19 Water Pollution in India

An Economic Appraisal

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Introduction

Water pollution is a serious problem in India as almost 70 per cent of its surface water resources and a growing percentage of its groundwater reserves are contaminated by biological, toxic, organic, and inorganic pollutants. In many cases, these sources have been rendered unsafe for human consumption as well as for other activities, such as irrigation and industrial needs. This shows that degraded water quality can contribute to water scarcity as it limits its availability for both human use and for the ecosystem.

In 1995, the Central Pollution Control Board (CPCB) identified severely polluted stretches on 18 major rivers in India. Not surprisingly, a majority of these stretches were found in and around large urban areas. The high incidence of severe contamination near urban areas indicates that the industrial and domestic sectors' contribution to water pollution is much higher than their relative importance implied in the Indian economy. Agricultural activities also contribute in terms of overall impact on water quality. Besides a rapidly depleting groundwater table in different parts, the country faces another major problem on the water front—groundwater contamination—a problem which has affected as many as 19 states, including Delhi. Geogenic contaminants, including salinity, iron, fluoride, and arsenic have affected groundwater in over 200 districts spread across 19 states.

Water as an environmental resource is regenerative in the sense that it could absorb pollution loads up to certain levels without affecting its quality. In fact there could be a problem of water pollution only if the pollution loads exceed the natural regenerative capacity of a water resource. The control of water pollution is therefore to reduce the pollution loads from anthropogenic activities to the natural regenerative capacity of the resource. The benefits of the preservation of water quality are manifold. Not only can abatement of water pollution provide marketable benefits, such as reduced water borne diseases, savings in the cost of supplying water for household, industrial and agricultural uses, control of land degradation, and development of fisheries, it can also generate non-marketable benefits like improved environmental amenities, aquatic life, and biodiversity.

Using available data and case studies, this chapter aims to provide an overview of the extent, impacts, and control of water pollution in India. It also tries to identify the theoretical and policy issues involved in the abatement and avoidance of water pollution in India.

Extent of Water Pollution in India

The level of water pollution in the country can be gauged by the status of water quality around India. The water quality monitoring results carried out by CPCB particularly with respect to the indicator of oxygen consuming substances (biochemical oxygen demand, BOD) and the indicator of pathogenic bacteria (total coliform and faecal coliform) show that there is gradual degradation in water quality (CPCB 2009). During 1995–2009, the number of observed sample with BOD values less than 3 mg/l were between 57–69 per cent; in 2007 the observed samples were 69 per cent. Similarly, during this period of 15 years between 17–28 per cent of the samples observed BOD value between 3-6 mg/l and the maximum number of samples in this category were observed in 1998. It was observed that the number of observations remained unchanged and followed a static trend in percentage of observations having BOD between 3–6 mg/l. The number of observed BOD value > 6 mg/l was between 13 and 19 per cent during 1995–2009, and the maximum value of 19 per cent was observed in 2001, 2002, and 2009. It was observed that there was a gradual decrease in the BOD levels and in 2009, 17 per cent had BOD value > 6 mg/1. The worrying aspect of this trend is the high percentage (19 per cent) of sampling stations exhibiting unacceptable levels of BOD, which might either mean that the discharge sources are not complying with the standards or even after their compliance their high quantum of discharge contributes to elevated levels of contaminants (Rajaram and Das 2008). However, the status of water quality cannot be adequately assessed through monitoring of basic parameters in the current inadequate number of sampling stations.

Another aspect of water pollution in India is inadequate infrastructure, comprising of monitoring stations and frequency of monitoring for monitoring pollution. Monitoring is conducted by CPCB at 1,700 stations, (Figure 19.2), under a global environment monitoring system (GEMS) and Monitoring of Indian National Aquatic Resources (MINARS) programmes (CPCB 2009). There is an urgent need to increase the number of monitoring stations from their current number, which translate as one station per 1,935 km^2 to levels found in developed nations for effective monitoring. For example, in the state of Arkansas in the US there are monitoring stations per 356 km^2 (Rajaram and Das 2008). CPCB (2009) also reports the frequency of monitoring in the country. It is observed that 32 per cent of the stations have frequency of monitoring on a monthly basis, 28.82 per cent on a half-yearly basis, and 38.64 per cent on a quarterly basis. This indicates the need for not only increasing the number of monitoring stations but also the frequency of monitoring.

The water quality monitoring results obtained by CPCB during 1995 to 2009 indicate that organic and bacterial contamination was critical in the water bodies. The main cause for such contamination is discharge of domestic and industrial wastewater in water bodies mostly in an untreated form from urban centres.

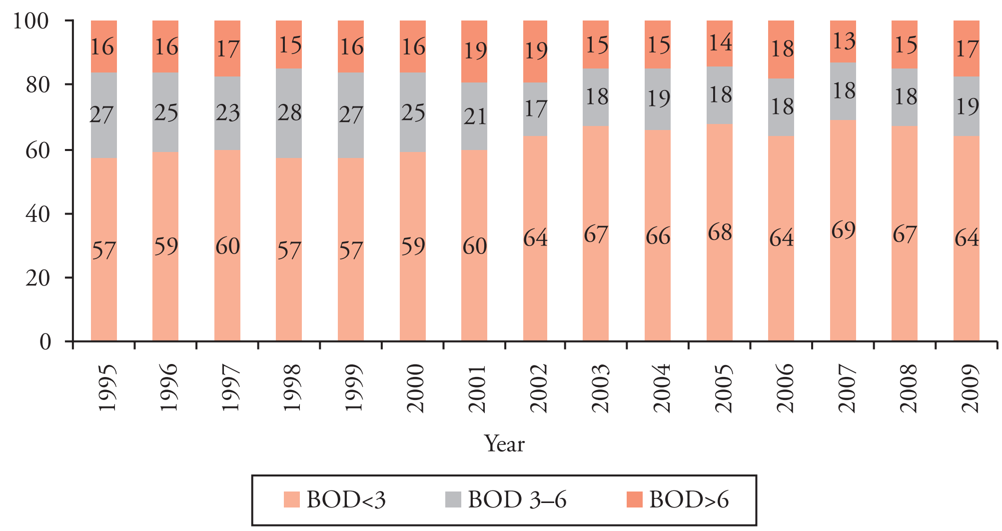

FIGURE 19.1 Trend of Biochemical Oxygen Demand (BOD), 1995–2009

Source: CPCB (2009).

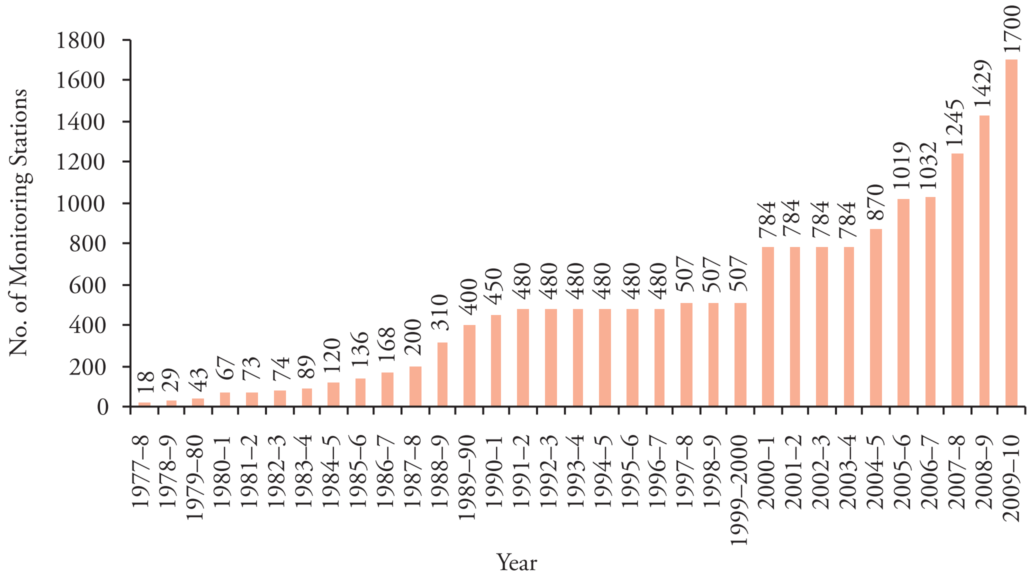

Figure 19.2 Growth of Water Pollution Monitoring Network in India

Source: CPCB (2009).

Secondly the receiving water bodies also do not have adequate water flow for dilution. Therefore, the oxygen demand and bacterial pollution is increasing.

Household borne effluents contribute a substantial proportion of water pollution in India. Untreated effluents from households pollute surface and groundwater sources. Local governments (city corporations, municipalities, and panchayats) have the responsibility of water supply and sanitation and are supposed to treat the effluents as per national water pollution standards or minimal national standards (MINAS) However, about 70 per cent of the effluents are not treated and disposed off into the environmental media untreated. Table 19.1 provides the summary statistics of wastewater generation and treatment in India in 2008. This table shows that cities, which have a population of more than one lakh (Class-I), treat only about 32 per cent of the wastewater generated. Note that out of the total effluent treatment capacity of 11554 MLD in the country, about 70 per cent (8040 MLD) has been created in 35 metropolitan cities. Metropolitan cities treat about 52 per cent of their wastewater. Delhi and Mumbai account for about 69 per cent of the treatment capacity of metropolitan cities. This indicates that smaller towns and cities have very little wastewater treatment capacity. Meanwhile, only 3.15 per cent of the rural population has access to sanitation services and 115 million homes have no access to toilets of any type.

CPCB provides source-specific pollution standards for industries with respect to pollution concentration of major water pollutants: (BOD), chemical oxygen demand (COD), suspended solids (SS), and pH. CPCB

Table 19.1 Wastewater Treatment Capacity in Urban Areas in India, 2008

Category	*No. of cities*	*Total water supply (in MLD)*	*Wastewater generation (in MLD)*	*Treatment capacity (in MLD)*
Class-I City	498	44,769.05	35,558.12	11,553.68 (32%)
Class-II town	410	3,324.83	2,696.7	233.7 (8%)
Total	908	48,093.88	38,254	11787.38 (31%)

Source: CPCB (2008).

launched a water pollution control programme in 1992 for industries. It identified 1,551 large and medium industries, and gave a time schedule to these industries for compliance with prescribed standards. It was found that many of these industries have effluent treatment plants (ETPs) but despite these they did not comply with prescribed pollution standards. In the industrial sector only 59 per cent of the large and medium industries had adequate effluent treatment in 1995. There are 0.32 million small-scale industrial units in India and due to the presence of scale economies in water pollution reduction, it is uneconomical for these units to have ETPs of their own (Murty et al. 1999). These small-scale units contribute almost 40 per cent of the industrial water pollution in India. However, small-scale units located in many industrial estates in India have gone for common effluent treatment plants (CETPs).

Agricultural run-offs affect groundwater and surface water sources as they contain pesticide and fertilizer residues. Fertilizers have an indirect adverse impact on water resources. Indeed, by increasing the nutritional content of water courses, fertilizers allow organisms to proliferate. These organisms may be disease vectors or algae. The proliferation of algae may slow the flow in water courses, thus increasing the proliferation of organisms and sedimentation. WHO has defined a permissible limit of concentration of nitrates of 45 mg/L of NO_3, which is also accepted by the Indian Council of Medical Research (ICMR). In the agricultural sector, fertilizer use increased from 7.7 MT in 1984 to 13.4 MT in 1996 and pesticide use increased from 24 MT in 1971 to 85 MT in 1995 (Bhalla et al. 1999). It has been observed that in states, such as Haryana, the NO_3 concentration has exceeded the permissible limits (Maria 2003).

Effects of Water Pollution

Lack of water, sanitation, and hygiene results in the loss of 0.4 million lives while air pollution contributes to the death of 0.52 million people annually in India (WHO 2007). Environmental factors contribute to 60 years of ill-health per 1,000 population in India compared to 54 in Russia, 37 in Brazil, and 34 in China. The socio-economic costs of water pollution are extremely high: 1.5 million children under 5 years die each year due to water related diseases, 200 million person days of work are lost each year, and the country loses about Rs 366 billion each year due to water related diseases (Parikh 2004).

McKenzie and Ray (2004) also observe similar effects of water pollution; however, the magnitude of the effect was modest. The study shows that India loses 90 million days a year due to water borne diseases with production losses and treatment costs worth Rs 6 billion. Poor water quality, sanitation, and hygiene result in the loss of 30.5 million disabilities adjusted life years (DALY) in India. Groundwater resources in vast tracts of India are contaminated with fluoride and arsenic. Fluoride problems exist in 150 districts in 17 states in the country with Orissa and Rajasthan being the most severely affected. High concentration of fluoride in drinking water causes fluorosis resulting in weak bones, weak teeth, and anaemia. The presence of arsenic, a poison and a carcinogen, in the groundwater of the Gangetic delta causes health risks to 35–70 million people in West Bengal, Bihar, and Bangladesh.

Murty and Kumar (2004) estimated the cost of industrial water pollution abatement and found that these costs account for about 2.5 per cent of industrial GDP in India. Parikh (2004) shows that the cost of avoidance is much lower than damage costs (Table 19.2). According to one estimate (Parikh 2004), India lost about Rs 366 billions, which account for about 3.95 per cent of the GDP, due to ill effects of water pollution and poor sanitation facilities in 1995. If India had made efforts for mitigating these effects in terms of providing better sanitation facilities and doing abatement of water pollution the required resources had ranged between 1.73 to 2.2 per cent of GDP. It may however, be emphasized that these damage costs do not fully reflect the loss in social welfare. These estimates only suggest that the abatement of pollution is socially desirable and economically justified.

Regulation of Water Pollution

Environmental policies are designed to alter the behaviour of economic agents, either individuals or group of individuals, in such a manner that the environmental externalities generated during the course of individual actions are internalized. As shown in Figure 19.3 policy responses can be classified into two categories: formal and informal. A legislative response requires policy responses mandated by the state. These policy responses

Table 19.2 Alternative Estimates of Costs of Water Pollution (Rs millions/year at 1995 prices)

A. Damage costs		
a	Value of annual loss of 30.5 million DALYs @ average per capita GDP of Rs.12000	366,000 3.95% of GDP (1995–6)
B. Avoidance costs		
a	Pollution abatement in organized industry	10,120
b	Pollution abatement in small-scale industry	45,980
c	Wastewater treatment in 3,696 cities/towns	3,620 to 10,540
d	Provision of toilets to 115 million households	35,300 to 56,630
e	Provision of safe drinking water	39,300
Annualized cost (assuming operations and maintenance costs of installed facilities at 20% of capital costs) Annual costs (capital + O&M)		134,320 to 162,550 26,860 to 32,510 161,180 to195,060
Annual cost as per cent of GDP (1995)		1.73 to 2.1%

Source: Parikh (2004).
Note: a, b, c, and d at 15% discount rate and 15 years life.

may originate from the government to achieve the given objective of maximizing social welfare or from society itself, as it feels the heat of externalities and exerts pressure on governments to bring out legislations to control externalities. Actions by the state to control externalities without public pressures can be put into the category of formal regulations and actions that emerge in response to civil society pressures to control individual behaviour in social interest are classified as informal regulations. Environmental regulations do not remain confined within the preview of governments in modern economic structures because firms are not individually governed units, they have to depend on markets to get investment capital and to sell their products. Markets also help in altering individual behaviour in a socially desirable manner. In India we find both formal and informal regulations in the area of environmental externalities (Figure 19.3).

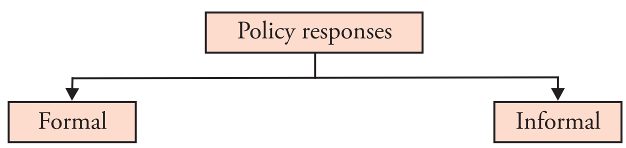

Figure 19.3 Environmental Regulations in India

Formal Regulations

Historically, there have been policy responses for prevention and control of environmental degradation in the country since the 1970s. The environmental policy in recent times has recognized the importance of the role of incentive based policy instruments in controlling and preventing environmental pollution. Formal regulations may be classified into two categories (Figure 19.4). State intervenes in the form of legislations and policies, and public investments for environmental cleaning activities, such as the Ganga Action Plan (GAP) and the Yamuna Action Plan.

Laws for Controlling Water Pollution in India

The acts that directly concern water pollution in India are the Water Act (1974), the Water Cess Act (1977 and 1988), and the Environment (Protection) Act or EPA (1986). While the first two are foundational legislations in the context of water pollution in the country, EPA is designed to fill the gaps still remaining in the legal framework for the control of industrial pollution. The act related to water cess is more of a revenue-generating legislation than a measure to restrict the consumption of water by industrial units. Pollution control boards at the central and state levels are empowered to prevent, control, and abate water pollution, and to advise governments on matters pertaining to such pollution. CPCB is to coordinate the activities of the state boards. Note that these laws have mainly remained confined to controlling industrial water pollution. CPCB has also

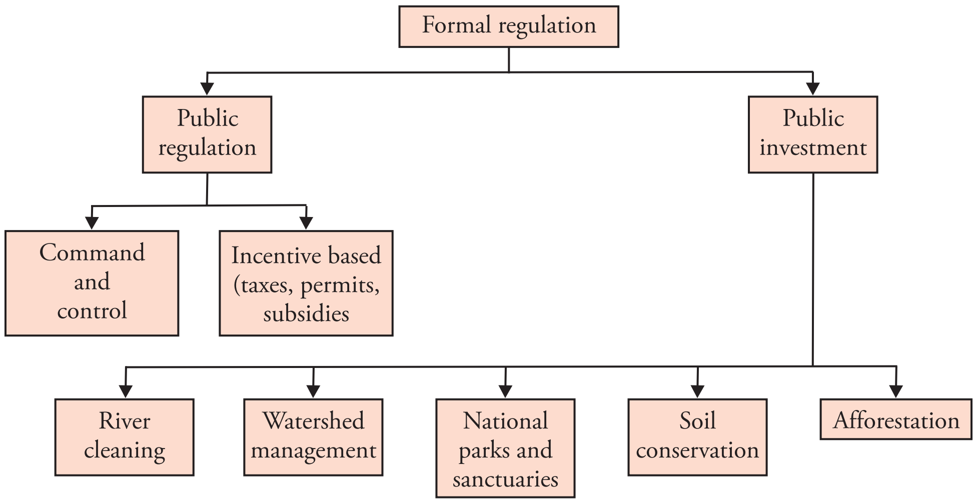

FIGURE 19.4 Formal Environmental Regulations in India

prepared a list of polluting industries in India. The acts also specify that industrial units have to provide, on demand, all information regarding their effluent and treatment methods. These laws however, do not cover the regulation of water pollution originating from the household and agriculture sectors. The legislative framework followed in India for the regulation of water pollution is summarized in Table 19.3.

Fiscal Instruments for Pollution Control in India

The government's approach towards prevention of pollution has been mostly through legislation-based command and control measures while natural resource management has been largely carried out through programmes supported by allocations from central (for example, programmes of the Ministry of Environment and Forests, Ministry of Non-conventional Energy

TABLE 19.3 Water Regulation Framework in India

Sl.no.	*Polluting sources*	*Effect on ecosystem*	*Specific standards*	*Current status*
1	Domestic sewage from towns and cities	Organic pollution of rivers, eutrophication of lakes, spread of water borne diseases	MINAS	Out of 26,500 mld of sewage from Class-I cities and Class-II towns treatment capacity exists only for about 7,000 mld (26%). Out of 271 STPs inspected by CPCB only 150 (55%) were complying with MINAS
2	Industrial effluents (point discharges)	Organic and inorganic pollution, toxic chemicals in food chain	MINAS (industry specific)	No comprehensive statistics on compliance exists as it is dealt mainly by SPCBs Widespread damage of ecosystem around industrial areas is well documented by CPCB
3	Industrial and mines run-off	Organic and inorganic pollution, toxic chemicals in food chain	No standards/ legislation	No comprehensive study as stored hazardous waste, mine spoils, etc. contribute large quantum of contaminants which pollute surface and groundwater
4	Agricultural run-off	Fertilizers leading to eutrophication pesticides in the food chain	No standards/ legislation	Nation wide studies have not been conducted, apart from regular news articles on pesticides in water and food items

Source: Rajaram and Das (2008).

Sources, and the Ministry of Agriculture, etc.) and state budgets. The use of fiscal instruments (other than the expenditure policy) in the environmental policy has been limited, even though the need to employ economic and fiscal policy instruments for the control of pollution and management of natural resources has gained recognition since the 1990s (Datt et al. 2004).

A task force was constituted by the Ministry of Environment and Forests (MoEF) in 1995 to evaluate the scope for market based instruments (MBIs) for industrial pollution abatement (Government of India 1997). The task force recommended explicit incorporation of MBIs in pollution control laws, greater reliance on economic penalties in the short and medium term, and completely replacing criminal penalties by MBIs in the long run. It also recommended modifying the existing water cess to make it a genuine effluent-based tax based on pollution load rather than the amount of water consumed, as also abolishing tax concessions on installation of pollution control equipment. It recognized the need for systematic data collection to estimate marginal abatement costs and the regulatory burden and called for the introduction of additional MBIs.

The actual use of fiscal incentives in the country has, however, been rather limited. These take the form of tax concessions for the adoption of pollution control equipment. Tax incentives are usually specified for identified abatement technologies and activities, not providing dynamic incentives for technological innovation and diffusion. Also, since most of these are end-of-the-pipe treatment technologies, these incentives do not promote more efficient use of resources. There are some provisions for the use of levies, cess, fines, and penalties, etc. for polluters, but their implementation and effectiveness needs strengthening (Kumar and Managi 2009).

Although it is widely known that command and control measures do not provide necessary incentives to polluters for the choice of least cost methods of pollution control, the Government of India has so far resorted only to such measures for controlling industrial pollution in India. On the other hand, fiscal instruments, such as pollution taxes or marketable pollution permits though also coercive, provide incentives to factories for adopting least cost pollution abatement technologies. Ironically, there have been no serious attempts in India to use such instruments for the abatement of industrial pollution. The current water cess, whose objective is to raise revenue to pollution control boards, is very nominal (Rs 0.015 to 0.07 per kilolitre [Kl]). Some of the recent research studies on water pollution abatement in India conclude that the rate of pollution tax on industrial water use should be several times higher than the prevailing rate of water cess if we want to realize the prescribed water quality standards in the country. One study carried out in 1989 (Gupta et al. 1989) estimated the cost of treatment per a Kl of residual water at 1987–9 prices at Rs 3.60 for the paper and pulp industry, at Rs 2.61 for oil refineries, Rs 2.21 for chemicals, and Rs 1.64 for sugar. Another study (Mehta et al. 1994) carried out in 1994 estimated the marginal cost of abatement for the reduction of 100 mg of bio oxygen demand in the residual water for the paper and pulp industry at Re 0.38 at 1991–2 prices. Yet another study published in 1999 (Murty et al. 1999) found that the pollution tax per 100 mg reduction of COD by the Indian manufacturing industry for realizing the standard of 250 mg per litre of residual water was Re 0.32 at 1995–6 prices.

MoEF also commissioned several case studies to examine issues relating to economic instruments for pollution abatement. These studies estimated abatement costs of pollutants and recorded wide variations across different industries. The studies pointed out the inefficiency of the current legislation, which requires all polluters to meet the same discharge standards, and called for the introduction of economic instruments for cost effective pollution control. They emphasized the need for regulators to allocate their monitoring resources more efficiently by targeting industries characterized by relatively high discharges and low costs of pollution abatement. These studies also observed that taxes and incentives based on efficiency instruments better align pollution control agencies with polluters than the command and control regime.

Some studies[1] give some information about the rate of tax to be levied on industries for making them comply with the prescribed water standards. Mehta

[1] See Gupta et al. (1989); Mehta et al. (1994); Murty et al. (1999); Pandey (1998); Misra (1999); World Bank (1999); and Murty and Kumar (2004).

et al. (1994) considered an abatement cost function for an effluent treatment plant in paper and pulp units in India, and concluded that marginal abatement costs of relatively high cost producers should serve as the basis for setting charges/taxes so as to ensure that producers find it cheaper to abate than to pollute. They recommended four options for experimenting by policymakers: (i) abatement charges with the government undertaking cleaning up, (ii) abatement charges with cleaning-up contracted out based on competitive bidding, (iii) a tax proportional to excess pollution on firms violating standards and subsidies for those going beyond the prescribed abatement standards, and (iv) a private permit trading system.

The water polluting firms in Indian industry are supposed to meet the standards set for pollutants (35mg/l for BOD, 250mg/l for COD, and 100mg/l for SSP) by the Central Pollution Control Board. A survey[2] of a sample of water polluting industries in India shows that most of the firms have effluent treatment plants and in addition some firms are using process changes in production and input choices to achieve effluent standards. However, there is a large variation in the degree of compliance among the firms measured in terms of ratio of standard to effluent quality. The laxity of formal environmental regulations by the government and the use of command and control instruments could be regarded as factors responsible for large variations in complying with pollution standards by firms. Using this data, Murty and Kumar (2004) provide estimates of taxes on one tonne of BOD, COD, and SS as Rs 20,157, Rs 48,826, and Rs 21,444 respectively.

Informal Regulation and People's Participation

Economic instruments and command and controls are instruments of formal regulation. The designing and implementation of these instruments involves a top-down or a centralized approach. The success of these instruments in controlling pollution depends upon the quality of governance and its ability to incur high transaction costs. A bottom-up or decentralized regulation involving civic society and local communities and with a very limited role of the government could save transaction costs and get rid of political and bureaucratic corruption. This approach draws theoretical support from the Coase Theorem (Coase 1960). The Coase Theorem states that the optimal level of pollution control could be realized through the bargaining between the polluters and the affected parties, given the initial property rights to either of the parties in the absence of transaction costs. Even with positive transaction costs, the bargaining could result in the reduction of externality though not to the optimum level. Recent empirical experiences show that the bargaining between the communities and polluters helped in reducing the water pollution when the government had been protecting the property rights to the environmental resource to the people (Murty et al. 1999; Paragal and Wheeler 1996; World Bank 1999).

The management of environmental resources can no longer be taken as the responsibility of a single institution like a market or the government (Murty 2008). The now well-known limitations of either the market or the government in managing the environment have paved the way for a mixture of institutions. Market agents, consumers, producers, and stockholders have incentives for controlling pollution. Consumers regulate the market for pollution intensive commodities by expressing preferences for green products or commodities produced using cleaner technologies. Investors also have incentives to invest in industries using cleaner technologies. Higher level of observed pollution in a firm is an indication to the investors that the firm uses inefficient technology resulting in the loss of profits. Profit losses may occur because of reduced demand for its products by green consumers, increased costs due to higher penalties imposed by the government for non-compliance with pollution standards, and the settlement of compensation to victims. In this case there may be a downward revaluation of the firm's stocks in the capital market. On the other hand, a good environmental performance by a firm may result in an upward evaluation of its stocks (Murty 2008).

Some recent studies have shown that stock markets in both developed and developing countries react to the environmental performance of firms. Also studies about firms' behaviour with respect to environment performance related changes in stock prices show that

[2] 'A Survey of Water Polluting Industries in India' (1996) and 'A Survey of Water and Air polluting Industries in India' (2000), Institute of Economic Growth, Delhi.

firms react to such changes by reducing pollution loads. Recent studies about this phenomenon in some developing countries like India (Gupta and Goldar 2005), Argentina, Chile, Mexico, and Philippines show that stock prices are even more volatile to news about the environmental performance of firms. The average gain in stock prices due to good news about environmental performance is found to be 20 per cent in these countries.

There is now evidence about a number of industries in the developing countries complying with environmental standards even in the absence of formal regulations by the government. One interesting example is the success story of PT Indah Kiat Pulp and Paper (IKPP) in Indonesia (World Bank 1999). IKPP is the largest and the cleanest paper producing company in Indonesia. A clean up started in some of its mills in the 1990s with pressures from local communities. Local villagers claimed damages from the mills with the help of local NGOs. Indonesia's national pollution control agency, BAPEDAL, mediated an agreement in which IKPP acceded to the villagers' demands. Further, the need for going to western bond markets for financing the expansion of IKPP to meet the growing export demand, made the company go in for cleaner technologies. The good performance of the company in pollution management has resulted in an increase in its stock value in comparison to Jakarta's composite stock index. Figure 19.5 describes the structure of informal environmental regulations in India.

Take for example pollution abatement by small-scale enterprises located in industrial estates in India. Use of command and control instruments by the government in an environment of non-availability of economically viable technological options for pollution abatement has been causing considerable hardships to small-scale enterprises. The government managed public sector has been the fountainhead of industrial development. But the government has not made any sincere efforts to promote economically viable pollution abatement technologies for small-scale enterprises via R&D in the public sector. The presence of scale economies in pollution abatement, especially in water pollution abatement, has compounded problems for industrial estates. In such a situation, it is not economical for the small-scale enterprises to have their own individual effluent treatment plants to comply with the command and control regulation. Collective action involving all the relevant parties for water pollution abatement (factories, affected parties, and the government) is now seen as an institutional alternative for dealing with the problem of water pollution abatement in industrial estates, especially in India (Murty et al. 1999). Collective action in industrial water pollution abatement is meant to bring about necessary institutional changes that are compatible with the choice of cost saving technologies. For example, a CETP can be adopted if necessary legislation is in place to define the property rights of the factories and the affected parties. A CETP for an industrial estate confers the benefits of saving in costs to the factories and the reduction in damages to affected parties. There are many incentives for polluters, affected parties, and the government for promoting collective action in industrial water pollution abatement.

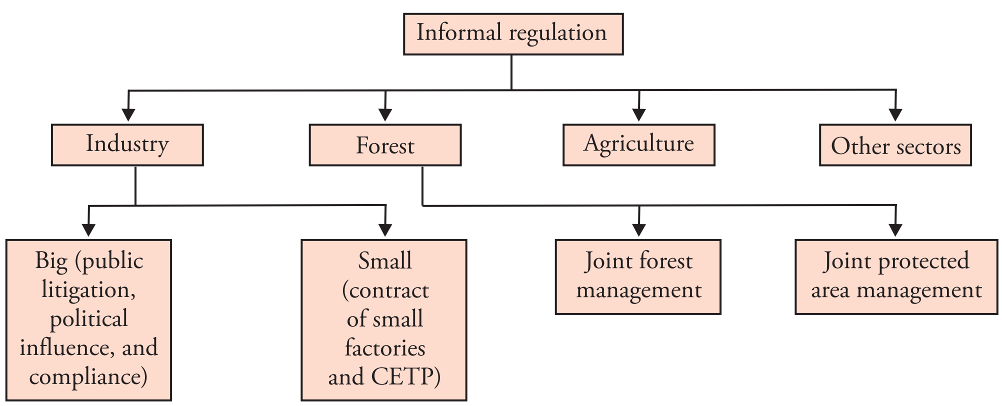

FIGURE 19.5 Informal Environmental Regulation in India

Source: Kumar and Managi (2009).

Historical developments leading to the adoption of CETP technologies by some of the industrial estates are clear evidence of the success of collection action approach. In this case collection action involves factories (polluters), people affected from pollution, NGOs, and government (see Murty and Prasad cited in Murty et al. 1999). There are three processes involved in the collective action for control of water pollution in an industrial estate. These are: (i) collective action of affected parties; (ii) collective action of factories, and (iii) the bargaining between a coalition of affected people and a coalition of factories. Collective action by affected people is possible if the damages from pollution are substantive enough to justify the transaction costs of coalition and bargaining. Factories in an industrial estate have to take recourse to pollution abatement methods taking into account possible collective action by the affected people. The available pollution abatement technologies may provide small factories a broad spectrum of technological choices out of which the common effluent treatment plant may be the least cost technology. Therefore, collective action by factories can be technology driven. Finally, the bargaining between a coalition of affected people and a coalition of factories produces the end result of collective action that is the realization of prescribed environmental standards.

Murty et al. (1999) reported the results of a survey of a number of industrial estates and an all-India survey of large-scale water polluting factories providing evidence of local community pressure resulting in the industries complying with standards. A number of agencies, such as local communities, elected representatives (members of Parliament, state assemblies, and municipal committees), industries, NGOs, and the government are found to be involved in the processes leading to the establishment of common effluent treatment plants in industrial estates. There are also several examples of physical threats, and public litigation cases against factories for claiming damages from pollution by the local people resulting in the big factories complying with the standards. Take, for example, the Pattancheru industrial estate in Andhra Pradesh. Local opposition to the pollution started in 1986 when about 3,000 villagers marched to the Chief Minister's office after suffering large-scale crop losses and health damages due to contamination of groundwater and the pollution of nearby river. In 1989, about 5,000 people held a demonstration before the state assembly, demanding an end to industrial pollution. In the same years farmers blocked the highway running through Pattancheru for two days. The villagers also filed court cases by jointly sharing the cost with contributions of Rs 200 per household. This legal action through the collective effort of the people ultimately forced the factories in the industrial estate to have a CETP for complying with water pollution standards. Similar experiences are reported from many other industrial estates in the region.

Informal regulation by local communities is resulting in factories complying with standards as explained by the examples given earlier. The amount of influence that the local communities exert on factories to undertake pollution depends, among other factors, upon their affluence, the degree of political organization, education, and environmental awareness. Pargal and Wheeler (1996) found a negative relationship between BOD load in a factory effluent and per capita income and educational levels of local communities in a sample of 243 factories in Indonesia. Similarly, Murty and Prasad (1999) found a negative relationship between the BOD effluent-influent ratio and a relative index of development of local community, and the political activity of the local community measured in terms of percentage of votes polled in the recent elections to the Indian Parliament.

Collective action constitutes costs to factories, the government, and affected parties. Factories incur the cost of abatement to meet standards. The effected people incur the cost of public litigation cases and the cost of organizing themselves as a society. The government incurs the cost of financial incentives provided to the factories. We now discuss a method of estimating cost to factories is given with a case study.

Given a threat of closure or legal action by an association of affected people, small-scale industries in an industrial estate are made to reduce pollution to meet prescribed standards. The industries have a choice between the following technologies for meeting the standards: (i) in house treatment, (ii) CETP, and (iii) a mix of both. Given the scale economies in water pollution abatement, in house treatment is not economical for small-scale enterprises. A survey of pollution abatement practices of isolated industries (Murty et al. 1999) shows that the capital cost of an effluent treatment plant for meeting water pollution standards for small-scale enterprises is almost equal to the capital cost of the main plant. Therefore, industries may prefer to go for a CETP, which is possible only if they are located as a cluster in an industrial estate. They can have a CETP only if there is a contract among the factories about (i) sharing capital and the operating costs, (ii) the prices charged for treating the pollutants, and (iii) the quality of influent accepted by CETP.

Industrial estates normally contain heterogeneous factories belonging to different industries with varying pollution loads and concentrations. As the members of the CETP, the member factories are required to supply wastewater of a standard quality, therefore, some of the factories may have to do some 'in house treatment' of their wastewater to bring the water pollution concentration at the agreed level before standing to the CETP for effluents treatment. Therefore, the cost of water pollution abatement in an industrial estate may also consist of in house treatment costs and the cost of CETP.

In this model, government regulators have still a role to play. But their role is not creating and enforcing environmental standards. It is merely a catalytic role of providing information about the environmental programmes designed and available cleaner technologies, and providing some financial incentives to local communities. Therefore, this new model constitutes a regulatory triangle consisting of the local community, the market, and the government.

Economic Instruments and Institutions

The discussion so far indicates that choices for policy responses will involve some mix of regulatory and market-based instruments, but this policy analysis must be done with respect to specific problems that need to be solved. Based on an analysis of the application of incentive based policies in other countries, Table 19.4 provides an inventory of economic instruments available and the targets that they are supposed to address.

The first three policy options are suited for municipalities' to reduce water pollution and the remaining policy options are better suited for reducing industrial water affluent. To address the problem of urban wastewater treatment for better handling of organic wastes coupled with chronic revenue shortages for such investments, introduction of wastewater user fees could be a strong consideration. Similarly, as a potential corollary to enhanced revenues from higher service fees (and possible partial privatization), considering increased government subsidies for wastewater treatment system development—common in many countries—is also deemed to merit a careful analysis. Groundwater contamination has been observed from leaking septic fields and the dumping of waste from cesspits into canals. It was considered timely for the government to explore providing technical assistance and possibly subsidized sanitation technologies to municipalities to encourage small-scale environmentally acceptable ways of

Table 19.4 Summary Evaluation of Economic Instruments for Water Quality Management

Economic instrument	*Principal problem addressed by the instrument*
User fees for wastewater treatment	Pollution of rivers, canals, and aquatic systems
Subsidies for wastewater treatment facilities	Pollution of rivers, canals and aquatic systems
Subsidized pollution control equipment	Pollution of rivers, canals, and aquatic systems
Subsidized sanitation	Surface and groundwater pollution plus offsite impacts
Industrial pollution discharge fees	Adverse impacts of industrial pollution
Tradable effluent discharge permits	Adverse impacts of industrial pollution
Voluntary agreements for environmental improvements	Potentially address wide range of water quality problems
Environmental damage charges and fines	Potentially address wide range of water quality problems
Environmental performance bonds	Potentially address wide range of water quality problems
Public environmental information disclosure	Potentially address wide range of water quality problems

disposing off household sewage in areas unlikely to be served by sewage treatment plants.

For reducing industrial water pollution, the government is providing tax rebates on the use and implementation of pollution reduction equipment. This is analogous to the subsidization of water-saving technologies. Note that the reduction of tariffs on the import of pollution control equipment could create incentives for increased pollution abatement and higher quality domestic production of environmental technologies. Similarly, various voluntary agreement options, such as enhanced self-monitoring of effluent discharges by industry, hold promise for introducing positive new relationships between the government and individual enterprises, municipalities, industry associations, community groups, and/or other entities to encourage a less polluting behaviour. The Indian experience shows that most of the action for reducing pollution is the result of public interest litigation (PIL) cases filed by various organizations in courts. Therefore, public environmental information disclosure can be an important tool for addressing the environmental problems in India. Greater disclosure of environmental information—perhaps starting with public dissemination of data from Environmental Impact Assessments and ambient environmental quality data collected by various agencies—can be used to hold those damaging the environment more accountable to the public and their financiers.

Effluent discharge tax or fees and tradable effluent discharge permits are the most popular incentive based policy options for reducing industrial pollution. Fees for industrial effluent discharge help in raising revenues and encourage the polluters to reduce pollution. Similarly, maximum discharges could be established for various types of discharges and tradable permits allocated among dischargers to lower compliance costs for achieving specified goals.

At present the country is considering the implementation of economic instruments for reducing air pollution, both domestic and global. The country is looking at avenues of controlling air pollution to reduce pollution through schemes like renewable energy certificates (RECs) and perform, achieve, and trade (PAT). Pilot schemes are also being conducted for pollutants like sulphur dioxide (SO_2) and nitrogen oxide (NO_x). The implementation of these schemes requires the setting up of meaningful emission caps and allocating permits; establishing an accurate monitoring mechanism; establishing the appropriate baseline based on the data that is currently available; identifying the appropriate institutional framework to manage the mechanism; and creating a legal framework necessary to manage emission of pollutant through market mechanism. However, unlike air pollution tradable permit schemes, water affluent trading programmes require spatial distribution of non-uniformly mixed pollution. Though theoretically this issue has been addressed in literature, establishing trading ratios that vary by each potential trading partner pair is difficult in practice.

Significant institutional adjustments are required that will take time to address and, therefore, warrant immediate attention. Within MoEF and pollution control boards, there appears to be an acute shortage of professionals with training in resource and environmental economics required for conducting a further analysis of economic instruments. Further, information is needed on the availability of staff in the context of a broader needs analysis for institutional strengthening. The same constraints and needs would seem to apply to other government agencies with water management responsibilities. In the meantime, consideration should be given to creating capacity for economic analysis within the MoEF and pollution control boards, perhaps by adding an environmental and resource economics section. This section could also be tasked with coordinating the needs assessment and even be drawn upon to help with in house training, where warranted. A second set of institutional adjustments is needed to build a stronger working network of agencies responsible for water management within the country. If acceptable, it would seem appropriate for MoEF and the pollution control boards to take the lead. With MoEF remaining as the lead authority in the water pollution sector, much stronger outreach to and engagement of related ministries and their associate bodies is needed if the recommendations relating to specific economic instruments identified as promising are to be acted upon in the interest of improving water resource management in the country.

Policy Implications

Measuring water pollution, estimating benefits from reduced pollution, and designing regulatory instruments for environmental improvements require interdisciplinary approaches. Detailed studies are needed to establish relationships between pollution at sources and ambient pollution of surface water bodies and groundwater resources. Some useful work on river quality modelling has been already going on in India but many more studies are needed for identifying the changes in water quality due to anthropogenic activities. Data of physical accounts of environmental changes are needed for the valuation of environmental services and the design of environmental policy instruments.

Environmental valuation is central for natural resource management. It is required for designing an environmental policy and environmental accounting for estimating a green GDP. Environmental value could be measured either as cost of abatement of environmental changes or the value that the households place on these changes. There are already a few studies about benefits and costs of water pollution abatement in India but many more detailed studies are needed.

There is an urgent need of increasing the number of monitoring stations in India to levels found in developed nations for effective monitoring. Moreover, presently the scope of monitoring is limited to conventional compounds (such as BOD, total suspended solids, faecal coli form, and oil and grease), which needs to be expanded to non-conventional pollutants, such as ammonia, chlorine, and iron also which have hazardous health impacts. Effective regulation requires that the monitoring responsibilities should be devolved to the states and further down to local bodies.

An effective industrial water pollution regulation policy requires the use of a combination of regulatory instruments consisting of economic instruments of pollution taxes and marketable permits, informal regulation by local communities, and direct public investments for environmental improvements. India still uses command and control regulatory instruments for water pollution abatement resulting in some big industries having effluent treatment plants and many industrial estates housing small-scale industries having common effluent treatment plants. However, their effectiveness in reducing water pollution is unclear. The top-down regulatory approach, in which the government plays a central role, has become ineffective in India because of high monitoring and enforcement costs and the quality of the regulator or the government. Some recent developments in India show that informal or voluntary regulation by local communities has resulted in some big industries complying with safe pollution standards.

In India, municipalities have the treatment capacity only for about 30 per cent of the wastewater generated in urban areas. This evidently indicates a gloomy picture of sewage treatment, which is the main source of pollution of rivers and lakes. To improve the water quality of rivers and lakes, there is an urgent need to increase the sewage treatment capacity and its optimum utilization. Moreover, as recognized by CPCB (2008), operations and maintenance of existing plants and sewage pumping stations is also very poor. Municipalities lack financial resources and skilled manpower capacity and as a result the existing treatment capacity remains underutilized in a number of cities. Municipal authorities should realize the problem of pollution of water bodies and pay attention to their liability to set up sewage treatment plants in cities and towns to prevent this pollution. Conditioning intergovernmental fiscal transfers from state governments to local bodies on the basis of wastewater treated could be an effective instrument for strengthening the financial position of municipalities (Kumar and Managi 2010). It will not only strengthen the financial position of local governments but also help in addressing the problem of domestic water pollution.

India should give emphasis on developing a 100 per cent treatment capacity up to the secondary level of treatment (CPCB 2008). Treated water can be used for irrigation purposes and for recharging replenishing groundwater. Industries should be encouraged to re-use treated municipal wastewater. Revenue obtained from the sale of treated wastewater for irrigation and industrial purposes could be used to supplement sewage treatment costs.

Note also that though India has defined wastewater discharge standards for the domestic and industrial sectors, there are no discharge standards for the pollution emanating from agriculture. Agriculture is the source of non-point water pollution and agricultural water pollution is linked, among other things, to the use of fertilizers and pesticides. Therefore, corrections in fertilizer and pesticide and electricity pricing policies could be an instrument for addressing the non-point water pollution in India.

References

Bhalla, G.S., Peter Hazell, and John Kerr (1999), 'Prospects for India's Cereal Supply and Demand to 2020', 2020 Brief No. 63, International Food Policy Research Institute, Washington DC.

Central Pollution Control Board [CPCB] (2008), *Status of Water Supply, Wastewater Generation and Treatment in Class-I Cities and Class-II Towns of India*, Control of Urban Pollution Series, CUPS/70/2009-10, New Delhi.

——— (2009), 'Status of Water Quality in India—2009', Monitoring of Indian Aquatic Resources Series, MINARS/ /2009-10, New Delhi.

Coase, R.H. (1960), 'The Problem of Social Cost', *Journal of Law and Economics*, Vol. 3, pp. 1–44.

Datt, D., S.C. Garg, G.K. Kadekodi, K.K. Narang, D. Sharma, and J.P. Singh (2004), 'Environmental Fiscal Reform in India: Issues and Some Steps Forward', (Draft), TERI, New Delhi.

Government of India (1997), *Report of the Task Force to Evaluate Market Based Instruments for Industrial Pollution Abatement*, submitted to the Ministry of Environment and Forests.

Gupta, S. and B. Goldar (2005), 'Do Stock Markets Penalize Environment-unfriendly Behaviour? Evidence from India', *Ecological Economics*, Vol. 52, pp. 81–95.

Gupta, D.B., M.N. Murty, and R. Pandey (1989), 'Water Conservation and Pollution Abatement in Indian Industry: A Study of Water Tariff', (mimeo), National Institute of Public Finance and Policy, Delhi.

Kumar, Surender and Shunsuke Managi (2009), *Economics of Sustainable Development: The Case of India,* Springer, New York.

——— (2010), 'Compensation for Environmental Services and Intergovernmental Fiscal Transfers: The Case of India', *Ecological Economics,* Vol. 68, pp. 3052–9.

Maria, A. (2003), 'The Costs of Water Pollution in India', paper presented at the conference on Market Development of Water & Waste Technologies through Environmental Economics, 30–1 October 2003, Delhi.

McKenzie, David and Isha Ray (2004), 'Household Water Delivery Options in Urban and Rural India', Working Paper No. 224, Stanford Centre for International Development, Stanford University, USA.

Mehta, S., S. Mundle, and U. Sankar (1994), *Controlling Pollution: Incentives and Regulation*, Sage Publications, New Delhi.

Misra, S. (1999), 'Water Pollution Abatement in Small-Scale Industries: An Exploration of Collective Action Possibilities in Nandesari Industrial Area in Gujarat', PhD Thesis, University of Delhi.

Murty, M.N. (2008), 'Policy Responses to Ecosystem Conservation in Hindukush Region', Discussion Paper, 'Ecosystem Services and Poverty Alleviation Study in South Asia (ESPASSA): A Situation Analysis for India and the Hindu-kush Himalayan Region, Annex 3', TERI, New Delhi.

Murty, M.N. and Surender Kumar (2002), 'Measuring Cost of Environmentally Sustainable Industrial Development in India: A Distance Function Approach', *Environment and Development Economics*, Vol. 7, pp. 467–86.

——— (2004), *Environmental and Economic Accounting for Industry*, Oxford University Press, New Delhi.

Murty, M.N., A.J. James, and Smita Misra (1999), *Economics of Water Pollution: The Indian Experience.* Oxford University Press, New Delhi.

Murty, M.N. and U.R. Prasad (1999) 'Emissions Reduction and Influence of Local Communities in India', in M.N. Murty, A.J. James, and Smita Misra (eds), *Economics of Industrial Pollution Abatement: Theory and Empirical Evidence from the Indian Experience*, Oxford University Press, Delhi.

Pandey, Rita (1998), 'Pollution Taxes for Industrial Water Pollution Control', (mimeo), National Institute of Public Finance and Policy, New Delhi.

Pargal, S. and D. Wheeler (1996), 'Informal Regulation of Industrial Pollution in Developing Countries: Evidence from Indonesia', *Journal of Political Economy,* Vol. 104, pp. 1314–27.

Parikh, J. (2004), 'Environmentally Sustainable Development in India', available at http://scid.stanford.edu/events/India2004/JParikh.pdf last accessed on 22 August 2008.

Rajaram, T. and A. Das (2008), 'Water Pollution by Industrial Effluent in India: Discharge Scenarios and Case for Participatory Ecosystem Specific Local Regulation', *Futures,* Vol. 40, pp. 56–69.

World Bank (1999), *Greening Industry: New Roles for Communities, Markets, and Governments*, Oxford University Press, New York.

World Health Organization [WHO] (2007), *Guidelines for drinking-water quality, Incorporation First Addendum, Volume 1, Recommendations*, Third edition, WHO, Geneva.