self-finance the entire US$1.5 million investment required for reengineering and yield enhancement. This option is not available to many firms with a potential interest in P2.

4.07 The same company enjoys other advantages that put it in a position to adopt cost effective measures for preventing pollution. Its professional and managerial staff is familiar with advanced manufacturing technology, in part because of long

term training in the United States. Furthermore, it has put in place the accounting systems needed to keep track of costs, generally, and materials, specifically. As a result, the firm is in an excellent position to identify and take advantage of any and all opportunities to lower costs, through the adoption of P2 measures for example.

4.08 As increased macroeconomic stability is achieved in Ecuador, nominal and real interest rates should fall, thereby facilitating the investments required for reengineering and yield enhancement. Also, demand for skilled engineers and managers ought to increase as economic liberalization proceeds and growth accelerates.

4.09 Something that USAID can do to promote P2 is to help firms put in place the systems for materials and cost accounting needed to make rational choices regarding technological adaptation (White, 1993; Savage and White, 1995; Todd, 1994). More often than not, waste and misallocation of energy, water, and other inputs occurs because costs are lumped together in general overhead accounts or because they simply go unrecognized in the accounting and capital budgeting process. Waste disposal, regulatory compliance, licensing and permitting are examples of the former. Liability (where applicable), loss of markets owing to noncompliance with international environmental management standards, and revenues foregone by failing to capture salable byproducts are examples of the latter.

4.10 It must be conceded that many P2 measures involve positive, as opposed to negative, costs for polluting firms. Where this is the case, human capital formation, macroeconomic stability, and technical assistance will not usually suffice to achieve socially efficient improvements in environmental quality. Public policy must be structured in ways that assure that pollution is reduced, through the application of P2 technology or other means, whenever public health and other benefits exceed costs. The policy instruments that can be employed to achieve efficiency are examined in the next section of this report.

5. Policy Options

5.01 Regulation's lack of success in Ecuador probably benefits the country in one sense, which is that a legal and bureaucratic culture oriented toward controlling pollution at the "end of the pipe" ("i.e.", after it has been generated) has never been established. Where such a culture is in place, controls frequently accomplish little more than to shift pollution from one medium to another. For example, disposal of the solid wastes that is collected by legally mandated filters and precipitators may worsen groundwater pollution if those wastes are dumped in poorly constructed landfills. To avoid this sort of outcome, the general thrust of public policy should be to prevent waste generation in the first place.

5.02 As is indicated in the preceding section, polluting firms sometimes benefit from adopting P2 measures. Donor agencies, public institutions, and nongovernmental organizations have a role to play in facilitating this sort of technological change,

by providing training and technical assistance. Where macroeconomic policy distortions have suppressed efficient financial intermediation, a revolving fund to finance P2 investment could be set up. At best, though, this should be regarded as a stop-gap that is no longer needed once the policy reforms needed for macroeconomic stability have taken effect.

5.03 One way to promote the adoption of P2 technology that is costly for the firms involved is to offer financial inducements. Income and property tax deductions, tax exemptions, accelerated depreciation, and subsidized loans can be offered for equipment and machinery that reduces pollution. Under Ecuador's Mining Law, incentives of this sort already exist for the country's extractive industries. As has been emphasized already, priority should be given to investments that prevent pollution, as opposed to controlling it. Among such investments are those resulting in the replacement of hazardous materials with more benign substitutes, process redesign and optimization, product redesign, as well as materials recycling.

5.04 Although many firms would express a preference for tax breaks, low-interest loans, and other positive incentives, subsidies can be difficult to administer. Applicants must be screened efficiently. In addition, incentives can lead to excessive entry into a polluting industry if they are not limited to existing firms. Almost always, credible charges are levied that the incentives scheme favors some firms or industries and places others at a disadvantage.

5.05 One way to reduce pollution while maintaining a "level playing field" for all firms and industries is to make regulations fairer and more effective. In Ecuador, this involves improved compliance plans, better management and disclosure of information, and updating penalties.

- Compliance Plans. Consistent with existing provisions of the 1989 Regulation, a more detailed protocol should be developed for (1) defining individual processes within facilities and (2) performing materials accounting for each process. The objective is to disaggregate production into component parts so that inputs and waste byproducts become more transparent to the firm. This allows for more effective targeting and prioritization of pollution prevention and process optimization initiatives. At the same time, protocols should be established so that Total Cost Assessment (TCA) methods developed by the U.S. Environmental Protection Agency (USEPA) or substitute techniques aimed at proper identification and allocation of the true costs of pollution control can be applied.

- Information Management and Disclosure. A management information system needs to be developed to compile, analyze and publicly report current figures and trends in emission, effluents, and solid/hazardous wastes. The purpose is to provide government, industry, and the public a perspective on pollution progress. This can build on the approach used in the PECIS study while providing a repository for information submitted in the compliance plans. For the first three years, data should remain reported only in aggregated form, leaving open the possibility of facility-specific information disclosure in the following years. Data should allow evaluation of P2 progress at the facility

level.

- Penalties. The penalty provisions of the 1976 Law and 1989 Regulation need to be reviewed and updated. This is already underway in Quito. Penalties should be commensurate with the severity of the violation from the standpoint of environmental damages. Allowance should be made to reduce or waiver penalties provided that certain prescribed P2 measures are undertaken by the noncomplying facility.

5.06 In recent years, the "polluter pays" principle has won wide acceptance as an instrument of environmental policy in a number of countries. For emissions to be reduced to an economically efficient level, charges paid by polluters should reflect marginal damages ("i.e.", the disutility associated with disease and other impacts resulting from the last unit of pollutants discharged). In practice, this is difficult to accomplish, given the difficulties involved in estimating pollution costs. However, there is no reason why a public authority cannot set fees high enough to cause polluters to stop emitting TSP or lead, for example, in areas where those contaminants have been linked to high incidence of morbidity and mortality. Such fees should be designed to foster pollution reduction and can be a highly effective tool for reaching any given ambient environmental standard.

5.07 Although many polluters can be counted on to balk at a proposal to impose emissions charges, some manufacturers will probably prefer them to subsidies and regulations. Charges, it should be remembered, comprise a clear signal that, with proper enforcement, apply equally throughout an industry, city, or country. By contrast, subsidies and regulations are often not applied in an even-handed manner. Support for charges, particularly among more efficient enterprises, can easily be enhanced by substituting them partially for income taxes.

5.08 Regardless of the relative emphasis placed on economic incentives, regulations, and emissions charges, an improved inspection system will have to be put in place. It might be appropriate to form a commission to review and make recommendations for restructuring the inspection system. This group, comprising representatives of government, the private sector, nongovernmental organizations, and the general public, should review all aspects of current inspection practices in Quito and Guayaquil including frequency, quality, results, type and timing of actions taken after inspections, and compensation of inspectors. The commission should also consider the effects of merging IEOS into MINDUVI and creating the new Consejo Nacional de Recursos Hidricos. Options for organizational and financial changes to upgrade the quality of inspection should include privatization of the function and incentives-based approaches to maintain its quality and integrity. The commission should complete its work within one year.

5.09 USAID can and should provide technical assistance and training to support improved regulations, application of the polluter pays principle, and other environmental policy initiatives in Ecuador. Consistent with EP3, it can also help to strengthen alliances among government, the private sector, and nongovernmental organizations aimed at preventing pollution.

- Voluntary Programs. The public and private sectors should be involved in the design and implementation of a voluntary program to spur pollution reduction beyond compliance levels. This may include listing chemical, energy-efficiency, and water-efficiency targets. Facilities would agree to make best efforts to reach such targets within a prescribed period of time. Lists of participating firms would be publicly available, as would progress evaluations.

- Training and Information Exchange. Programs of training in pollution prevention and clean technology should be designed and implemented for specific industries ("e.g.", wood products, textiles, "etc.") and for specific cities. Priority should be given to assisting firms in complying with national and municipal laws and regulations. This should include both the technology and hardware aspects as well as the management and software side. The latter should include, for example, orientation to methods of life-cycle analysis, total cost assessment, total quality management. Industry environmental leaders should be recruited to explain the application of "best practice" guidelines.

- Demonstration Projects. Government and the private sector should collaborate to identify innovative technologies with special promise in Ecuador and also to set up pilot demonstrations. This sort of initiative should be aimed at reducing the risk of major process and material changes that individual firms would be reluctant to undertake on their own. The focus should be on technology adaptation for generic processes used by multiple industry sectors ("e.g." cleaning, degreasing, coating, and soldering). To participate, a facility must agree to rigorous monitoring and costing protocols, and to share the results with interested firms within and outside its sector. Initial and continuing results of the demonstration should be disseminated through trade associations.

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MUNICIPAL SOLID WASTE

by

John Strasma, with Douglas Southgate, and Lori Lach

1. Solid Waste Generation in Urban Ecuador

1.01 The amount of trash that the residents of Ecuador's cities throw away is about what one would expect, given prevailing consumption patterns and standards of living. A survey sponsored by the country's leading environmental organization revealed that, on average, urban households generated 0.54 kg/day/capita of solid waste in 1990 (Landin "et al.", 1993). In Guayaquil, the average disposal rate was 0.62 kg/day/capita (Landin "et al.", 1993, p. 30). In southern and northern Quito, average rates for households as well as small businesses are 0.42 and 0.49 kg/day/capita, respectively, while in the central part of the city the average rate is 0.74 kg/day/capita due to the large number of day visitors (EMASEO, 1995, pp. 45-63).

1.02 These estimates are plausible in light of patterns of household solid waste generation in other Latin American cities. Citing Pan American Health Organization (PAHO) data, Landin "et al." (1993) report rates for four major urban areas: about 0.5 kg/day/capita for Lima and 0.8 to 0.9 kg/day/capita for Buenos Aires, Rio de Janeiro, and Mexico City. In Wisconsin, where standards of living are much higher, household solid waste generation averages a little more than 1.0 kg/day/capita (Strasma "et al.", 1995, p. 2).

1.03 In addition to household garbage, significant quantities of solid waste are generated by manufacturing enterprises, public and private sector institutions, and commercial establishments. Landin "et al." (1993, pp. 41-42) estimate that daily industrial solid waste generation is between 360 and 420 tons. Guayas province, where Guayaquil is located, and Pichincha, which is Quito's province, generate the most industrial waste: 174 and 126 tons/day, respectively. Much of these amounts consists of industrial scrap that never reaches a landfill because it is recycled or sold as a byproduct.

1.04 Many industrial firms make their own arrangements for hauling refuse to landfills. By contrast, practically all waste from government buildings and commercial establishments (including restaurants, small stores, and so forth) is collected and transported along with household garbage. There are special daily collections from public markets.

1.05 Garbage from hospitals, airports, and seaports is supposed to be handled differently. Quito once had a special truck to pick up medical waste from sixteen hospitals and clinics; unlike other vehicles, it did not compress the waste in order to avoid

breaking bags and other containers. However, that truck is not working, so medical refuse is now hauled to municipal landfills in the same packer vehicles that pick up from households. Also, the incinerator at the city's international airport is out of order, so wastes from airplanes, which total approximately 1,400 tons per week, are handled the same as trash from other sources. This is inconsistent with international agreements and national law, which mandate prompt incineration of wastes from flights and ships arriving from other countries.

2. Health Impacts of Deficient Solid Waste Services

2.01 Adequate solid waste collection and disposal may not be as important for human health as access to potable water and sewerage services is. However, trash accumulating in ravines and vacant lots in poorly-served neighborhoods undermines property values and therefore discourages the investment needed to improve those neighborhoods. Moreover, deficient collection and disposal can lead to disease. Solid wastes with high organic and moisture contents can serve as a breeding place for insects, a reservoir for bacteria, and a source of food for vermin. Furthermore, human exposure to toxic substances can result because of leaching from landfills, uncontrolled incineration, and improper handling of medical and other special refuse.

2.02 Solid wastes are often a breeding ground for insects that spread malaria, dengue fever, yellow fever, typhoid fever, and bacillary dysentery, among other illnesses (Benenson, 1990). In addition to serving as disease vectors, flies and mosquitos facilitate transmission by biting and stinging people. Scratching due to scabies or a mosquito bite, for example, abrades the skin, thereby providing an opening for the invasion of bacteria and viruses. Solid waste of high organic content is likely to be teeming with such organisms. Salmonella (the cause of typhoid and paratyphoid fevers), shigella (responsible for bacillary dysentery), and other fecally transmitted pathogens are abundant in many of Ecuador's urban neighborhoods due to poor sanitation and lack of adequate water supplies.

2.03 Vermin attracted to garbage for food and refuge provide another route for pathogen transmission. Rats, cats, dogs, and other mammals can spread disease in two ways. As sources of fleas and lice, they may aid in the transmission of "Rickettsia prowazekii" (responsible for typhus fever), "Yersinia pestis" (the cause of plague), and "Trypanosoma sp." (responsible for Chagas' disease), although disease-causing agents must be present in the population or environment first. They can also be direct vectors for the transmission of Shigella and viruses causing rabies (Benenson, 1990). Cats can be carriers of the virus causing toxoplasmosis, which apparently results in hundreds of miscarriages and birth defects ("e.g.", blindness) each year in Guayaquil (Martinez, 1995). Seagulls, pigeons, and other birds are less of a threat, but their droppings contain Cryptococcus, which can cause respiratory infection when inhaled (Benenson, 1990).

2.04 Improper disposal of solid wastes may also expose human populations to toxic materials. Burning of plastics, for example, can release chlorinated hydrocarbons into the air. Landfill leachate contains harmful organic compounds as well as heavy metals. When it reaches streams, rivers, or groundwater bodies used by households or farms, human exposure can result (Pffefer, 1992).

2.05 Likewise, improper disposal of medical wastes may increase the public health threats posed by infectious disease organisms. Some pathogens, like Human Immunodeficiency Virus, are relatively frail and are not likely to survive in the ambient environment. But others, such as Hepatitis B, can withstand harsher treatment. Illness and even death can result if wastes from hospitals and clinics where the victims of these diseases are being treated are collected, transported, and disposed of in the same manner as commercial and household trash. As is mentioned above, this is the prevailing pattern in Ecuador (Suarez "et al.", 1992; Barzallo, 1995).

2.06 One option is to burn medical wastes. One hospital in Quito and three in Guayaquil have incinerators. But only one of the four is operational (Suarez "et al.", 1992) and it should be kept in mind that incineration carries health risks as well. Recent investigation in the United States reveals that the burning of medical wastes releases dioxin (2,3,7,8-TCDD), which is carcinogenic and fetotoxic (USEPA, 1981), into the air (Federal Register, 1995).

2.07 Existing data do not allow for estimation of the public health impacts of inadequate solid waste collection and disposal. Collection crews and people who scavenge at landfills are most at risk since they come into direct contact with bacteria and viruses. Risks are also significant for those who live close to carelessly managed dumps or who reside in crowded areas where collection services are lacking. In addition, the general public may be threatened because medical and hazardous wastes are collected and buried together with other garbage.

3. Models of Solid Waste Collection and Transport

3.01 In Guayaquil, Machala, and Quito, there are three very different organizations for collecting and hauling solid waste. Each represents an effort to improve on traditional systems, in which these services were provided by municipal agencies that were subject to political interference and complex bureaucratic rules. Each of the new arrangements has supporters and detractors. Limited observation in the three cities leads us to conclude that funding and the political support behind management may be more important than formal organizational structures.

3.02 Guayaquil: A City Contracts Out, With Some Success. In the late 1980s, trash collection broke down completely in Ecuador's largest city (Ohnesorgen, 1990). Once the group of politicians responsible for this and other municipal service failures was voted out of office, Guayaquil was divided into two zones and a local private firm was hired to operate in each zone.

Contractors were paid monthly lump sums for collecting and disposing of wastes generated in their respective zones.

3.03 A new scheme was put into effect in 1994, when the city government auctioned contracts to collect garbage in the two zones to the lowest qualified bidders. The auction variable was price per ton hauled to the city landfill, rather than a monthly fee for operating in a specific area. Various international and local companies competed, offering US$25 to US$40 per ton for the most part. The winning bid, which was submitted for both zones by a partnership of local investors and a Canadian firm, was only US$9 per ton.

3.04 The new system has been functioning since late last year and the quality of service, which is monitored mainly by city staff stationed at the landfill, seems to be good thus far. Some experts and many rival bidders predict that the Canadian-Ecuadorian partnership will lose money. Close supervision by the city government is being urged.

3.05 The case can indeed be made that the low bid reflects inexperience. For instance, trucks and tires are lasting half as long in Guayaquil, in a two-shift operation, as they do in Canada, where one-shift operations are typical. Trucks have an expected life of about 15,000 hours of service, whether they run four hours a day or 14 hours a day, and they must be depreciated accordingly. Just as municipal solid waste services in all three of the cities examined in this report have not been setting aside depreciation charges, the private operator may find itself in an awkward position, about three years into the seven-year contract, when trucks need to be replaced but there is not enough money to do so.

3.06 That being said, it must be recognized that companies sometimes try to break into international operations by bidding "strategically." That is, they offer a low price, knowing they won't make a normal profit, just to be sure they get a contract. The Canadian partner, for example, has no previous experience in Latin America. It has bid already on contracts in Colombia and intends to compete for others. Good service in Ecuador raises its credibility in nearby countries and it may be able to capture scale economies in purchasing, management training, and so forth by doing business in Guayaquil.

3.07 It is also true that US$9 per ton might not be an entirely unrealistic price. True, collecting garbage a bag at a time in residential areas is very expensive. However, the bid price is probably an accurate reflection of the lower expenses of emptying full containers at markets and factories. It is significant that the Canadian-Ecuadorian contractor has a senior engineer and two secretaries busily promoting new business from large generators. They call on supermarkets and factories, which are currently hauling their own waste, and point out that the City of Guayaquil would provide that service free, just as it does to households and small stores. All the contractor asks is that the factory or supermarket invest in a dumpster or container. The contractor will then call daily or whenever the container is full. This arrangement gives the contractor tons of waste at a relatively low cost.

3.08 Efforts to win business from large generators seem to be having an effect. Whereas the municipal government expected the contractor to haul 1,200 tons/day to the city landfill, actual deliveries have averaged nearly 1,600 tons/day. The government is probably not losing money since, in all likelihood, deliveries multiplied by the US$9 fee are less than the 12 percent surcharge on electricity bills that finances solid waste collection and street cleaning (see below). Moreover, large waste generators are being served well.

3.09 Once Guayaquil's experiment with the contracting of solid waste collection and transport has run for a year or so, the data needed for financial evaluation ought to be available. An evaluation should reveal whether a price change is needed for the Canadian-Ecuadorian partnership to earn a normal profit. Also, consideration should be given soon to an alternative bidding regime in order to strengthen incentives to operate in marginal neighborhoods, which currently receive poor service. Such a regime should be implemented well before the current seven-year contract is re-bid.

3.10 Quito: An Autonomous Entity Makes Progress, But It's Not Easy. Steep hills, narrow streets, and financial problems pose huge challenges for any provider of solid waste services in the Ecuadorian capital. These challenges have been faced since early 1994 by the Empresa Municipal de Aseo (EMASEO), which was created to replace a city department.

3.11 The degree to which EMASEO is truly an autonomous enterprise remains an open question. Its board of directors comprises the mayor, the chiefs of two city departments, a city council member, and an employees' representative. Since the departmental heads answer to the mayor in all other matters, the latter individual dominates the board and can easily influence purchasing, personnel, and other decisions. EMASEO's capacity to function autonomously is also circumscribed because it is subject to many of the bureaucratic controls applied to its predecessor and throughout the public sector. For example, firing a worker is all but impossible unless he or she is caught engaging in theft, bribery, or some other crime. Also, EMASEO gets regular visits from the Contraloria General del Estado, which audits all state agencies.

3.12 No serious conflicts between EMASEO and its board have been reported to date. The general manager, who has considerable experience in the construction business and who ran Quito's autonomous sewage company for five years, is close to the mayor, who appointed him. He is mainly preoccupied by financial matters. Whereas a 12 percent surcharge is levied on electricity bills to pay for solid waste services in Guayaquil, the surcharge is only 10 percent in the national capital. According to EMASEO's manager, labor, fuel, and maintenance costs have risen more rapidly than surcharge revenues have done in recent years; in 1995, the company will have an operating deficit.

3.13 Financial difficulties make it difficult for EMASEO to expand service. The percentage of households served is higher in Quito than in Guayaquil, in part because more innovative approaches have been applied in the former city. For example, small side-loading trucks have been acquired from Japan to serve

poor neighborhoods, which are hilly and have narrow streets. These trucks are being operated under contract with micro-entrepreneurs. To extend this model to other parts of the city currently receiving inadequate service, every opportunity to reduce the cost of collecting and disposing solid wastes will have to be exploited fully. This might require additional modification of institutional arrangements. Almost certainly, it will involve developing alternatives to hauling large volumes of garbage great distances to a new landfill, located 45 km north of central Quito. These alternatives are examined later in this report.

3.14 Machala: A Traditional City Department Hopes To Change. As in Quito, Guayaquil, and other Ecuadorian cities, garbage collection and street sweeping in Machala have been the responsibility of a municipal department, which also happens to issue operating licenses to stores, restaurants and bars, and so on. The department's 100 or so unionized employees, who operate three packer and three dump trucks, have been picking up garbage at curbside on routes that cover half the city. This service is provided every other day. The rest of the city, consisting mostly of squatter settlements scattered along and over canals and swamps, has received no service whatsoever.

3.15 The city council recently approved an ordinance that authorizes the creation of an autonomous enterprise, wholly owned by the city government, that will pick up and haul away solid wastes. One option for the new entity would be to operate exactly as the municipal department has done in the past, collecting garbage entirely on its own. However, it also has the prerogative to contract those services out to private firms or persons.

3.16 For the time being, no changes will be made in that half of the city currently receiving curbside service. But in squatter neighborhoods, where most roads are too narrow for a truck to pass, trash is to be picked up from households and carried out to transfer points by tricycles with a 1-m3 box. At the transfer points, packer trucks, operated by five-person crews, are to retrieve what the tricycle operators have dropped off on the ground.

3.17 The original proposal was for tricycles to be owned and worked by micro-entrepreneurs living in squatter neighborhoods and recommended in some way by their respective communities. Beyond providing collection services, those individuals were expected to encourage people not to litter and to present their trash in plastic bags. A commercial bank stood ready to finance the tricycles, with three-year loans to be paid off with a monthly deduction from fees paid by the contracting enterprise for services rendered.

3.18 By late 1994, the issue of how exactly to contract tricycle owner-operators was still being debated. Per-kilo payments could have been offered. Alternatively, compensation could have been based on keeping a particular area clean. Resolution of this issue, and others related to the involvement of micro-entrepreneurs, has been deferred. Because of the border conflict with Peru, in early 1995, banks cut back on new loans and raised interest rates dramatically. In addition, the USAID-funded

engineers and Peace Corps volunteers who were advising on implementation of the scheme had to be withdrawn for a while.

3.19 However, tricycle pickup in squatter settlements held obvious advantages, so Machala's director of public services arranged for two tricycles to be bought and four casual laborers to be hired. Four areas are receiving service every other day from a tricycle manned by a two-man crew. [Experience shows that two people are needed to push a fully loaded tricycle.]

3.20 Two factors appear to be contributing to the success of the new system. First, the casual laborers who man the tricycles know that they can be dismissed without notice or indemnization if a foreman is unhappy with their performance. Casual observation suggests that they work longer and harder and leave less trash on the ground than do unionized city employees. Second, the tricycles can be purchased cheaply (US$200, versus US$200,000 for a packer truck) and are also relatively inexpensive to maintain (with a typical repair bill amounting to less than US$20).

3.21 Aside from making a final decision to abandon the idea of contracting with micro-entrepreneurs, Machala's garbage company should consider what improvements should be made at transfer points. It does not take a pair of workers very long to fill a tricycle box and, between visits by a packer truck, a pile of garbage at a transfer point can grow into an unsightly and smelly nuisance. An alternative would be to install dumpsters, but this would oblige the purchase of trucks capable of raising and emptying such containers.

4. Sanitary Landfills and Open-Air Dumps

4.01 As far as most clients of a solid waste services system are concerned, collection and hauling are the main criteria for judging performance. A more complete assessment, though, involves examination of final disposal as well. As is reported in this section of the report, Guayaquil, Quito, and Machala have addressed disposal issues in various ways.

4.02 Guayaquil's Sanitary Landfill. In most Ecuadorian cities, wastes have been hauled to open-air dumps that have no liners, covers, or barriers to keep out scavengers. It has been common for the poor to build shacks right beside or on top of wastes, if they couldn't find anywhere else to live. Until recently, this was the case in Guayaquil as well.

4.03 The port city will soon have a new, modern landfill, with impermeable clay on the bottom, rock "chimneys" through the waste to help methane gas escape into the atmosphere, and perimeter fencing to catch windblown paper while keeping animals, squatters, and scavengers out. Rock channels are being constructed to carry rain water and leachate under the waste and out at the lower end of the waste pile. In time, pipes may be laid to channel the leachate somewhere for treatment, though sewage treatment in Guayaquil is woefully inadequate at present (Frederick with Southgate and Lach, 1995).

4.04 In all likelihood, amortization expenses for the new facility, which has been designed in accordance with U.S. Environmental Protection Agency (USEPA) standards, will amount to several dollars for every ton of garbage that is delivered and, in effect, entombed. For some components of the waste stream ("e.g.", construction and demolition debris), the cost is not warranted. There is a more fundamental problem with the entombment approach, which is that it is probably far beyond the financial means of all but a few Ecuadorian cities. If development banks made adoption of that approach a prerequisite for financing of solid waste systems, as some are tempted to recommend, local governments might have to choose between cutting back on some services (to pay for expensive landfills) or forgoing landfill improvements entirely.

4.05 Recent and Planned Improvements in Quito. Until recently, solid wastes generated in the national capital were dumped in an unlined portion of the Zambisa canyon, in the northeastern part of the city. The site is now surrounded by residential neighborhoods, including some affluent ones. In response, operations have been improved and plans for opening a sanitary landfill, like the new facility in Guayaquil, are being pursued.

4.06 Improvements at Zambisa, which used to be nothing more than an open dump, are intended to reduce odors as well as exposure to disease. Dirt is bulldozed over all garbage an hour or two after it has been deposited. Scavengers, of which there are two hundred or so, can no longer live on mounds of waste, as was formerly the case. They still sift through garbage as quickly as it arrives, looking for paper, cardboard, metal, plastic and glass bottles, and even edible food wastes. However, the scavengers have been persuaded to move out most of their children and livestock.

4.07 Zambisa continues to be a threat to public health. Methane gas is present and at times catches fire. Also, there is no way to capture leachate, which flows out the bottom of the site. Mosquitos can breed in stagnant water collecting in pools as well as in the old tires that litter the area. The municipal government will be dealing with these problems for years to come.

4.08 To be sure, neighbors would benefit greatly if Zambisa were closed. EMASEO has plans to build a new sanitary landfill some 45 kilometers north of central Quito. However, switching to the new site would add US$2.50/ton to average hauling costs, which along with collection expenses now amount to US$30/ton. It is understandable, then, that the company is trying to persuade the neighbors to allow the landfill to continue functioning.

4.09 Sooner or later, the new landfill will be needed. Permanent entombment of all garbage may be too costly, although the site north of the city should have well-lined and protected cells for medical refuse and toxic and hazardous wastes. Already, construction of a new transfer station in southern Quito is under way. Garbage from that part of the city will be hauled to the new facility, where it will be compressed into semi-trailers for the haul to either the present landfill or the new one.

4.10 Machala's Open-Air Dump. Surrounded by residential neighborhoods, a school, an asphalt plant, and a banana plantation, the dump where Machala's garbage has been deposited for fifteen years was formerly a sand and gravel pit. The site is still privately owned, although the municipal government has not paid rent for some time. It is speculated that the owner plans to reclaim the site for development of some sort once the pit is full.

4.11 Several scavengers have put up flimsy shelters along the dirt road leading to the dump and several dozen people work over waste as it arrives. They compete with a few dogs and hundreds of large birds. The municipal government keeps a bulldozer at the site and uses it to cover some of the older waste with a layer of dirt.

4.12 Machala has a possible location for a new landfill, much farther from the center of the city. However, with its entire annual garbage budget only totalling US$500,000, municipal leaders understandably wonder whether site preparation is affordable. One alternative would be to develop a regional facility, to serve all cities, towns, and villages in the area. It would also be appropriate to seek closer sites for construction and demolition debris and for composting vegetable matter, which is less hazardous.

5. Making Garbage Collection and Disposal in Ecuador More Efficient

5.01 On the basis of limited observation in Guayaquil, Quito, and Machala, we have suggestions to make about how to improve solid waste services in the country. Three recommendations have to do with collection and hauling. First, use of plastic bags can be suggested, but should not be obligatory. Second, no single mode of garbage collection should be applied across the entire country. Third, the net value of developing new micro-enterprises should not be exaggerated. With respect to final disposal, decisions about construction standards about new landfills will have to be made and objections from the neighbors of the new sites will have to be dealt with in some way.

5.02 Each of these ideas and recommendations is elaborated in the paragraphs that follow. The possibility of reducing waste volumes through increased recycling is examined in the next part of the report.

5.03 On the Use of Plastic Bags. The residents of Guayaquil and Machala have been instructed to put their trash out in plastic bags. The expected advantages are that the bags are light and the workers can pick them up and put them in a truck or tricycle box with less mess and fuss than is involved if people present garbage in open containers ("e.g.", old cooking oil cans).

5.04 Use of plastic bags does not necessarily result in major reductions in litter. Dogs, cats, and rats often tear into bags, making a mess along the curb or sidewalk. Scavengers sometimes do the same, even though they face occasional fines for

littering. A better way to reduce littering is to install more metal racks to store garbage out of the reach of animals, as is routinely done in many middle-class Latin American neighborhoods.

5.05 In all likelihood, obliging the poor to put garbage in plastic bags, which cost 100 sucres (US$ 0.04) apiece, would make little sense because the use of open containers in the neighborhoods where they reside probably does little harm. As a rule, someone is at home all the time in a typical slum household (to guard against theft) and it is the habit of many such individuals to take out the trash, bagged or otherwise, right when a garbage truck or tricycle, led by a worker ringing a cowbell, passes nearby.

5.06 Appropriate Technology for Garbage Collection. In the past, per-unit collection costs have been driven up markedly in Ecuador as Quito, Guayaquil, and other cities have tried to rely exclusively on modern packer trucks. The financial burden implied by this approach has made it impossible to serve all neighborhoods. The problem is much like the limited extension of municipal water systems resulting when per-household costs are driven up by the application of high-cost water delivery technology (Frederick with Southgate and Lach, 1995).

5.07 This experience should be kept in mind when considering the diffusion of any new mode of garbage collection. For example, tricycles that work very well in Machala, which is totally flat, may not transfer to the hillier slums of, say, Quito. Side-loading small trucks seem to be especially well suited to the latter city, where it would also make sense to place animal-proof containers at the foot of alleys and paths that are too narrow for vehicles. As a rule, no single collection mode is apt to be appropriate for all parts of a heterogeneous country like Ecuador.

5.08 On Small-Scale Community-Based Garbage Collection. In various studies of solid waste management in Ecuador and other developing countries, it is recommended that local micro-enterprises be organized to collect garbage in poor neighborhoods using low-cost methods. Those micro-enterprises would also be involved in community-organizing aimed at reducing litter.

5.09 Balanced against the appeal of this approach, which was advocated for the slums of Machala (see above), is all the effort required to organize micro-enterprises and to arrange financing for their equipment. An alternative, which Quito is employing, is to contract with the owners of pickups and larger trucks. Since many of those vehicles sit idle a good deal of time, the prices that must be offered to engage them are not very high. Furthermore, there is no need to arrange credit for truck purchases. It is estimated that the total cost, including vehicle rental as well as wages for casual laborers hired to load garbage, amounts to 15 to 18 percent of what would be spent if EMASEO did the job itself (Sevilla, 1995). This sort of contracting can be done on a short-term ("e.g.", six-month) basis, with renewal based on quality of service provided.

5.10 Norms for New Landfills. As existing dumps are filled in Quito, Machala, and other cities, new facilities will have to be developed. Obviously, one set of choices that will have to be

faced relates to construction standards.

5.11 Those choices could well be driven by forces outside of Ecuador. In particular, there appears to be a tendency to apply USEPA standards in new landfills financed by development banks. The principle guiding those standards can accurately be described as entombment. Impermeable covers are put in place to prevent water from filtering in, so as to minimize anaerobic decomposition, and plastic and/or clay liners are installed at the bottom to prevent leachate from reaching underground aquifers. Instead, that leachate is channeled out through a network of pipes. Also, methane, which is a product of anaerobic decomposition, is monitored and maybe burned.

5.12 The purpose of all this effort, which involves a considerable expense, is to keep garbage from rotting. For some categories of garbage, like construction and demolition debris, the effort is entirely misdirected. Likewise, yard wastes and food scraps lend themselves well to composting ("i.e.", aerobic decomposition), which can be managed fairly cheaply and which yields a usable product (see below).

5.13 New technologies for controlled decomposition of solid wastes, as an alternative to entombment, are being developed, which should have an impact on USEPA standards for the construction and operation of landfills. In the meantime, expensive landfill capacity should not be displaced with non-hazardous materials. Construction and demolition debris should be deposited elsewhere and recycling should be promoted.

5.14 Resolving Landfill Siting Controversies. Even if new landfills and other solid waste facilities are constructed and operated properly, at least a few neighbors are bound to object. For example, community opposition caused municipal authorities not to locate the new transfer station in southern Quito at the site that would have made sense from the standpoint of minimizing transportation costs. Likewise, businesses and residents of the town closest to the proposed landfill north of the city have protested vigorously. One of their concerns is that tourism in the area, which is traversed by the equator, will diminish. No negotiations between town representatives and EMASEO are taking place at present, nor has any date for beginning construction been set.

5.15 There are, of course, two extreme reactions to neighborhood opposition. One is for decision-makers to back down and the other is for them to barge ahead, perhaps claiming that the neighbors of an undesirable facility have a "civic duty" to put up with it. Between these two extremes are various intermediate responses. Waste streams can be diminished in various ways, thereby postponing the date at which construction of a new landfill can no longer be avoided. Once that date is approached, local opposition can be addressed by reaching a binding agreement on how the landfill is to be operated and also by offering compensation.

5.16 Negotiations with local communities have become a routine feature of landfill development in the United States. Among the subjects of negotiation are hours of operation and fencing and other measures for preventing the spread of garbage. When

bargaining reaches an impasse in Wisconsin, each party must submit a "final and best offer," only one of which can be selected by an independent arbitrator. This arrangement provides a strong incentive both sides to be reasonable and to reach an agreement on their own.

5.17 Over the years, compensation for landfill neighbors has changed dramatically in the United States. The traditional practice was for payments to be made only when neighbors sold their properties and when a real estate appraisal demonstrated that the landfill had depressed the price. Nowadays, it is common for landfill operators to collect trash for free in surrounding communities and also to pay local governments fees ranging from US$0.25 to US$1.00 for every ton delivered to the landfill. In addition, payments to individual neighbors are made. A neighbor might get as much as US$1,000 when he or she agrees to stop opposing a landfill. Also, individual households are paid US$200 to US$2,000 yearly as long as the landfill operates. Needless to say, the size of payment depends on the recipient's proximity to the facility.

5.18 There appears to be no tradition for compensating the neighbors of waste disposal sites in Ecuador. This is a serious omission since some of the costs neighbors incur because of landfill development are tangible and should be covered in some way.

6. Recycling's Contribution

6.01 Obviously, expenditures on solid waste services can be brought down by diminishing solid waste volumes. The combined approach for accomplishing the latter is often expressed as "the three Rs": reducing material use; reusing containers, packaging, and other things; and recycling. Quite a lot of materials reduction seems to have been achieved in Ecuador and reuse of containers and packaging is commonplace, particularly among the poor. For example, steel and aluminum cans have walls just as thin as the newer models in the United States. Some consumers take cloth bags to the store and the poor often take food purchases home in old newspapers to avoid buying plastic bags. Also, tires are usually recapped at least once before being discarded.

6.02 Future investigation of solid waste management in Ecuador should address the various ways that manufacturers could reduce material use. Also, several issues associated with the reuse of containers and packaging merit closer examination. For example, at least some illness results from the reuse of bottles that have not been cleaned properly, although there has been no empirical research of this problem in the country. The comments and recommendations offered in this section of the report have to do with the economics of recycling as well as scavengers' role in that process.

6.03 Markets for Recycled Products. To be sure, there are several recyclable materials that are routinely sold at prices that cover collection, processing, and marketing costs. Aluminum

cans, cardboard and newspapers, and glass bottles usually fall in this category. However, many enthusiasts in the United States have learned the hard way that prices for some materials fall well short of costs. For example, the expense of gathering, washing, granulating, and pelletizing enough foam plates and cups to make recycled polystyrene exceeds that commodity's price by a wide margin. Indeed, the gap between cost and price is so wide that it is usually cheaper to dispose of the plates and cups in a landfill. Where "success" has been achieved in the recycling of such products, it is usually because labor has been volunteered by schoolchildren or some other group, a purchaser wants to enhance its "green" image and is willing to pay more for recycled materials, or both.

6.04 Scavengers, who are principal agents of recycling in a poor country like Ecuador (see below), are fully aware of the fundamental economics of their line of work. On 20 March 1995, for example, several of them working at Zambisa did not bother to retrieve a huge pile of foam plastic plates that was covered with rotting food. They knew that, once a deduction had been made for processing expenses, a buyer would offer them little or nothing for the material. By contrast, scavengers interviewed on Quito streets confirmed that they find it worth their while to pick up clean polystyrene foam packaging material, particularly outside commercial stores that throw out large amounts every night. Of course, paper fiber in various forms is routinely collected and recycled. Corrugated cardboard is especially prized since it fetches a good price from intermediaries.

6.05 It is highly unlikely that city governments, voluntary organizations, and the like can improve greatly on the recycling that scavengers do already. As Porter (1994) has observed in a study of solid waste management in Jakarta, Indonesia, the prices they receive for recyclable materials can be regarded as reasonably efficient since individual scavengers' rights to work in particular areas are usually respected and since there is a certain degree of competition among intermediaries and presumably among plants as well. Much more is to be gained by exploring options for recycling in poor neighborhoods, which are less attractive to scavengers than middle-class areas are, and also for the composting of food scraps and other organic wastes, which scavengers seldom retrieve and which comprise up to 70 percent of household solid wastes in urban Ecuador (Landin "et al.", 1993).

6.06 One of the more promising initiatives to increase recycling in poor neighborhoods got under way in March 1993 in El Carmen, which is a neighborhood in southern Quito. Under the sponsorship of Roque Sevilla, a leading businessman and environmentalist as well as an elected member of the city council, a micro-enterprise was formed to involve residents in the recovery of plastic, paper, glass, cardboard, and metals. As its predecessor had done, EMASEO is supporting the venture by providing plastic bags free of charge, covering some out-of-pocket expenses, and advising on operations. Also, its employees pick up bags containing materials that cannot be recycled. The micro-enterprise sells recyclables to the usual buyers. Similar initiatives have been organized in other neighborhoods.

6.07 Since organic materials comprise well over half the trash thrown out by urban households in Ecuador, composting represents

a major opportunity to reduce expenditures on solid waste services. It must be emphasized, though, that composting is unlikely to be an economic bonanza for Guayaquil, Quito, or any other city. The basic problem is that the end-product's market value is usually low because concentrations of plant macronutrients ("i.e.", nitrogen, phosphorous, and potassium) are not very high and also because it sometimes contains shards of glass and plastic. In general, compost is most prized by certain agricultural producers ("e.g.", cut flower enterprises) that require a potting medium that is rich in organic matter and free of plant pathogens. Once that market is saturated, the product can be used for soil improvement, for example in places where erosion has taken a heavy toll. However, this latter use does not carry a high market value.

6.08 At best, composting ventures in Ecuador have achieved modest results. A few years ago, for example, Fundacion Natura and Machala's municipal government sponsored a demonstration of organic compost beds, in which vegetables were raised in decomposed kitchen refuse. The communal plots were abandoned after a couple of years, though some households decided to use home-produced compost in backyard gardens. However, even if composting is not profitable, it might still be a worthwhile venture for a solid waste service insofar as transportation and landfilling costs are reduced.

6.09 What To Do about Scavengers. As has been indicated already, scavengers are the primary agents of recycling in Ecuador, as they are in just about every other poor country. Nobody would think of interfering with them in any urban neighborhood, provided they do not litter as they go about their business. In addition, scavengers generally respect each others' right to pick through garbage along particular streets. Also, garbagemen wait a day or so before collecting furniture, sports gear, bicycles, and other items that might have value in order to give scavengers a chance at retrieval.

6.10 Long commonplace, scavenging at dumps and landfills has been discouraged in recent years in a number of Ecuadorian cities. The most extreme measures are being applied at Guayaquil's new sanitary landfill. Fences, closed-circuit TV cameras, floodlights, and armed guards are being used to keep out scavengers and other unauthorized persons. So far, these measures have proven effective. By contrast, past sporadic attempts to restrict access to Machala's unfenced dump have had no lasting impact.

6.11 In Quito, picking through garbage is permitted at Zambisa. But scavengers have been talked into moving their children and most of their livestock away from the site, in order to limit exposure to disease. When and if the new landfill north of the city is opened, scavenging might well be banned, since it is risky to operate heavy equipment with dozens of people around and also because damage to clay and plastic liners must be avoided.

6.12 While it is undeniable that sifting through garbage at a landfill can damage one's health, it is also true that scavengers' alternative employment options are very limited. For the most part, they have little education and quite a few have criminal records. Furthermore, it must be recognized that they

provide a service. Even the employees of Guayaquil's new landfill, who are pleased by the tidiness and simplicity resulting from an absence of scavengers, admit that they regret seeing perfectly good material buried.

6.13 Short of making the human capital investments that would, over the long term, reduce the number of people for whom scavenging is the most remunerative line of work, the twin aims of employing low-skilled individuals and recycling can probably be served best by setting up a Materials Recovery Facility (MRF) at Ecuador's major landfills. MRFs in rich countries usually hire unskilled laborers to break open plastic bags of trash, to push the contents onto conveyor belts where magnets remove ferrous metals, and to pull plastics, glass, and aluminum off the belt by hand. Worthless objects fall into a dumpster at the end of the belt and are hauled to a landfill.

6.14 Since wages for unskilled workers in Ecuador are quite low, MRFs in Quito, Guayaquil, and other cities should be less capital-intensive than their counterparts in the States are. Indeed, Ecuadorian facilities could be quite simple, consisting of an open shed, to provide protection from the sun and rain, and a small bulldozer to feed trash onto a conveyor belt. If operation of an MRF has a sizable impact on trash going to a landfill, the entity in charge of the solid waste system might choose to let people working in the facility market recyclable materials in lieu of being paid a wage. Also, people working at MRFs should be encouraged to take measures ("e.g.", wearing gloves and masks) that prevent the spread of disease.

7. Administrative and Financial Issues

7.01 Institutional arrangements governing the collection, hauling, and disposal of garbage in Ecuador are in flux and continue to arouse considerable debate. However, it might well be that the practical consequences of choices among those arrangements are not especially important. For example, EMASEO's performance strongly suggests that creating a municipal enterprise with formal autonomy does not always cut down very much on red tape in purchasing and labor relations. Two institutional issues are probably of much greater substance. The first is how to go about contracting with private firms, which is possible in each of the three cities examined in this report. The second issue is financing of solid waste services.

7.02 Contracting. Although many Latin American cities are contracting with private firms to provide various solid waste services, many city governments and municipal enterprises have little experience and less information on how to supervise the process of calling for bids, negotiating contracts, and enforcing the terms of the contracts. Consultants are available, of course, and copies of contracts used in the United States and Europe circulate freely. As is discussed at the end of this report, USAID could enhance the ability of local public government in Ecuador to supervise the contracting process through training and technical assistance.

7.03 Financing of Solid Waste Services. The institutional arrangements governing solid waste services are in flux in each of the three cities examined in this report. Moreover, cost accounting was not done well (or at all, in some cases) under previous regimes. What this means is that the expense of providing solid waste services is difficult to determine.

7.04 EMASEO considers that average collection and hauling costs in Quito are about US$30 per ton, while operation of the controlled landfill at Zambisa probably costs another US$3 per ton. Between fees paid to the private contractor and salaries received by municipal employees working at the landfill and other locations, total expenditures on street sweeping, garbage collection and hauling, and operation of the new landfill amount to US$10 or so for every ton delivered to that facility. Amortization of landfill construction costs and other capital expenses probably approach US$10 per ton as well. Running the old system of garbage collection and disposal in Machala involved an average cost of US$15.69 in 1993; at that time, the average cost of serving poor neighborhoods with tricycles was estimated to be US$4.77 (Stern, de Jesus, and Romero, 1994).

7.05 The relationship between these costs and revenues from surcharges on electricity bills, which range from 7 to 12 percent, varies from place to place. Since the surcharge in Guayaquil is 12 percent and the fee paid to the private contractor to collect and haul away garbage is only US$9 per ton, the municipal government is probably turning a profit, notwithstanding the contractor's aggressive pursuit of new business (see above). When interviewed in March 1995, Machala's Director of Public Services stated that the 10 percent surcharge would probably be enough to finance all solid waste services. However, the municipal government was delinquent in paying old lighting bills. In order to retire outstanding debt and also to have all new bills on time, the City and the electricity company have agreed to let the utility deduct directly from surcharge payments. After these deductions, which amount to half of total surcharges, there is not enough left to pay for all solid waste services (Barzallo, 1995).

7.06 In Quito, the surcharge on electricity bills is 10 percent and EMASEO reports that it is received in full, but is not really enough to cover expenses. The enterprise has no depreciation reserves or capital with which to buy new vehicles to replace the present fleet, most of which is older than its normal service life. EMASEO is thinking seriously about contracting out services, largely so that private investors can arrange and be paid for the purchase of new vehicles. In the meantime, it has had to seek financial support from the municipal government to cover cash shortfall.

7.07 There does not seem to be any satisfactory alternative to the present method for financing solid waste services. It would certainly be reasonable to have large generators, like factories, supermarkets, and apartment buildings, contract directly with private haulers, whom they would pay for the service. This is standard practice in the United States. But a general system of user fees is not feasible at present and would work against full coverage of low-income areas. If a price per bag were charged, many residents would burn garbage or throw it into ravines, just

as poor people in the countryside usually do. Policing this sort of behavior would be much more difficult in Ecuador than in the United States, where junk mail found in illegally-discarded trash can be used to identify perpetrators. Besides, user fees would be resisted by the poor, who object to proposals to force the use of plastic bags, which cost about US$0.04 apiece (see above).

7.08 Another alternative would be to use general municipal tax revenues to fund solid waste services. For two decades after Ecuador became an oil exporter, in 1972, local tax rates were very low and collection tended to be sporadic. Those rates have risen appreciably in the 1990s and collection has become much more energetic. However, local tax revenues, which must be used to support various municipal services, can not yet be characterized as a highly reliable funding base for the collection, transportation, and landfilling of solid wastes.

7.09 Surcharges on electricity tariffs have drawbacks. If diesel and other fuel oil is subsidized, as it has been in the past, there would be incentives for factories and other large consumers to generate their own power, which would diminish public utility revenues. But the surcharge system has important merits. For one thing, it works. Electricity companies are quick to cut off illegal hook-ups and also to cut off service when bills remain unpaid, which means that surcharge revenues are much more reliable than a solid waste system's cut of local tax revenues, for example, would be. Another advantage is that all households, businesses, and other establishments that consume electricity pay. This is appropriate because they all produce solid wastes. It also bears mentioning that surcharge revenues are less immune to the impacts of inflation than local tax revenues are since electricity tariffs tend to rise in line with increases in the general price level. Finally, the surcharge is, in the main, progressive since the rich probably spend a higher percentage of their income on lighting than the poor do. This is an important an advantage in Ecuador, where the distributional impacts of taxes and other public policies have been strongly regressive.

7.10 Society as a whole has a strong interest in reliable funding for comprehensive solid waste services. Exposure to disease is not limited to those poor neighborhoods where trash collection is sporadic since direct and indirect contact between the residents of those neighborhoods and the rest of any city's population is routine. Furthermore, inadequate collection causes drains and sewers to be clogged, which interferes with wastewater removal. As is stressed in a companion report on urban water issues in Ecuador, public health is seriously jeopardized in Guayaquil, Machala, and other cities as a result (Frederick with Southgate and Lach, 1995).

8. Opportunities for External Development Agencies

8.01 Development agencies can make a substantial contribution to the improved delivery of solid waste services in Ecuador. For one thing, technical assistance and training can be offered to help public officials make informed choices among the policy choices they face. One area that should be emphasized is

techniques for contracting out services as well as supervising contractors' performance. While there is scope for bringing consultants from abroad, some of the most lasting and productive initiatives would involve internships abroad for engineers and other technical staff, complemented by study tours for political leaders who would need to understand and approve the new management procedures. Sister city and state programs may be a good vehicle for carrying out this sort of interchange.

8.02 Financing for the construction of new facilities, remediation of problems at older solid waste facilities, and the like might also be appropriate, especially for the World Bank and IDB. However, this support should be linked to positive steps taken by local governments and enterprises toward sustainable self-financing. Among those steps are proper cost accounting and the establishment of a reliable revenue base.

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