URBAN ENVIRONMENTAL PROBLEMS AND POLICY OPTIONS FOR DEVELOPING COUNTRIES

Peter Kennedy

Department of Economics

University of Victoria

15 November 1998

ABSTRACT

This report describes some of the key urban environmental problems currently facing developing countries, and outlines the policy options available for their management. It addresses four key areas: air pollution; sanitation and wastewater treatment; solid waste management; and industrial effluent and hazardous waste.

Written for the *Economic Development Institute*, *World Bank*

TABLE OF CONTENTS

1. INTRODUCTION

Rapid urbanization is posing perhaps the most immediate environmental threat to human health and welfare in developing countries. The fraction of the world's population living in urban areas in 1975 was roughly 34%. By the year 2000 that fraction will have increased to over 50%. By the year 2020 it will likely have increased to nearly two-thirds. Coupled with absolute population growth, this trend means that over 5 billion people will be living in urban areas by the year 2020.

The most rapid change is happening in developing countries. Urban population growth rates in the developing world are around 3.5% annually; the corresponding figure for developed countries is about 1%. Growth rates are highest in Africa and Asia, at around 4%, building on a current urban population fraction of around 30%. Growth rates are somewhat lower in Latin America and the Caribbean, but these regions are already more than 70% urbanized.

The driving forces behind these urbanization rates vary across regions. In Africa, current urbanization is due largely to armed conflict and natural disasters. In Asia and Latin America, trade liberalization is a key factor. The liberalization of global trade has caused a shift in production in these regions towards labor-intensive, and pollution-intensive, manufacturing. This manufacturing is heavily concentrated in urban areas, and the relative expansion of this sector has caused an influx of people from rural areas.

The environmental impacts of rapid urbanization are among the most serious problems facing developing countries. These "brown issues" are the focus of this report.

The report is structured as follows. Chapter 2 examines the problem of urban air pollution, including the closely related problem of transportation. Chapter 3 deals with sanitation and wastewater treatment. Chapter 4 examines solid waste management, and Chapter 5 deals with industrial effluent and toxic waste.

Each chapter has the same basic structure. A first section describes the scope of the problem in developing countries, illustrated with specific examples from major urban areas. A second section discusses the key issues, and a third section then examines various policy options. A final section describes some examples of best policy practice in developing countries.

2. URBAN AIR POLLUTION

2.1 SCOPE OF THE PROBLEM IN DEVELOPING COUNTRIES[1]

Air quality in the largest cities of many developing countries has deteriorated markedly over the past twenty years, despite high rates of economic growth. Rising wealth levels have so far not brought about the adoption of cleaner technologies at a rate fast enough to compensate for the increasing scale of economic activity and the trade-induced shift in many developing countries towards relatively polluting manufacturing.

The air pollution problem is particularly severe in megacities such as Beijing, Cairo, Jakarta, Mexico City, and Seoul. On a variety of air quality measures, Mexico City has the most polluted air in the world, where 29% of children have dangerously high blood lead levels, and where particulate matter alone is estimated to contribute to 6400 premature deaths per year. Similarly, in Jakarta, ambient levels of particulate matter exceed World Health Organization (WHO) standards 173 days per year on average.[2]

2.2 MAJOR URBAN AIR POLLUTANTS: SOURCES AND EFFECTS

The relative importance of different pollutants, in terms of their impact on human health and other environmental indicators, varies across cities, due mainly to differing geographical characteristics. Similarly, the contributions of different air pollution sources varies across cities, and across pollutants. To the extent than any general statements can be made, the most serious air pollutants in developing country cities are suspended particulates and airborne lead, while the largest (and fastest growing) contributor to the local air quality problems in most cities are motor vehicles. The following provides an

[1] Except where indicated otherwise, the data source for this section and the next is World Resources Institute (1996), *World Resources: A Guide to the Global Environment*, Oxford University Press, New York.
[2] WHO recommends exposure to particulate matter of less than 60 -90 micrograms per cubic meter per day.

overview of some of the most important urban air pollutants, together with their main sources and effects.

Suspended Particulates

Suspended particulates comprise a variety of airborne particles, both organic and metallic. The most dangerous particulates are those less than 10 microns in diameter (PM10), which can be easily breathed into the lungs. There are three main health effects of particulates. First, they cause eye and respiratory irritation, and elevate the risk of serious lung infections. Such infections are a major killer of young children and the elderly in developing countries. (For example, in Jakarta, respiratory infections account for 12.6% of *all* deaths, which is more than twice the national average). Second, long-term exposure is thought to contribute to and exacerbate the effects of chronic lung diseases, including asthma, bronchitis, and emphysema, all of which cause considerable suffering and lost productivity. Third, there is some evidence to indicate a carcinogenic effect from long-term exposure to some particulates.

The main anthropogenic sources of particulates are combustion, industrial processes, and the formation of sulfates from sulfur dioxide emissions. In terms of sectors, vehicle emissions (especially diesel-powered vehicles and two-stroke engine motorcycles) are the single most important source of particulates in many cities. For example, vehicle emissions are responsible for 24% of particulates in Bombay; 35% in Mexico City; 44% in Jakarta; and 88% in Colombo. Other important urban contributors are refuse burning, coal-fired power plants and boilers, and a variety of manufacturing processes.[3]

Indoor sources of particulates are also a serious problem in many of the poorest areas in developing countries (in both urban and rural regions) where smoky fuels, such as fuelwood, animal dung and charcoal, are used for domestic cooking and heating. Women and children are typically most at risk to particulate exposure from these sources.

[3] Urban areas are also sometimes exposed to high levels of particulates from non-urban sources. Witness the smoke levels in some Malaysian and Indonesian cities in 1997, due to slash burning in rural areas of Indonesia.

Lead

Lead is a highly dangerous pollutant, causing illness and nerve damage, and most importantly, the impairment of neurological development in children. It is one of the most sinister of all airborne pollutants. Motor vehicles are the main source of atmospheric lead emissions: the combustion of leaded gasoline accounts for 80% to 90% of ambient air lead concentrations in most developing country cities. Lead levels are especially high along heavy traffic routes. Lead pollution has dropped precipitously in developed countries over the past twenty years with the introduction of unleaded gasoline, and a similar trend is emerging in many developing countries, but lead levels in many developing country cities, especially Cairo and Bangkok, are well in excess of safe limits.

Ground Level Ozone

Ground level ozone is an eye and respiratory irritant, and causes damage to urban vegetation and building materials. It is also an important source of damage to crops and forests in surrounding areas. Ground level ozone is a particular problem in cities that are subject to temperature inversion, which prevent the dispersion of air, such as Mexico City.

Ozone is produced in the atmosphere by the reaction of nitrous oxides, volatile organic compounds (VOCs) and carbon monoxide in the presence of sunlight. The main sources of these emissions are motor vehicles (see below).

Carbon Monoxide

Carbon monoxide is produced from the imperfect combustion of carbon-based fuels. It causes headache, poor concentration and lethargy, and in high doses, unconsciousness and death.

The main source of carbon monoxide emissions is motor vehicles. They account for almost 100% of these emissions in large cities. Coal-fired power plants are also a relatively important source in urban areas with fewer cars.

Hydrocarbons

Hydrocarbons comprise a large group of gaseous organic compounds, produced through combustion and vapor release from fossil fuels. Among the most important are volatile organic compounds (VOCs), which are catalytic in the formation of ground level ozone (see above). Exposure to hydrocarbons can cause headache and dizziness, and many hydrocarbons are suspected carcinogens.

The main anthropogenic source of hydrocarbons in urban areas is motor vehicles, accounting for over 75% of total emissions for this pollutant in many cities. Like many vehicle emissions, the production of VOCs from cars is highest at low engine revolutions, and so tends to be worse in areas of high traffic congestion.

Nitrous Oxides

Nitrous oxides are produced principally through the combustion of carbon-based fuels. Nitrous oxides are an important precipitation acidifier. In urban areas, its main contribution to air pollution is as a catalyst in the formation of ground level ozone. (See above).

Motor vehicles account for over 80% of nitrous oxide emissions in car-intensive cities. Fossil fuel-fired power plants, and a variety of industrial processes are also important sources.

Sulfur Dioxide

Like nitrous oxides, sulfur dioxide is produced primarily through the combustion of fossil fuels, particularly high sulfur coal. It is also an important precipitation acidifier. In urban areas its main impact is as a respiratory irritant.

The main anthropogenic sources of sulfur dioxide are fossil fuel-fired power plants, industrial processes, and motor vehicles.

2.3 POLICY OPTIONS

The foregoing discussion underscores the importance of motor vehicles as a source of urban air pollution, especially in the megacities of the developing world. If left unchecked, that problem is likely to grow significantly over the next twenty years or so. Car ownership rates rise with wealth, and many developing countries, particularly in Asia and Latin America, are now reaching wealth levels at which car ownership rates are set to soar. Thus, any policy mix designed to address urban air quality must first and foremost confront the problem of motor vehicle emissions.

Policy Options for Vehicle Emissions

The problem of vehicle emissions is intertwined with the problem of road congestion, not only in terms of aggregate miles driven, but also in terms of the pace at which traffic moves since this is an important determinant of engine efficiency, and hence, of exhaust emissions. The two issues should be viewed as related, but nonetheless separate. In particular, some policies designed to address emissions (such as emissions control technology requirements) will have little impact on congestion. The key principle behind congestion management is controlling the number of cars on the road, according to location and time of travel. In contrast, the main focus of emissions policy is the management of emissions. Policy instruments should be targeted as closely as possible at the primary source of problem at hand.

Fuel Taxes and Emission Fees

Fuel taxes are a particularly blunt instrument for addressing road congestion. While, fuel consumption is closely related to number of miles driven, and while congestion is a cause of higher fuel consumption, the combustion of fuel *per se* does not cause congestion. For example, zero emission (electric) vehicles cause as much congestion as vehicles of the same size powered by gasoline engines.

As an instruments for emissions pricing, fuel taxes are somewhat more direct, but are nonetheless imperfect, especially in urban situations. Fuel consumption is a primary determinant of emissions, but not the sole one, especially with respect to carbon monoxide, VOCs and nitrous oxides. Emissions of these pollutants are also related closely to engine tuning, driving style and trip characteristics. For example, emissions of these pollutants are much lower in highway driving than in city driving.

A more direct instrument for addressing emissions is an emissions fee. However, it is technically difficult to monitor and price tailpipe emissions directly. The technology for doing so exists, but the cost of retrofitting the existing car fleet with onboard emission monitors is prohibitive. There are a number of alternative instruments available. First, *extrapolative emission fees* could be imposed. These fees are calculated on the basis of miles driven and the average emissions-per-mile for the particular car concerned. This average is usually calculated on the basis of a periodic standardized emissions test, the results of which may not always be a good reflection of actual emissions under normal driving conditions, especially since idiosyncratic factors are so important. The cost of administering an extrapolative emissions fee scheme may more than offset any advantages such a scheme has over fuel taxes.

Fuel Composition Pricing

The chemical composition of a fuel is of course a primary determinant of its waste profile. The addition of lead to gasoline is a clear example: the combustion of unleaded gasoline does not produce lead emissions. This means that pricing fuel according to its composition can help to sharpen fuel taxes as an instrument for emissions management. If the social cost of a particular fuel component is thought to be extremely high, then a good policy is to set an effectively infinite price on the component; that is, to ban its use entirely. Lead in gasoline is a good candidate for an outright ban. The use of discriminatory taxes that render leaded gasoline more expensive than unleaded gasoline can help to create the right incentives for transition to a complete lead ban.

Other pricing instruments can be targeted at fuel composition. For example, alternative fuels that can be burned in vehicles as a substitute for, or additive to gasoline, such as propane (after some retrofitting) and ethanol, can be priced differently to gasoline according to their emission profiles.

Emission Standards and Technology Standards

The command-and-control alternative to emissions pricing is to impose emission standards on vehicles. This entails setting maximum limits on tailpipe emissions under some standardized test. Alternatively, standards may be applied at the design level, requiring the use of a specified emissions control technology, such as a catalytic converter, or requiring the use of a particular engine technology, such as an electric engine. Fuel economy standards will also influence emission levels, but they are a very blunt instrument for that purpose.

Instruments Aimed at Congestion

A plethora of instruments designed to address congestion will also affect emissions. Among the most important are road tolls, parking fees and restrictions, traffic restrictions and bans, tradeable vehicle ownership permits, and the judicious pricing of public transit. Infrastructure construction policies are clearly also important, especially with respect to the balance chosen between road construction and public transit provision.

Broader planning instruments, such as land use zoning and housing density regulations, can also have a marked impact on car use (as the urban sprawl and associated car use in many “developed” cities clearly demonstrates). These are critical elements of any integrated urban transportation plan. However, as noted earlier, these policies are primarily designed to address the problem of congestion and noise, and are not always well-suited to addressing an emissions problem.

Policy Options for Commercial Stationary-Source Emissions

Industrial plants and small factories must also be regulated as part of any comprehensive air quality policy program. A key consideration with respect to that regulation is compliance cost, since the competitive position of much manufacturing in developing countries relies on their relatively low production costs. It is therefore important that emission policy targets take careful account of compliance costs, and that the implementation those targets be based on least-cost measures. This means that economic instruments, such as emission fees and tradeable permits should in most circumstances be the policies of choice. Nonetheless, the optimal policy regime will generally involve some mix of command-and-control measures, economic instruments, and other policy instruments, such as information disclosure.

Command-and-Control Measures

- *Performance Standards*. Performance standards place restrictions and conditions on the day-to-day performance of firms in terms of their emissions. Among the different types of performance standards, emission standards are generally the preferred instrument. These put restrictions on the volume of emissions per unit of time (such as a month). Wherever possible, the standard should be tied to the total volume of the targeted pollutants, rather than to concentration levels or some other indirect indicator of emissions.

- *Design Standards*. Design standards (or technology standards) impose requirements for the use of particular pollution control equipment (such “scrubbers” on coal-fired power plant smokestacks), or the use of a particular production technology (such as oxygen bleaching for pulp and paper production). The key to good policy with respect to design standards is to recognize that the mere existence of a cleaner technology, even if it is currently in use in some other country, does not necessarily mean that it should be required of firms in a developing country. Requirements with respect to technology use should be based on sound cost-benefit analysis.

Economic Instruments

Economic instruments, which assign a price to emissions, have two potential advantages over command-and-command instruments: the creation of ongoing incentives for abatement and cleaner technology adoption; and least-cost implementation of aggregate emission targets. The following are the economic instruments best suited to the regulation of air pollution.

- *Emission Fees*. Emission fees assign an explicit price per unit of emissions. For example, a fee of $50 per ton may be assigned to emissions of sulfur dioxide from an industrial plant. This creates an on-going incentive for the firm to reduce its emissions. Ideally, the emissions price should be set to reflect the environmental damage caused by the emissions. Thus, the price will differ across pollution types, and possibly across different regions of a country, according to geographical characteristics and population densities. Note that the key function of an emissions fee should be to align private costs with social costs, and thereby change private incentives, rather than to raise revenue *per se*.

- *Abatement Subsidies*. An abatement subsidy paid to polluters has an incentive effect for an individual polluter similar to that associated with an emissions tax. However, there are two key differences between emission taxes and abatement subsidies. First, at an industry level, an abatement subsidy can encourage excessive entry, and can therefore potentially have a perverse effect on aggregate emissions. Second, the payment of an abatement subsidy implicitly assigns the property rights over assimilative capacity to the polluter. This has important political implications, and equally important implications for government revenue and expenditure.

- *Emissions Trading*. A tradeable emission permit scheme sets a target level of aggregate emissions of a given type, and then issues (or auctions) permits totaling that target level. Allowing those permits to be traded between sources then allows the emissions target to be met at least cost, since firms for whom abatement is very costly can purchase permits from firms for whom abatement is less costly. Emissions trading schemes require “deep” markets in order to function well; that is, the market for emissions should involve many different sources, each being small relative to the entire market. However, even where these conditions do not hold, scaled down versions of emissions trading that only allow direct “trades” across sources, administered by the regulator, can yield substantial cost savings in the implementation of an aggregate emissions target.

Policies for Household Emissions

Controlling household emissions from sources such as refuse burning in developing countries is difficult, for two reasons. First, the large number of households often crowded in small areas in the poorest regions makes the monitoring of regulations difficult, especially given the very limited monitoring resources available. Second, the level of poverty in the poorest urban areas means that the imposition of fees or the credible threat of financial penalties is impossible. In many instances, the only feasible approach is the alleviation of poverty, with transfers tied to pollution abatement measures, such as subsidized refuse collection.

Similarly, achieving reductions in the level of exposure to indoor pollution requires the subsidized provision of cleaner fuels for cooking and heating, or direct wealth transfers. The provision of information about the consequences of pollution is also a valuable policy measure.

Pollution Abatement vs. Mitigation

There is an old English adage that “an ounce of prevention is worth a pound of cure”, and like most old adages, it is *not* necessarily true; the relative price of prevention and cure could be quite different. In particular, if the social cost of mitigating action is less than the social cost of pollution abatement, then mitigation is the better policy. In many instances, the cost of exclusive mitigation will likely be higher than the cost of exclusive abatement. However, a mix of abatement and mitigation, especially as a transition policy towards long-term abatement, can often be better than an exclusive focus on one or the other.

2.4 EXAMPLES OF BEST PRACTICE

Vehicle Emission Standards in Korea

Emission standards (for particulate matter and nitrous oxides) for diesel-powered passenger cars were introduced in Korea in 1993. Pre-announced tighter restrictions were introduced in 1996, and further tightening of standards have been announced for implementation in 1998 and 2000. This progressive and pre-announced introduction of standards allows for pre-planning for compliance, and thereby reduces the overall cost of compliance.

Tradeable Permits for Vehicles in Singapore

In 1990, Singapore introduced the Vehicle Quota System (VQS), under which anyone wishing to own a vehicle must have a certificate of entitlement (COE). Vehicles already registered at the inception of the program were issued a COE free of charge, but anyone wishing to buy a new car must bid for a COE in monthly tender offerings. Successful bidders pay a price for their COE equal to the lowest successful bid. A COE is valid for ten years from the date of purchase, at which point it must be renewed at the prevailing COE price, which is calculated as the 12-month moving average of COE prices for that vehicle category.

Differential Pricing for Unleaded Gasoline in Singapore

Unleaded gasoline was introduced in Singapore in 1991. To encourage its use, unleaded gasoline is sold at a lower price and now accounts for about 65% of gasoline sales. The switch to unleaded gasoline has also paved the way for the use of catalytic converters (which can only be used in conjunction with unleaded fuel). All new vehicles are subject to emission standards that can only be met with the use of catalytic converters.

Emission Fees in Korea

Korea introduced its Emission Charge System (ECS) in 1983. This system imposes a fee for non-compliance with standards, and that fee increases with the extent of the violation. Thus, the system is a hybrid of a command-and-control emissions standard and an emissions fee. As such, the current system does not have all of the advantages of a true emissions fee program, but the Korean approach to implementation has successfully eased the adjustment costs associated with switching to a “polluter pays” system, and a more complete ECS is scheduled to come into effect in the year 2000. The pre-announcement of this change has given firms time to adjust to the new system, and has thereby reduced compliance costs.

3. SANITATION AND WASTEWATER TREATMENT

3.1 Scope of the Problem in Developing Countries[1]

Lack of access to adequate sanitation poses one of the greatest risks to human health in developing countries. It is estimated that over 420 million urban residents worldwide do not have access to even the most basic latrine. These people have no alternative but to defecate in waterways and on open land. Even where sanitation facilities do exist, they are often in poor repair or improperly maintained, and are shared by so many people that long lineups and unpleasant conditions deter their use.

Even where sanitation service is available, most sewerage is discharged directly into waterways without treatment. For example, in India, only 8 out of 3,119 towns and cities have wastewater collection and treatment plants; a further 209 have partial treatment facilities. In Jakarta, based on 1989 figures, an estimated 200,000 cubic meters of largely untreated wastewater flows into the city's waterways every day. This lack of wastewater treatment is not confined to the poorest developing countries: in Santiago, 96% of city's wastewater is dumped into the rivers that run directly through the city.

Lack of sanitation and wastewater treatment are the main causes of intestinal diseases in developing countries. Diarrhea and intestinal worm infections account for an estimated 10% of the total disease burden in developing countries, killing more than 3 million children each year, and causing an additional 1.8 billion episodes of illness annually. In Jakarta, an estimated 20% of deaths in children under five are attributable to diarrhea.

---

[1] Except where indicated otherwise, the data source for this section and the next is World Resources Institute (1996), *World Resources: A Guide to the Global Environment*, Oxford University Press, New York.

3.2 Key Issues

The Effects of Poor Sanitation and Wastewater Disposal Practices

Poor sanitation and wastewater disposal practices pose a variety of serious health hazards, including:

- direct exposure to fecal matter near homes;
- contaminated drinking water;
- ingestion of fish from polluted waters; and
- ingestion of food fertilized with wastewater.

The most widespread diseases associated with these hazards are:

- diarrhea and intestinal worm infections;
- typhoid;
- hepatitis; and
- cholera.

The Costs of Poor Sanitation and Wastewater Disposal Practices

The diseases associated with poor sanitation impose enormous costs in terms of human suffering and lost productivity. In addition, the spillover of urban wastewater to water supplies for surrounding farming regions, and to coastal fishing areas, adversely affects productivity in these sectors and harms their potential to secure status as reliable exporters of high quality produce. Moreover, the threat of disease is likely to be a significant deterrent to tourism from wealthier countries. To the knowledge of the author, no reliable studies have been done to estimate the total magnitude of these costs to developing countries.[2]

[2] A 1994 World Bank cost-benefit study of waste treatment in Santiago goes at least some way to measuring these costs. See The World Bank Environment and Urban Development Division (1994), *Chile - Managing Environmental Problems: Economic Analysis of Selected Issues*, Report No. 13061-CH, World Bank, Washington, DC.

The Costs of Providing Better Sanitation and Wastewater Treatment

The 1980s was designated the International Drinking Water and Sanitation Decade (IDWSD), the goal of which was to provide adequate drinking water access and sanitation to all people on the globe. Despite investments of nearly $100 billion during the period, the goal was not met (due in large part to population growth). This underscores the enormous cost of providing drinking water and sanitation facilities to large numbers of people, especially if unrealistically high quality standards are set. In particular, the infrastructure needed for universal pipe-to-household water supply and large scale water-flushed sanitation systems is simply beyond the reach of the poorest developing countries. Similarly, the cost of full tertiary wastewater treatment is prohibitive for most cities and towns in developing countries.

3.3 Policy Options

The high cost of state-of-the-art sanitation and wastewater treatment is not necessarily cause for despair in developing countries. Sound cost-benefit analysis should consider a variety of options and project scales, including less ambitious but potentially very valuable sanitation and treatment projects.

To this end, a number of key policy principles emerged from lessons learned from the IDWSD with respect to the provision of drinking water, sanitation systems, and wastewater treatment:

- the technologies adopted should be responsive to local demands, and should be simple and cost-effective;
- system design and maintenance should involve communities and households;
- governments need to play a larger role in system operation and maintenance; and
- these services are economic commodities and should be appropriately priced.

Technology Choice

Simpler systems may yield a higher net benefit than more sophisticated, and more costly, systems. For example, low-cost "ventilated pit" latrines, which reduce odor and flies, can be an effective way to encourage greater usage of shared facilities. Some way further along the cost scale, but still much less costly than the conventional sewerage systems used in wealthy countries, is the "condominial wastewater collection system", which links individual latrines from a block of houses in series along a central sewer that links directly to the main sewer, thereby eliminating the need for individual house-to-street connections.

Similarly, the use of novel wastewater treatment technology can achieve significant net benefits under some circumstances. For example, the use of wetlands as natural filtration systems can be as effective in some cases as secondary treatment plants. Even simple low cost, primary screening can provide substantial net benefits relative to no treatment at all. Moreover, it is important to recognize that the same treatment standards will generally not be universally appropriate, even within a particular country. The benefits of wastewater treatment are a direct function of the damage caused by untreated effluent. In some instances, judicious disposal without treatment may be the best policy. This is especially true where there is access to heavily flushed, deep water coastal disposal.

It needs to be stressed that the "political correctness" that has so heavily influenced the wastewater debate in many developed countries should not be allowed to displace sound cost-benefit analysis with respect to treatment approaches in developing countries. Technology choices should be based on a realistic assessment of net benefits for the particular application concerned, rather than on some pre-conceived notion of what is a "proper standard".

At the same time, it is important that a far-sighted view be taken with respect to the choice of technology; investments with respect to infrastructure should be based on sound forecasts of future conditions, which could be very different from those prevailing at the time of the investment. In this respect, flexibility to upgrade can be an important consideration in technology choice.

Community Involvement

Community involvement is essential to a successful sanitation program, since local customs and norms can have a significant effect on the appropriateness, or otherwise, of a particular system design. Moreover, the sense of ownership that comes with involvement can foster greater responsibility, and pride in the project.

Operation and Maintenance

The "public good" nature of sanitation and wastewater treatment infrastructure also extends to its operation and maintenance. This is particularly true of shared sanitation facilities. There is therefore an important continuing role for public sector involvement in these on-going activities.

Pricing and Financing

Limited financing constitutes the main obstacle to the provision of improved sanitation and wastewater treatment. City governments in developing countries often have only a very thin tax base from which to draw revenue for public projects. A partial solution is to impose user fees on drinking water supplies, sanitation services and wastewater treatment. Moreover, pricing services in this way can create better incentives for appropriate water use, and for wastewater effluent control, especially by industry. However, the substantial fixed costs associated with sanitation and wastewater treatment means that some overall subsidization by government will generally be needed to ensure efficient provision. Pricing should be used, but full cost recovery is unlikely to be an appropriate goal for most sanitation and wastewater treatment programs.

3.4 Examples of Best Practice

The Orangi Pilot Project in Karachi, Pakistan

The Orangi Pilot Project is one of the great success stories in terms of implementing the policy principles described in the previous section. Orangi is a low-income settlement located on the western periphery of Karachi. Prior to 1981, the settlement had only a very primitive open drain and sewer system, exposing residents to significant health risks and extremely unpleasant living conditions. A non-government organization (NGO) called the Orangi Pilot Project (OPP) instituted a scheme to construct a low cost sewer system in the settlement. The central role of OPP was one of coordinating the community to cooperate in the self-construction and self-financing of the sewer system. The cooperative community spirit, that overcame what would otherwise have been a significant public good under-provision problem, was fostered by building small partnerships among residents at the individual street level. The success of the OPP has spawned a number of similar schemes, yielding significant net benefits to the urban poor of Karachi.

Urban Sanitation in Tegucigalpa, Honduras

In 1991, the Honduran office of a Washington-based NGO, Cooperative Housing Foundation (CHF), initiated a sanitation program in the city of Tegucigalpa. The key component of the CHF scheme was to provide accessible loans to women for financing the installation of home sanitation, ranging from simple ventilated latrines to pour-flush toilets, depending on their ability to pay. The program has helped to provide improved sanitation to over 1700 households.

Wastewater Fees in Bangkok

Thailand has been planning the introduction of wastewater fees in the Bangkok Metropolitan Area. Households and small industries would be charged a surcharge on their metered water bill, while large industries would be charged both a water surcharge plus an additional fee based on violations of BOD concentration standards in their discharge. (Sensibly, households and small industries have been excluded from the BOD charge in recognition of monitoring costs relative to the individual volumes of material involved). The BOD charge constitutes a blend of economic instrument and command-and-control regulation, since pricing applies only to above-standard BOD concentrations. This is a promising first step towards an incentive-based scheme that can also provide revenue for maintenance and expansion of the wastewater treatment program. Implementation of the fee system is likely to be smoother if the fees are introduced gradually over time, according to a pre-announced timetable. In addition, the BOD fee should be based on total BOD content rather than on concentration levels, as is planned currently, since the latter can encourage wasteful dilution at source in an effort by firms to avoid the BOD charge.

4. SOLID WASTE MANAGEMENT

4.1 SCOPE OF THE PROBLEM IN DEVELOPING COUNTRIES[1]

Urban areas produce vast quantities of solid waste in highly concentrated spaces. The quantity of waste produced tends to increase with the level of wealth, and so developing countries typically produce much less solid waste than OECD countries. For example, per capita annual solid waste generation in Bangkok, Thailand is around 321 kg; in Sao Paulo, Brazil it is 352 kg; in Washington DC. it is 1246 kg. However, while the quantity of waste rises with wealth, so too does the ability to install the infrastructure to deal with it. Moreover, while developing countries generate less solid waste per capita, the total volume of waste generated relative to the land area available for its disposal means that solid waste management is as much a problem in many developing countries as it is in OECD countries.

The solid waste problem in developing countries is compounded by relatively low collection rates. The collection rate in Washington, DC is almost 100%; in Sao Paulo that rate is around 85%, and in Bangkok it is around 80%. In Guatemala City the collection rate is only 65%, and in some developing countries it is as low as 50%. Low collection rates mean that a large volume of waste is disposed of by “unofficial” means, including dumping on land and in waterways, household incineration, and street litter. The blockage of drains and sewers by garbage is a serious problem in many cities.

Even where collection rates are high, disposal still poses enormous problems, especially in densely populated countries where landfill sites are scarce. A common alternative is to use solid waste for “land reclamation”. For example, the largest dump site in Manila has so far reclaimed 34 hectares of Manila Bay.

[1] Except where indicated otherwise, the data source for this section is World Resources Institute (1996), *World Resources: A Guide to the Global Environment*, Oxford University press, New York.

4.2 KEY ISSUES

The solid waste management problem is not simply one of waste disposal. It is crucial to view the waste management problem as one involving a flow of materials that begins with the production and consumption of goods. It is helpful from a policy perspective to partition that flow of material into four main stages:

- waste generation;
- waste separation and diversion;
- waste collection; and
- waste disposal.

These four stages are illustrated in Figure 4.1. The figure also illustrates the main policy issues pertaining to each stage. We will discuss each stage in turn.

Waste Generation

The key issues at this stage of the waste stream are the volume, composition, and source mix of waste.

The Volume of Waste

The volume of waste generated is a direct function of the volume and type of material used in the production and packaging of goods. It is important to recognize that the full social cost of consuming these goods includes the cost of any necessary subsequent disposal. If that cost is not fully reflected in the private cost of consuming (in terms of the price paid for a good at the point of purchase, plus the private cost of disposal), then the volume of material entering the waste stream will generally be excessive relative to what is efficient.

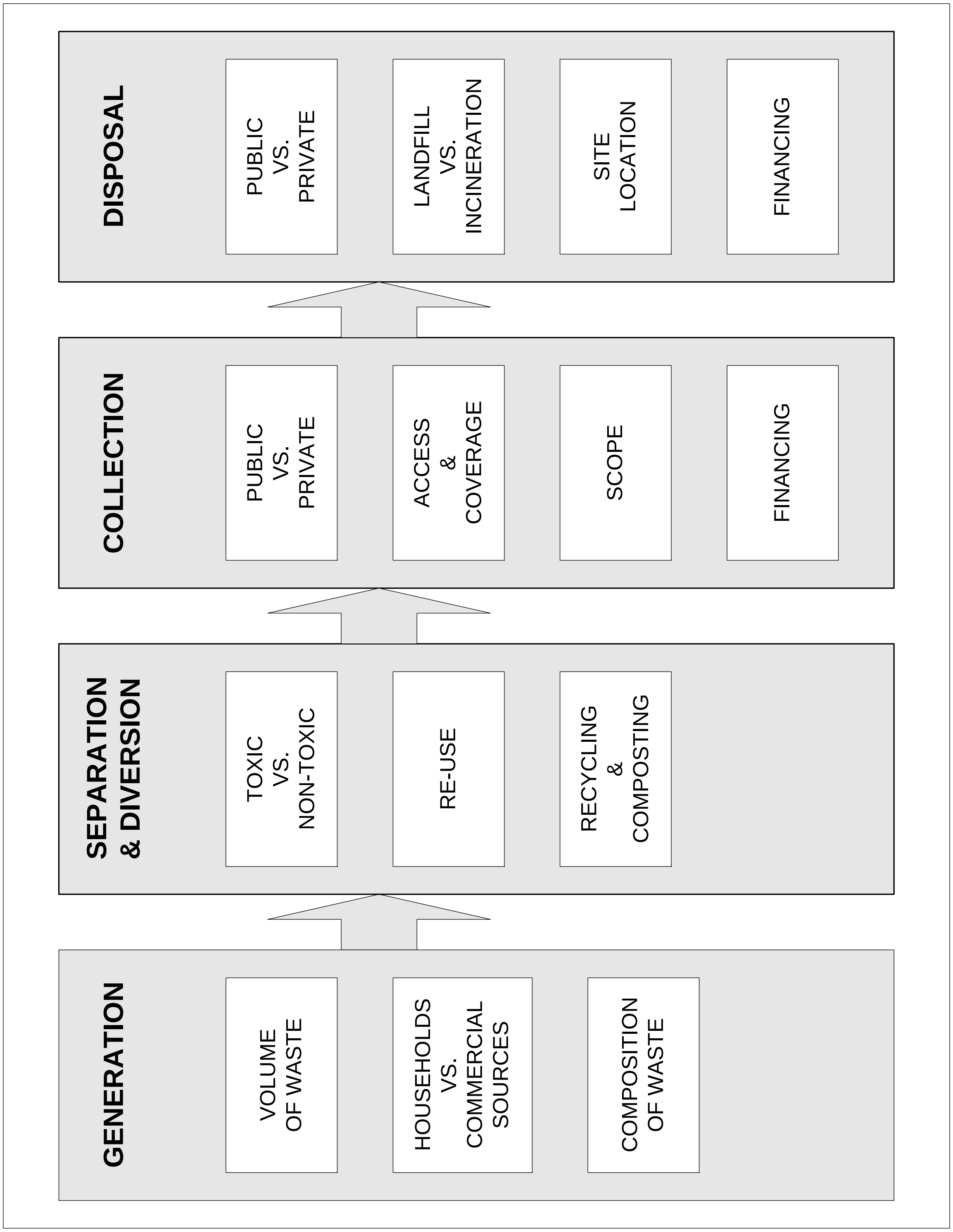

Figure 4.1

Key Issues in Solid Waste Management

The Source Mix of Waste: Households vs. Commercial Sources

The share of waste produced by households versus commercial sources is also important from a policy perspective, since it determines to a considerable degree the concentration of waste sources for collection purposes, and it also determines how the generation of waste will respond to various policy instruments; households and commercial sources are likely to respond quite differently to a given instrument. Moreover, the incentives at play are likely to differ across different types of commercial sources, such as manufacturing industries, merchants, construction sites, public markets, etc.

The Composition of Waste

The breakdown of waste between households and commercial sources, and the breakdown across different commercial sources, will also affect the composition of the waste entering the waste flow. Of particular importance are the distinctions between toxic and non-toxic waste, and biodegradable and non-biodegradable waste. The environmental impacts, the appropriate collection methods, and the best disposal methods for these different waste types are generally quite different. In the poorest urban areas, garbage sometimes becomes mixed with fecal matter, which can pose serious health risks to wastepickers and official collectors. If the cost of disposal according to waste type is not reflected in the private cost of consumption then the composition of material used in the production of that good, and in its packaging, will generally not be efficient.

Waste Separation and Diversion

The diverse composition of waste entering the waste stream makes the separation and possible diversion of waste a critical aspect of solid waste management. In an ideal world, all waste would be finely separated into waste classes according to its suitability for reuse and recycling, and otherwise according to the most appropriate disposal method for the waste type. However, it is important to bear in mind that separation of the waste stream into different waste classes is costly. The appropriate degree of separation must be determined according to a careful consideration of the attendant costs and benefits, rather than according to some preconceived notion of what is “environmentally sound”. In particular, the diversion of reusable and recyclable waste from the waste stream should generally *not* be pursued as a waste management goal in its own right. Separation and diversion is worthwhile only if the social cost of disposal exceeds the net cost of separation and diversion. Nonetheless, waste separation and diversion has a key role to play as part of an integrated waste management strategy. The optimal degree of separation and diversion will depend on the particular circumstances of the urban area involved.

Toxic vs. Non-Toxic Waste

At least some degree of separation will generally be appropriate for toxic and non-toxic material, and complete separation of the most dangerous waste types, such as radioactive waste, will almost always be called for. Separation of toxic and non-toxic waste usually has significant benefits both in terms of subsequent separate disposal, and in terms of choosing a collection method that takes proper account of the associated exposure to risk.[2]

Material Re-Use

Much of the material entering the waste stream is potentially suitable for reuse, either by the primary source of the waste, or by a second party. The preponderance of wastepickers in many developing country cities is clearly indicative of that fact. The important policy issue relates to whether or not there is enough reuse of waste material based on the costs and benefits involved. For example, wastepickers act on the basis of private costs and benefits, but the social costs and benefits of their work may be very different from those private costs and benefits. In particular, the wastepickers bestow an external benefit on other urban dwellers by reducing the amount of material requiring costly disposal.

Recycling

The degree of recycling (and composting) should similarly be based on a proper assessment of costs and benefits. The fact that a waste type is recyclable does *not* mean

[2] Issues relating to the disposal of toxic waste are discussed in more detail in Chapter 5.

that it should necessarily be recycled. In particular, if the net social cost of recycling a particular material (that is, the full cost of recycling less the value of the recycled material) is more than the social cost of disposal in a landfill, then the material should be landfilled rather than recycled. The key policy issue relates to whether or not the private costs and benefits associated with recycling reflect the true social costs and benefits.

Waste Collection

The main policy issues with respect to waste collection relate its implementation and financing.

Public vs. Private Collection

The institutional arrangements for collection, in terms of the mix of public versus private service, and the nature of contracts between public authorities and private agencies, will generally have important implications for cost-effectiveness, for the scope and quality of service, and for the effectiveness of policy instruments targeted at other stages of the waste stream.

Collection Coverage

Collection coverage in many developing countries is very limited. This is due to a number of factors, including the difficulty of physical access to many areas due to narrow and unpaved street; the large number of urban settlements that fall outside official city boundaries (and therefore outside the jurisdiction of any particular local authority); and the significant cost of providing collection service even where access is possible. The use of central collection points, to which households cart their own garbage, alleviates some of the problems associated with accessibility and collection costs, but these central collection points have important drawbacks: they discourage the use of the collection service because household dumping or incineration is often easier for the household than transporting their trash to the collection site; and they can often become *de facto* dump sites, with the attendant problems of pests, vermin and noxious odors (especially in the hot climates that characterize many developing countries).

An important consideration with respect to collection coverage relates to “good” versus “bad” equilibria. There is some evidence to suggest that people are more likely to dump their waste if the area is already very dirty and litter-strewn. That is, the dirty and littered state of some cities, and of some sections of cities, can be self-perpetuating. The provision of even incomplete collection services can therefore potentially have a significant impact on dumping and litter levels by shifting an area from a “bad” (dirty) equilibrium to a “good” (clean) equilibrium.

Collection Scope

If programs are put in place to separate waste types in the waste stream then there arises the question of whether or not collection service should extend to recyclables, separate from the collection of garbage.

Financing

Financing the cost of providing collection services poses a serious obstacle to service expansion, both in terms of scale and scope. Local authorities usually have very modest tax bases, and are often unable to collect taxes at all in the poorest areas, especially when the poorest settlements lie outside official city boundaries.

Waste Disposal

There are a number of important issues with respect to waste disposal, relating both to institutional arrangements and to disposal technology.

Public vs. Private Ownership and Management

There is no particular reason why the same institutional arrangement should apply to both collection services and disposal sites, and the private construction and ownership of waste disposal facilities is a potentially sensible arrangement under some circumstances.

Incineration vs. Landfilling

The suitability of one disposal method over another depends on a host of factors, the most important of which are the availability of proximate sites relative to population concentrations; the geographical characteristics of the region, especially with respect to air patterns, and ground and surface water drainage patterns; and the composition of the waste. Unsanitary landfills can pose serious surface and groundwater contamination risks, especially if they are used for toxic waste disposal. The use of garbage for "land reclamation" can cause pollution to surrounding coastal areas, and can render the "land" too contaminated for any valuable eventual use.

Site Location

There is an important tradeoff between the cost of transporting waste to areas beyond population concentrations, and the cost associated with locating disposal sites where large numbers of people are exposed to the noxious fumes and potentially far more dangerous hazards.

Financing

Lack of financing for the construction and operation of disposal facilities means that state-of-the-art landfill and incineration systems, whose associated environmental impacts are much lower than for older technologies, may be out of reach for many developing countries, especially in urban areas outside the relatively wealthy megacities.

4.3 POLICY OPTIONS

The key policy principle for solid waste management is to identify incentives at the various stages of the waste stream, and to target instruments where private costs and benefits differ from social costs and benefits. Figure 4.2 illustrates a selection of the most important policy instruments that can be used at the four stages of the waste stream. Each of these are discussed in turn.

Policies Options at the Waste Generation Stage

The basic idea here is to use policy instruments to change incentives with respect to the volume and composition of waste generated.[3] The main policy options are the following:

Product Taxes

Product taxes based on the social cost of disposal of the associated waste will shift demand towards goods that are less solid waste-intensive. The extent to which that demand pressure translates into pressure on producers to change the nature and packaging of their products depends to a considerable degree on market structure and the size of the jurisdiction over which the policy is applied. Product taxes applied at the level of an individual urban authority are likely to have no effect on production practices. Moreover, product taxes affect waste disposal practices only indirectly, in the sense that they change incentives with respect to the type of product purchased according to its waste profile. However, once a product is purchased, the product tax paid has absolutely no effect on incentives with respect to disposal method choice for the purchaser; a product on which a tax has been paid is just as likely to end up being dumped as one on which no tax has been paid.

Eco-Labeling and Education

The provision of information about the waste profile of products can be a valuable tool for harnessing the potential power of “green consumerism”. However, information disclosure should not be relied upon as the sole policy measure, since the external costs associated with purchase decisions, even by “green consumers”, are not being addressed.

Packaging and Materials Restrictions

The objective of standards with respect to product materials and packaging is to directly control the material entering the waste stream. Restrictions may relate to the type of

[3] It is important to point out that the policy concern here is waste generation, and not consumption *per se*.

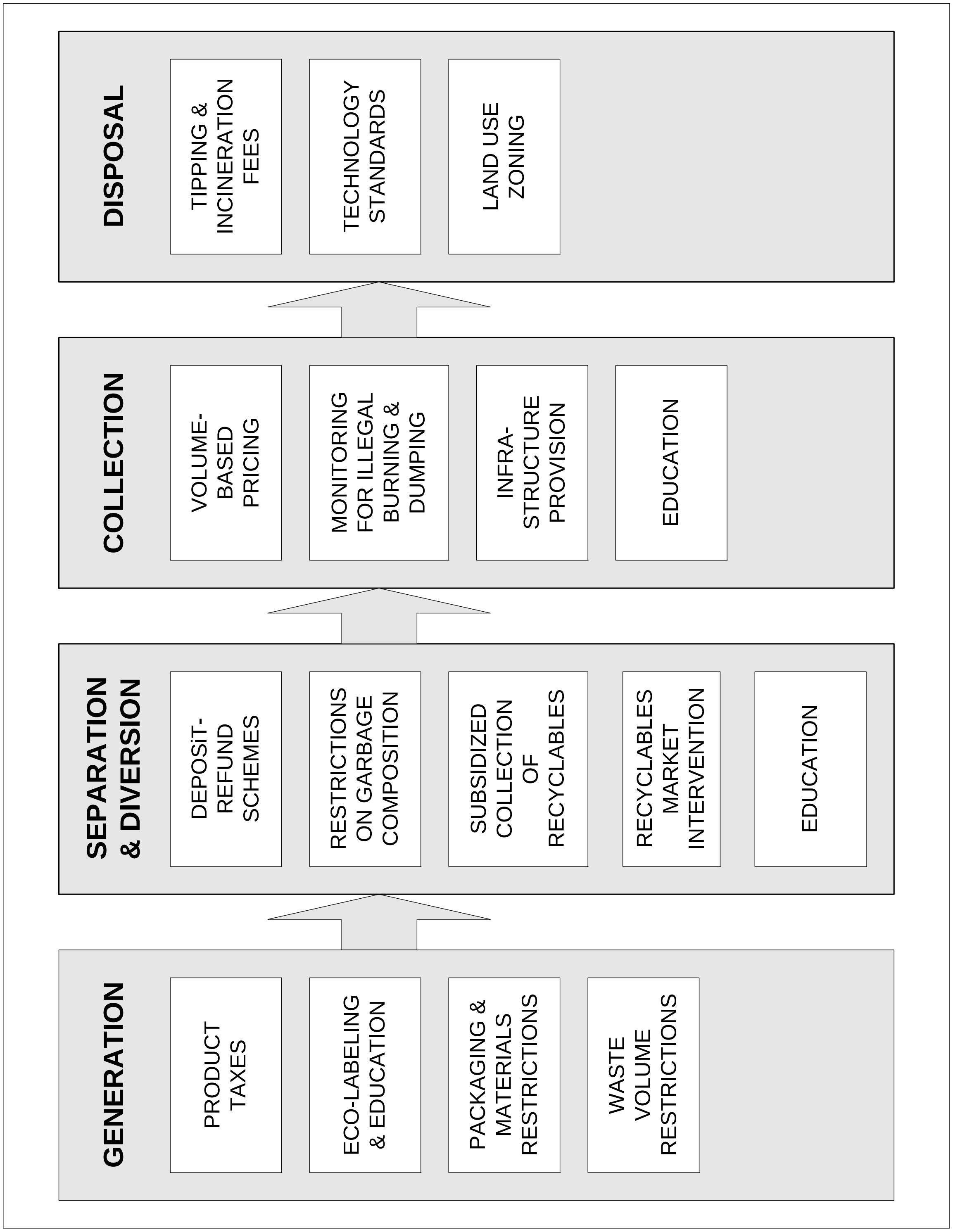

Figure 4.2

Policy Options for Solid Waste Management materials that can be used, or they may relate to requirements for retailers and producers to accept packaging returned by the consumer. One important consequence of such restrictions is that a consumer who is willing to pay the full social cost of the product he prefers will not be able to do so if it does not satisfy the required standards. As with all command-and-control measures, this means that particular waste reduction targets implemented through materials restrictions will not be achieved at least cost. It should also be noted that materials and packaging restrictions cannot be effectively applied at the level of an individual urban area.

Waste Volume Restrictions

Waste volume restrictions are a particularly blunt instrument for affecting the volume of waste generated. Imposing restrictions on the volume of waste eligible for collection (the typical approach to applying waste volume restrictions) will in many instances simply encourage dumping and household incineration.

Policy Options at the Separation and Diversion Stage

Policies applied at this point are intended to affect incentives with respect to waste stream decisions once product purchases have been made. They are not aimed at reducing the volume of waste, although they do create incentives with respect to the composition of waste generated.

Deposit-Refund Schemes

Deposit-refund schemes can have a significant effect on incentives with respect to waste stream decisions. Under such schemes, a deposit paid on product packaging or other material that remains after consumption of the product (including used batteries, used tires, etc.) is paid at the time of purchase, and is refunded only if the material is returned to a designated site (which might be the store from which the product was purchased or some separate collection point). The idea is to divert recyclable and reusable material from the waste stream.

Deposit-refund schemes are an excellent policy choice for implementing waste diversion targets. Moreover, if the deposit is set equal to the difference between the marginal social cost of garbage collection plus disposal, and the net marginal social cost of recycling, then the scheme will implement the efficient degree of waste diversion. In particular, the material will only be returned if the cost of diversion (including separation and storage costs) is less than the deposit, and hence, less than the social benefit of diversion.

Deposit-refund schemes also make effective use of markets. In particular, private services naturally develop through which dealers collect refundable material from people unwilling to incur the inconvenience of returning the material themselves, to the mutual benefit of both parties.

It is worth pointing out that deposit levels and targeted return rates cannot be set independently, since one is a market equilibrium response to the other: a higher deposit will elicit a higher return rate.

Restrictions on Garbage Composition

Policies of this type put restrictions on the type of materials that can be included with garbage. Such policies are often used to prohibit the disposal of recyclable material as garbage, and are thereby intended to encourage waste stream diversion. For this purpose, garbage composition restrictions are a decidedly inferior instrument to deposit-refund schemes, for two reasons: first, they require explicit monitoring; and second, they do not allow people with different costs of waste diversion to behave differently, as required for efficiency. Moreover, these types of restrictions can encourage the elicit dumping and incineration of the banned materials.

However, in some instances, garbage composition restriction can be a valuable adjunct to other polices. In particular, it is generally good policy to ban highly toxic waste from being discarded as garbage, since the optimal degree of diversion for such waste is likely to be one hundred percent. Nonetheless, a deposit refund system for such materials can help to create incentives for compliance with a material ban.

Subsidized Collection of Recyclables

Subsidized collection of recyclables is the subsidy equivalent of a deposit-refund scheme: the deposit-refund scheme imposes a penalty (the foregone deposit) if the material is not returned for recycling, while the subsidized collection of recyclables rewards recycling directly. Subsidized recyclables collection is an inferior policy to a deposit refund scheme, for two reasons: first, it is revenue-negative for the subsidizing government; and second, it can actually have a perverse effect on the overall volume of waste, since the subsidy on recycling effectively reduces the cost of waste disposal for the consumer of the product.

One important qualification is needed on this judgement of recyclables collection subsidies. If the subsidy is attached to the fixed costs of recyclables collection rather than the marginal cost, then a subsidy can help to overcome a potential inefficiency associated with private incentives in the face of economies of scale.[4]

Intervention in Markets for Recyclables

Recycling is sometimes subsidized indirectly through intervention the markets for recyclables, either in the form of direct subsidies or through mandated recycled material content requirement in some products (as is sometimes used in paper production). There are a variety of arguments, some more dubious than others, for subsidizing particular industries, and there is nothing particularly special about the recycling industry that raises any different arguments in favor of subsidization. The most compelling argument for (strictly limited time) subsidization of recycling is an "infant-industry" argument; a short-term subsidy *may* sometimes be justified in order for the industry to overcome fixed start-up costs.

---

[4] Efficiency requires the equality of marginal costs and benefits. The existence of significant fixed costs can mean that marginal cost and marginal benefit are equated where total private cost is greater than total private benefit even though total social benefit exceeds total social cost. (This is the so-called "natural monopoly problem").

Education

Education is an important adjunct to all policies, but as noted earlier, it should not be viewed as a substitute for incentive-based policies.

Policy Options at the Waste Collection Stage

The key policies here are directed at influencing the private costs of socially optimal waste disposal versus dumping or household incineration (where "socially optimal" waste disposal refers to the disposal method with the lowest social cost).

Volume-Based Pricing

This instrument attaches a price to the disposal of garbage and so creates incentives for garbage reduction, both through waste diversion and through reduced waste generation. In principle, the collection fee should be set equal to the marginal social cost of collection and disposal. In many circumstances, volume-based pricing is an excellent policy instrument, and it has been very successful in many applications in OECD countries.

However, there are two potential drawbacks with this policy instrument. First, it can induce dumping and household incineration since these disposal methods may be a lower cost alternative for many people. This is especially likely if an area is currently in a "bad" equilibrium with respect to dumping, since the social stigma associated with dumping is much less in that case. Second, volume-based pricing, as opposed to weight-based pricing may encourage garbage compression.[5] However, this may not necessarily be a serious problem, because some of the costs of garbage disposal are in fact more closely related to volume than to weight.

[5] When volume-based pricing was first introduced in Seattle, Washington, it precipitated the infamous "Seattle stomp", wherein householders would stomp on their garbage in an effort to compress it, and thereby avoid a higher collection fee.

An additional consideration in favor of volume-based pricing is that it is revenue-positive for the collecting authority, and can therefore help to defray the financial costs of collection and disposal.

Monitoring for Illegal Dumping and Incineration

Some degree of monitoring is needed as an adjunct to volume-based collection fees in order to limit the avoidance of collection fees through unofficial disposal methods. The costs of monitoring can be reduced by fostering community reporting.

Policy Options at the Disposal Stage

Policies at this stage are not designed to influence incentives for households and other waste sources; rather, they are designed to ensure that disposal sites are located and constructed in an appropriate manner. Note that the use of tipping fees (imposed on private waste collectors) can help to encourage disposal at least-cost facilities if the tipping fees are chosen to reflect the true cost of disposal, inclusive of the costs associated with noxious fumes to neighboring residents, and any other air or water pollution associated with poor quality facility design or construction.

4.4 EXAMPLES OF BEST PRACTICE

Subsidization of Wastepickers in Cairo, Egypt and Madras, India

In Cairo, the Zabbaleen people have traditionally been wastepickers. The wastepickers provide a valuable service, by diverting recyclable and reusable material from the waste stream. To encourage this activity, programs were introduced during the 1980s to facilitate more efficient recycling by providing these people with machinery to convert rags and plastics into useful secondary materials. The program constitutes a subsidy on the fixed costs of recycling that would otherwise have been a barrier to entry for the Zabbaleen people.

In Madras, around 3000 tonnes of solid waste is produced every day. In an attempt to alleviate this growing problem, central collection containers were placed at the ends of streets, which were then collected periodically by city trucks. However, the scheme was not a great success, due largely to the inconvenience to households associated with carting their own garbage to the collection containers. Under a program known as "Exnoras" (for EXcellent, NOvel and RAdical ideas for urban environmental management), wastepickers were employed formally as "street beautifiers" and provided with tricycle carts for the collection of waste door-to-door. The street beautifiers are paid a fee by the households on the street. There are now over 900 "Civic Exnoras" in Madras, each comprising groups of 75-100 families jointly funding a street beautifier.

Volume-Based Collection Fees in Inchon, Korea

Inchon Metropolitan City is an international trading center located on the middle-west coast of the Korean peninsula. Over the period 1985-1994, the population increased by almost 60% to over 2.2million. Gross regional domestic product grew at 5.9% per annum over that period. This growth has resulted in a major solid waste management problem. The construction of new landfills and incinerators has been strongly resisted by local residents.

As part of a solution, volume-based collection fees were introduced. It began as a pilot project in 1994 and was extended to the entire metropolitan area in 1995. The fee program has resulted in a 30% reduction in garbage collected, and a 43% increase in the collection of recyclable and reusable waste (excluding collection by private dealers). Collection fees are set at a lower rate in low income areas. The revenue collected from the program has allowed the Waste Control Division of the city to become self-financing.

Resource Recovery Program in Manila, Philippines

Metropolitan Manila has a population of around 8 million, and generates 3500 tons of solid waste every day. Inadequate collection has transformed the local Pasig River into an informal garbage dump. Leachates from local landfills is an important contributor to the contamination of water supplies and fish-yielding waterways.

The cities and towns that comprise metropolitan Manila cooperated to coordinate a waste stream diversion program, whereby local junk dealers are subsidized to hire “eco-aides” who collect paper, plastics, bottles, cans and car batteries door-to-door from households. Households are paid for the collected materials by the eco-aides, who are in turn paid by the junk dealers. The subsidy takes the form of providing the junk dealers with green-painted pushcarts, green shirts for the eco-aides, plus ID cards for the eco-aides and the dealers. A publicly funded information program has informed households about the program, eligible items, and the prices paid.

The program works because households are paid for the collected material, thereby giving them an incentive to divert it from the waste stream. The subsidy helps to defray the fixed costs of the collection, which could otherwise undermine a valuable service. This form of subsidy is a much better idea than a subsidy paid on the price of collected items.

A Deposit-Refund Scheme in Taiwan

In 1988, Taiwan began the introduction of a recovery-recycling program for several types of solid waste, including PET (polyethylene terephthalate) bottles, glass bottles, aluminum cans, waste paper, used tires, lubricant oils, mercury cell batteries and pesticide containers. The program is to be supported by a deposit-refund scheme. The first application was to PET bottles. The return rate in the first year was around 41%, and had climbed to almost 80% by the fourth year (1992).

The key element to the success of this scheme has been the setting of the deposit fee, which has been high enough to create incentives for container return. In contrast, a similar scheme in Korea has been much less successful, largely because the deposit fee has been set too low.

5. INDUSTRIAL EFFLUENT AND HAZARDOUS WASTE

5.1 SCOPE OF THE PROBLEM IN DEVELOPING COUNTRIES

Global trade liberalization over the past twenty years has fostered enormous growth in the manufacturing sectors of many developing countries, especially in South East Asia and Latin America. Much of that industry is relatively polluting, and most of the growth has been concentrated in urban areas. For example, three quarters of Thailand's factories dealing with hazardous chemicals are located within the Bangkok metropolitan area and its neighboring provinces. This concentration of industry has precipitated a growing industrial pollution problem in the urban areas of many developing countries.

Industrial sources contribute to urban pollution in a variety of ways. In this chapter we focus on industrial effluent and hazardous waste. To gain some idea of the scale of the regulatory problem, consider the case of Jakarta. It is estimated that there are currently over 30,000 industrial effluent outfalls into Jakarta Bay. One measured consequence of this pollution is a mercury content level in commercial fish species from Jakarta Bay that far exceeds World Heath Organization standards. A host of other consequences go unmeasured, and in many cases are entirely unknown. Most of these effluent outfalls are associated with small factories whose discharge goes almost entirely unmonitored. The situation in Jakarta is typical of many major urban areas in the rapidly industrializing countries of the developing world.

5.2 KEY ISSUES

Major Pollutants: Sources and Effects

A wide variety of industries contribute to industrial effluent and hazardous waste. Among the most important are:

- cement plants;

- chemical plants;
- dry cell battery production;
- food and beverage industries;
- lead smelting;
- metal finishing and electroplating;
- paint and solvent production;
- pharmaceutical plants;
- pulp and paper mills;
- refineries;
- rubber processing;
- tanneries; and
- textile manufacturing.

Effluent from these sources contains various organic and inorganic compounds, including:

- acids and caustics;
- biological oxygen demand (BOD) intensive substances;
- grease and oil;
- heavy metals, such as cadmium, chromium, lead and mercury;
- organochlorines, including polychlorinated biphenyls (PCBs) and dioxins;
- suspended solids; and
- various synthetic organic compounds.

Some of these toxins, including the organochlorines and most of the heavy metals, are known to cause physiological and genetic damage, reduced fertility rates, and birth defects, both in humans and other animal species. These toxins are particularly insidious because they are biocumulative (that is, they accumulate in animal fats), and so tend to become concentrated in animals at the top of the food chain (including humans). They also tend to accumulate in silt, where they can continue to contaminate waterways and bays for decades, even long after new discharges have been stopped. The environmental impacts of many other inorganic and synthetic organic compounds are entirely unknown, because they have not been fully studied.

Point Source versus Non-Point Source Pollution

The difficulty of regulating industrial effluent is compounded by the fact that much of the pollution originates from non-point sources; that is, the effluent cannot be traced to an identifiable point, such as a discharge pipe. Chemical pollution finds its way into drains and sewers through a variety of routes, including street runoff, unmonitored dumping, and infiltration from contaminated groundwater. Atmospheric emissions also contribute to non-point source water pollution through the contamination of precipitation. Non-point source pollution can be particularly difficult to regulate because policy instruments cannot be targeted directly at the source of the pollution, since the source is unidentifiable.

The Mixing of Hazardous and Other Solid Waste

The appropriate method of disposal for non-toxic solid waste, such as paper and food scraps, is very different from that for hazardous waste, such as certain building materials, contaminated materials (such as paint rags and fabric filters), discarded batteries, industrial ash, medical waste and radioactive waste. In particular, the disposal of hazardous waste in landfills can cause surface and groundwater contamination, and soil contamination, while their disposal in low-temperature incinerators, designed for non-toxic materials, can produce dangerous atmospheric emissions. To reduce the risk of environmental damage, hazardous waste must be treated prior to disposal (such as in the removal of acids and heavy metals from dead batteries), or incinerated at very high temperatures, or stored or buried in sealed, durable containers. Implementing this differential treatment of waste requires that waste types be separated prior to collection, since it is generally too costly to separate waste by type once it is taken to disposal sites as an aggregated mixture.

Regulation: Balancing Costs and Benefits

The regulation of industrial effluent and hazardous waste involves a host of issues, but first and foremost is the specification of a regulatory goal. In particular, what level of abatement from current pollution levels is appropriate? The answer to this question must be based on a careful assessment of costs and benefits. For some of the most toxic substances, a proper cost-benefit analysis is likely to indicate a policy goal of zero pollution. However, for other substances, the balance of costs and benefits will call for reduced but nonetheless positive levels of pollution, at least in the short run.

The Importance of Cost-Benefit Analysis

Striking a balance between costs and benefits requires the measurement of abatement costs and environmental damage for a vast array of substances. This is a costly procedure in itself, and one fraught with considerable uncertainty, especially on the damage side. Measurement studies of this type are uncommon even in wealthy developed countries; in many developing countries they are simply out-of-reach. However, the long-run costs of failure to conduct proper cost-benefit analyses can far exceed the short-run costs of conducting the studies. In particular, regulatory goals that are too lax can allow the continuance of extensive environmental degradation and adverse health effects, whose associated costs may far outweigh the costs of controlling the pollutants involved. Conversely, the imposition of excessively strict standards can unduly inflate production costs for the regulated industries, and undermine their competitive positions in the global market. This adverse impact on industry flows through to shareholders, workers and consumers, through foregone profits, lower wages and lost employment opportunities, higher prices and reduced government tax revenues.

The scope of the regulatory problem in many developing countries relative to the resources available means that regulatory priorities must be set. Ideally, this prioritization should be based on estimated net benefits given whatever prior information is available. A valuable tool to assist with the setting of priorities is the sharing of information among developing countries, and the observation of experiences from other parts of the world. Well coordinated investigative programs within a region can allow a group of countries to markedly enhance their knowledge base at a fraction of the cost involved if individual countries act independently. While the transportability of results from a study done in one country to a situation in another country is limited, there are nonetheless significant gains to be made through information sharing. Similarly, the observation of experiences in other countries can be valuable for setting priorities, although it is important to stress that the regulatory goals of one country may not necessarily be appropriate for another country whose economic and environmental characteristics may be very different.

Irreversibility and Uncertainty

It is sometimes claimed that the combination of irreversibility and uncertainty with respect to environmental impacts, dictates a zero tolerance rule for some pollutants, especially for long-lived cumulative pollutants whose effects are largely unknown. This proposed policy rule reflects the so-called “precautionary principle”. However, this “principle” is in fact a very poor guide to policy, and is not an appropriate substitute for proper cost-benefit analysis. The main shortcoming of the “precautionary principle” is that uncertainty and irreversibility often applies to both the damage side *and* the abatement cost side of a pollutant regulation problem. In particular, the adoption of expensive abatement and production technology, or the shut-down of an industry, is usually irreversible; that is, it cannot be undone without significant cost if it is later discovered that a pollutant is less dangerous than the worst-case scenario envisaged. Moreover, uncertainty with respect to future technologies, combined with the costs of new technology adoption, means that installing the best available technology today may preclude the installation of an even better technology that becomes available tomorrow. A proper cost-benefit analysis must take account of uncertainty and irreversibility with respect to environmental damage *and* abatement measures.

The over-zealous allocation of scarce to pollution abatement on the basis of the “precautionary principle” means that other environmental problems, and other social and economic problems more generally, that may in fact be more pressing, and more deserving of resources, must go unaddressed. The more appropriate approach to regulation is a cost-benefit framework, encompassing a proper treatment of risk and uncertainty.

Short-Run versus Long-Run Regulatory Goals

Regulation is necessarily a dynamic process. Environmental goals that are appropriate today, based on current knowledge, current wealth levels and current technologies, may not be appropriate in the future. The key to good policy design in a changing economic setting is to set long term goals based on expectations about future conditions, to revise those goals as future conditions are realized, and to implement the transition towards long-term goals with a planned profile of shorter-term goals. There are two primary advantages to this approach. First, it allows the pursuit of long-term goals while at the same time ensuring that shorter-term goals are appropriate for the prevailing conditions. Second, an announced transition phase towards long-term goals can drastically reduce the costs of achieving those goals, since it allows firms to adjust their technologies and practices more gradually.

Cost-Effectiveness

We have argued that regulatory goals should be based on full cost-benefit analyses, but political impediments and the costs of conducting full analyses will often mean that regulatory targets are set without due consideration to costs and benefits. Even in these circumstances, economic principles still have an important role to play in guiding the implementation of those goals. In particular, regulation should be cost-effective. That is, whatever regulatory goal is set, it should be implemented at least cost. This will often favor the use of economic instruments over command-and-control instruments.

5.3 POLICY OPTIONS

Policy Options for Managing Industrial Effluent

The main types of policy instruments available for implementing policy goals with respect to industrial effluent are:

- Command-and-control policies:
    - performance standards; and
    - design standards.
- Economic instruments:
    - effluent fees and abatement subsidies;
    - effluent trading; and
    - production input taxes and deposit refund programs.
- Other instruments:
    - political suasion; and
    - information disclosure.

These policy instruments are discussed in general in Chapter 2 (section 2.3) in the context of managing air pollutants, so we will confine discussion here to the relative merits of the various instrument options for managing industrial effluent.

Command-and-Control

There are two main shortcomings with command-and-control policies. First, they generally do not achieve aggregate goals at least cost, because standards are generally set uniformly without regard for individual abatement costs. Second, that they do not create on-going incentives for effluent reduction because units of effluent within the allowed standards are not priced. Their main advantage is that they allow the quantity of effluent to be controlled directly (assuming compliance).

Economic Instruments

Effluent fees (and abatement subsidies) give a firm more flexibility with respect to effluent volume than a command-and-control standard. This latitude facilitates attainment of least-cost abatement, but at the same time removes from the regulator direct control over effluent quantities. In principle, this is not necessarily a problem, since the effluent fee should ideally be set equal to the value of marginal damage, and quantity is then determined endogenously as a function of abatement costs. However, in reality, specific quantity targets are often set for political reasons, or due to limited information on costs and benefits.

An alternative economic instrument that stipulates aggregate effluent quantities directly, but nonetheless sets a price on effluent, is an effluent trading program.[1] Effluent trading works best where there are many polluters (thereby allowing a deep market for permits), and where environmental damage from a particular type of effluent is largely independent of the location of the source (since this means that trades can occur across sources with no net change in environmental damage). For example, the discharge of heavy metals and organochlorines into a particular body of water by a large number of plants, concentrated in one area, is a good candidate for least-cost control through effluent trading.

In establishing either an effluent fee system or an effluent trading program, it is important to target the source of environmental damage. In most instances, the source of damage is the quantity of polluting substances released per time period, not the total quantity of effluent (which may be mostly water), nor the concentration of the substance in the effluent. Setting regulations in terms of total effluent quantity or substance concentrations can simply lead to "dilution" responses by firms, with no change in the actual quantity of polluting substance discharged. The same consideration applies to command-and-control effluent standards.

There is also a potential role for input taxes and deposit-refund schemes in the management of effluent. Input taxes are levied on particular inputs into production, whose use results in the discharge of a particular type of effluent. For example, the use of chlorine for bleaching in pulp and paper mills leads to the presence of organochlorines in the effluent from those mills. Putting a tax on chlorine as an input creates an incentive against its use, and so indirectly, creates an incentive to reduce the flow of organochlorine effluent. Similarly, a deposit-refund scheme on certain types of industrial

[1] Effluent trading can be made operational either through a tradeable effluent permit program or a tradeable effluent reduction credit program.

inputs can discourage their eventual discharge through post-production effluent, since many substances, such as heavy metals, can be recovered from effluent prior to its discharge. A deposit-refund system enhances incentives for that recovery.

It must be stressed that pricing or restricting the use of inputs is only an indirect approach to managing industrial effluent, since there may not be a direct correlation between input use and effluent. However, monitoring and enforcement considerations may favor input regulations. This is particularly true where non-point sources are a significant contributor to total effluent discharge, since it is generally not possible in such cases to manage effluent at source. Even with respect to identifiable point sources, monitoring the use of inputs, which usually have a market trail that can be traced, is sometimes easier than monitoring end-of-pipe effluent.

Other Policy Instruments

Political suasion and information disclosure (such as eco-labeling programs, "polluter blacklists", and toxic inventory release programs) are valuable adjuncts to other forms of regulation but in general they do not provide an adequate substitute for direct measures. Nonetheless, they can be very useful arrows in a comprehensive policy quiver.

Policy Options for Managing Hazardous Waste

The most common policy goal for many types of hazardous waste (or "scheduled waste") is to ensure its proper disposal, although reducing the quantity of waste produced should also be an important consideration. The setting of standards for labeling, storage, transportation and final disposal of these waste types are the main policy instruments available. These standards must be enforced by threat of penalty for non-compliance.

This command-and-control approach can be usefully supplemented in some instances with deposit-refunds schemes. These schemes are most applicable for hazardous waste management where there is a clear relationship between the inputs used in a production process and the hazardous waste generated. A deposit paid on the inputs in question is refunded only if the hazardous waste is disposed of in an appropriate manner (such as at a licensed incineration or waste processing plant).

Security deposits are a variation on a deposit-refund scheme, and these can be particularly useful for creating incentives for exercising due care during the storage and transportation of hazardous waste. A security is posted prior to storage and transportation, and that security is refunded only if the waste eventually reaches a disposal facility without accidental leakage or spillage.

One of the main problems facing developing countries in the management of hazardous waste is the cost of constructing and operating disposal facilities. Incineration, waste processing, and secure landfill disposal are all extremely expensive. The use of taxes and fees on the production and disposal of hazardous waste can assist with the financing of these costs, and at the same time can create incentives for reduced waste generation. However, such taxes and fees must be used carefully, or else they can induce dumping. In particular, imposing a high disposal fee at a secure landfill can create an incentive for firms to find “alternative” disposal means, especially if there is limited monitoring. This perverse effect of a disposal fee can be moderated if it is used in conjunction with a deposit-refund program, since the loss of a deposit raises the private cost of illegal disposal. Moreover, where there is a clear relationship between inputs and hazardous waste generated, disposal-financing taxes can be imposed on inputs without distorting hazardous waste disposal choices. Requiring that records be kept of input purchases can also assist with monitoring the disposal of hazardous waste generated.

The Basel Convention on Trade in Hazardous Waste

The Basel Convention restricts the international export and import of hazardous waste between signatory countries. The Convention was adopted in March 1989 and came into force in May 1992. An amendment to the Convention was adopted in September 1995 that bans the export of hazardous waste from OECD countries to developing countries. Such restrictions are not without controversy, but all policy consideration with respect to hazardous waste must be cognizant of the restrictions and limitations imposed by the Basel Convention.

Monitoring and Enforcement Options

No environmental regulation is effective if it is not complied with, and fostering compliance generally requires monitoring and enforcement (M&E). The costs of M&E are typically not systemically higher or lower under any particular form of policy instrument, though as noted above, input taxes and restrictions can be useful for managing non-point source pollutants, and compliance with design standards may sometimes be easier to monitor than compliance with performance standards.

Equally important is the design of the M&E policy itself. There are a number of key issues to consider in this respect. First, polluters respond to the magnitude of the *expected penalty* for non-compliance. Roughly speaking, the expected penalty is equal to the value of the actual penalty for non-compliance weighted by the probability of being discovered in non-compliance. Thus, the expected penalty can be made higher (and hence more effective) by increasing either the actual penalty, or the monitoring probability, or both. Since monitoring is costly, it might appear that the best policy is to set the monitoring probability low, and the actual penalty high. However, the scope for increasing the penalty size is limited by the wealth of the polluter (since the highest fine that can be imposed on a firm is that which will send it bankrupt), and by the incentives created for penalty avoidance and evasion when large fines are levied. Thus, the M&E policy must carefully balance the size of the actual penalty and the probability of enforcement.

A second key issue with respect to M&E policy design relates to use of *self-reporting*. Often much maligned by environmentalists, self-reporting can be a valuable arrow in the M&E policy quiver. The key to a successful self-reporting policy is to set the penalty for non-compliance relatively low, and the penalty for mis-reporting very high. This ensures that a firm in non-compliance has an incentive to report truthfully, which allows the implementation of an emergency clean-up response if warranted. Setting too high a penalty for non-compliance versus mis-reporting gives the firm an incentive to hide its non-compliance, especially for a one-time accidental discharge, which may lead to much more damage than if the discharge is reported quickly and cleaned up. Creating the correct incentives for reporting such accidents is especially important with respect to hazardous waste.

5.4 EXAMPLES OF BEST PRACTICE

Effluent Fees for Palm-Oil Mills in Malaysia

During the 1970s, palm-oil mills were the largest source of water pollution in Malaysia. In response to this problem, an effluent fee system was introduced in concert with command-and-control performance standards. Standards on BOD effluent were phased in over a four year period, and became progressively stricter over the period. This pre-announced phase-in gave firms time to construct treatment facilities and to become familiar with their operation.

The fee system comprised a fixed administrative fee plus an effluent fee of M$10/tonne of BOD load discharged. Firms were still required to comply with the standard (which was set initially at 5000 parts per million (ppm) and reduced to 500ppm over the phase-in period). As part of the phase-in, firms not in compliance with the standard were effectively charged an additional fee of M$100/tonne for above-standard effluent loads. This gave firms additional flexibility to adjust to the new standards according to their own abatement costs. Later, non-compliance was enforced through the threat of plant closure. The program reduced effluent discharge to less than 1% of the levels prevailing at the inception of the program.

Effluent Fees in Singapore

Firms in Singapore may apply for permission to discharge industrial effluent that exceeds allowable standards for BOD and TSS directly into public sewers upon payment of a “tariff”. The tariff is designed to recover the costs incurred in treating the additional pollution load at the wastewater treatment plant; it is a variable charge based on pollutant concentration in the effluent.

Hazardous Waste Management in Korea and Malaysia

In Korea, waste which includes hazardous substances is classified as “specified waste” and is subject to separate collection and transportation according to toxicity. Vehicles transporting hazardous waste must be colored yellow and must comply with regulations specified under a collection-transportation-license issued by the Environmental Management Office. Storage facilities must bear appropriate information stating the type of waste, the volume of waste and storage duration.

In 1995, Malaysia gave approval to a private company, Kualiti Alam Sdn. Bhd, to establish an integrated hazardous waste treatment and disposal plant at Bukti Nanas, Negeri Semblian. The company was awarded the exclusive right to establish and operate an integrated treatment and disposal plant for 15 years. The purpose of this exclusivity arrangement was to ensure a viable supply of material and so justify the significant investment for the firm, since there are substantial economies of scale in hazardous waste treatment and disposal.

Eco-Labeling Programs in Singapore, China and India

Singapore introduced an eco-labeling program in 1992, called the Green Label program. The program sets specific guidelines for the manufacture, distribution and disposal of consumer products. An Advisory Committee, made up of representatives from industry, academic institutions and statutory bodies, awards the right to display a Green Label logo to products that meet the guidelines.

China and India both adopted eco-labeling programs in 1993. The ECOMARK program in India has set criteria for a variety of consumer products, including soap and detergents, paper, paints, plastics, lubricating oils, packaging materials, textiles, cosmetics, electrical and electronic goods, and batteries. The program in China has established standards for a similar range of products.

The Potential for Cost Savings in Achieving Coal Processing Industry Effluent Standards in India

Coal processing industries in Bihar, India are subject to uniform standards on TSS concentrations. These standards are widely violated because of limited monitoring and high compliance costs. Compliance costs are estimated to differ widely across firms, and so there exists the potential for significant cost savings by allowing different effluent concentrations for different firms. Replacing the existing command-and-control approach with an effluent charge would yield substantial cost savings relative to universal compliance with the existing uniform standards, with no net reduction in overall environmental quality.