Report

ESTIMATING INDUSTRIAL POLLUTION IN INDIA: IMPLICATIONS FOR AN EFFLUENT CHARGE

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October 2000

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New Delhi

PREFACE

Pollution from industries constitute a considerable part of total pollution in India. But reliable information on the nature and level of emissions/discharges by plants/factories is not available. This makes it difficult for regulators to come up with cost effective strategies — in terms of both design of environmental regulations as well as their enforcement — for industrial pollution control.

This lack of information, which severely constrains effective environmental management, points towards the need to adopt alternative ways for estimation of environmental parameters as complements to direct measures of such parameters at the firm level. This report uses one such alternative of estimating these parameters from information on pollution intensities and abatement costs from secondary sources.

This study was undertaken at the instance of the Ministry of Environment and Forests, Government of India. The terms of reference required the institute to (i) estimate industrial pollution discharge in India; (ii) estimate the cost of water pollution abatement; and (iii) to estimate the revenue potential of an effluent charge on industries.

While the study suggests introduction of a water pollution charge, it also recommends that the regulator should prioritise its monitoring effort and allocate its monitoring resources more efficiently by targeting industries characterised by relatively high effluent discharges and low costs of pollution abatement.

At the NIPFP, the study was designed and conducted by Dr. Rita Pandey.

The Governing Body of the Institute does not bear any responsibility for the views expressed in the report. This responsibility lies mainly with the author of the report.

New Delhi
October, 2000

Ashok Lahiri
Director

ACKNOWLEDGEMENTS

In the course of this study I have received help and support from a large number of individuals. I would like to place on record the help that I have received from Dr. David Shaman and Dr. Raymond S. Hartman both at the World Bank, Washington, D.C. I had useful discussions with Dr. Marcel P. Timmer, Eindheven University of Technology, Netherlands, who also provided some very useful data.

I am especially grateful to Dr. Ashok Lahiri, Director, NIPFP for his encouragement throughout this study and also for extremely useful suggestions on an earlier draft of the report. I have benefitted from discussions with Professor B.N. Goldar. I would like to thank Somsankar Ghosh and Saubhik Deb for their very able research assistance. Shri Rajinder Negi provided excellent secretarial assistance.

Finally, I would like to thank the Ministry of Environment and Forests for providing funds to carry out this study.

October, 2000 RITA PANDEY

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ESTIMATING INDUSTRIAL POLLUTION IN INDIA: IMPLICATIONS FOR AN EFFLUENT CHARGE

1. Introduction

Pollution from industries constitute a considerable part of total pollution in India. However, in India, reliable information on the nature and level of emissions/discharges by plants/factories is not available. This makes it difficult for regulators to come up with cost effective strategies — in terms of both design of environmental regulations as well as their enforcement — for industrial pollution control.

In so far as the design of environmental regulations is concerned the economists have long argued that economic instruments (such as effluent/emission charges) are a cheaper way *vis-a-vis* the traditional regulatory measures also known as Command and Control (CAC) measures to achieve the same environmental targets. For implementing economic instruments, information on the amount of pollution generated and the associated costs of its abatement is required. This information does not exist. For enforcement of regulation, it may be noted that various industries emit different pollutants in varying quantities with harmful effects on human health and natural environment. In the absence of basic information on the nature and level of discharges by firms, it is difficult for the regulators to set priorities for enforcement of environmental regulations in terms of both the industrial sector that should be targeted for greater intervention, and in terms of the geographical area where intervention should be focused.

This lack of information, which severely constrains effective environmental management, points towards the need to adopt alternative ways for estimation of environmental parameters as complements to direct measures of environmental parameters at the firm level. One such alternative method is to estimate these parameters using the pollution intensities and abatement cost coefficients developed by World Bank studies (Hettige, *et. al.* 1995 and NIPR 1994) for different industrial sectors. Pollution intensities provided in Hettige *et.al.*, 1995, have been developed using a modelling exercise called Industrial Pollution Projection System (IPPS). It is important to note that the purpose of such estimation is not to supplement regular monitoring of pollution sources. Proper monitoring of pollution sources are

extremely desirable and necessary. The purpose of this exercise, in the absence of required information, is to provide the regulator with information which can be used to design cost effective strategies for industrial pollution control.

2. Objectives and Plan of the Study

2.1 The Study has the Following Objectives:

(i) to estimate industrial pollution discharge (effluent) in India using the pollution intensities available in IPPS;

(ii) to estimate the cost of pollution abatement using the abatement cost coefficients available in the World Bank study; and

(iii) to estimate the revenue potential of an effluent charge on industries.

2.2 Outline of the Report

The report is organised as follows. The introductory section presents the issues involved and outlines the need for the study. Section 3 briefly summarises the IPPS methodology. In section 4, we describe the nature and distribution of industrial activity in India, and the data and estimation procedure used in estimation of pollution load in India by industrial sectors and states. This section also examines the implications of these results in terms of targetting of enforcement efforts. In section 5, we estimate the costs of pollution abatement in Indian industries along with their implications for modifications in current regulation, and the design of effluent charge. A discussion on determining the rate of effluent charge and who should implement it is presented in section 6. The concluding section provides specific recommendations.

3. The Industrial Pollution Projection System

The IPPS is a modelling system which merges the United States' (US) Environment Protection Agency (EPA) data on pollution emissions and the Longitudinal Research Database (LRD) on industrial activity at the plant level to calculate pollution intensity of industrial sectors. This is defined as the level of pollution emissions per unit of industrial activity. Three alternative measures of

Industrial activity have been used viz., value of production, value added and employment. Pollution intensities have been computed for the year 1987.

3.1 Data Used in IPPS

The EPA maintains a number of databases on pollution emissions. Four databases, namely, the Toxic Release Inventory (TRI), the Aerometric Information Retrieval System (AIRS), the National Pollutant Discharge Elimination System (NPDES) and the Human Health and Ecotoxicity Database (HHED) have been used in the calculation of pollution intensities.

The TRI, in 1987, contained information on annual emissions of 328 toxic chemicals to the environment. It covers all US manufacturing establishments which (i) produce, import or process 25,000 pounds or more of any listed chemical and (ii) employ 10 or more full-time employees. In 1987, about 20,000 establishments reported their releases of listed chemicals to EPA.

The AIRS is the US national database for ambient air quality, air emissions and compliance data with the US Clean Air Act. The EPA's NPDES database contains the self-reported data of establishments for which standards for water discharge have been laid down under the US Clean Water Act. Approximately 60,000 plants report data of their releases. The HHED contains various indices of toxicological potency.

The LRD is manufacturing census data which contains information from the Census of Manufacturers (CM) and the Annual Survey of Manufacturers (ASM). The LRD thus contains information on approximately 200,000 plants.

3.2 Pollution Intensity: Definition and Estimation

Pollution intensity is defined as the ratio of pollution discharge/emission per unit of manufacturing activity. In calculating the pollution intensity, the choice of the variable to measure the level or size of manufacturing activity is very important. The IPPS provides estimates for three alternative measures of the level of manufacturing activity viz., value of output, value added and employment. Hettige, *et. al.* (1995) have shown that in the case of US, the ranking of industrial sectors by their pollution

load[1] is almost identical, irrespective of whether the value of output or employment is used as the unit of measurement. Total value of output was, however, judged superior to value added because energy and materials inputs are critical in the determination of industrial pollution. The above study recognises that physical volume of output would be the ideal unit of measurement of the level/size of manufacturing activity. But, individual firms use different units to report the volume of output. This does not allow comparison across industries, and lack of data on volume of output in several countries[2] limits the application of this system. Thus, in the above study pollution intensity estimates for physical volume of output were not obtained.

Pollution intensities have been estimated for different environment medium (air, water and land) and for major pollutants (see Table 1). Three alternative estimates of pollution intensities have been obtained. This was done to correct for the upward bias resulting from the use of EPA data which cover establishments discharging pollutants in quantities over a threshold level of emissions and thus excludes the cleaner facilities. To correct for this, manufacturing data from LRD was grouped into three classes. Group 1 contained plants reporting emissions to EPA and if they could be matched to LRD data, group 2 contained plants which were reporting to EPA but could not be matched to LRD, and finally, group 3 contained those plants which did not report to EPA.

Pollution intensities derived for group 1 were defined as the Upper Bound (UB) estimates. These intensities were presumed to be affected by the presence of some extreme outliers. To correct for the upward bias of Upper Bound estimates, Inter-Quartile Mean (IQ) intensities were calculated for group 1. This was done by calculating the mean of the plant intensities after dropping those which are below the first quartile or above the third quartile. This provides a measure of central tendency. The ratio of total EPA emissions reported in a sector from groups 1 and 2 as a ratio of the total level of economic activity in that sector reported by LRD (from all three

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1 Pollution load is: Pollution intensity x level of manufacturing activity (manufacturing activity is defined as value of output/value added/ employment).

2 For instance, in India data on physical volume of output is not available from the Annual Survey of Industries (ASI) data. While it may be possible to assemble this data from different sources for different industrial categories, the advantage of using ASI data is that the variables are consistently defined and therefore comparable across industries. Also, ASI contains data at quite disaggregated level.

groups) was defined as the Lower Bound (LB) pollution intensity. This intensity measure assumes zero pollution load of plants in group 3. To the extent that these facilities have some emissions, the LB estimate is biased downward. Hettige, *et. al.* (1995) recommend the use of LB because of the larger sample used for this measurement compared to the sample used in deriving UB and IQ estimates.

Pollution intensities based on value of output for water and air pollution for selected industrial sectors by major water and air pollutants are presented in Appendix 1A and 1B, respectively. Toxic and metal pollution intensities for selected industrial sectors by medium (water, air and land) are presented in Appendix 1C and 1D, respectively. IPPS employment intensities are presented in Appendix 2A to 2D.

4. Industrial Pollution in India: Data and Estimation

Industrial pollution intensities available in IPPS are used to estimate the industrial pollution load in India. Pollution loads are estimated separately by multiplying the pollution intensities (available by industrial sector) by the value of output and number of persons employed in each industry. Estimates of pollution load are obtained in respect of the Central Pollution Control Board (CPCB) notified 17 categories of polluting industries. As noted earlier, for estimation of industrial pollution load, data on economic variables such as value of output and persons employed are required. Since CPCB does not collect these information, we have obtained the same from ASI[3]. Although ASI collects data at the factory[4] level but according to *Collection of Statistics Act*, in India, it cannot disclose it. It, however, provides information at both industry and state level.

ASI uses National Industrial Classification (NIC). All the factories in the ASI frame are accordingly classified in their appropriate industry groups corresponding to NIC classification. Since this study considers CPCB notified 17 polluting industries, it is necessary to map the CPCB's 17 industry categories to ASI data. The results of this exercise are reported in Table 2. It would be seen from Table 2 that for some industries in the CPCB list, the match with ASI data is poor. For instance,

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[3] ASI provides the most detailed and comprehensive data on industries.

[4] The factory is defined as: premises where ten or more workers are employed and manufacturing process is carried on with the aid of power or where twenty or more workers are employed and manufacturing process is carried on without the aid of power.

NIC code 300, manufacture of industrial organic and inorganic chemicals other than for laboratory and technical uses, would also include chemicals other than caustic soda (row 2, Table 2). Similarly, NIC code 400, generation and transmission of electric energy, would also include other sources of power.

4.1 Mapping 4-digit NIC Code to 4-digit ISIC Code

As mentioned earlier, we have obtained information on economic variables capturing industrial activity, from the ASI which uses NIC classification. However, IPPS pollution intensities are available at 4-digit International Standard Industrial Classification (ISIC) codes. It is thus necessary to map the 4-digit NIC code to the 4-digit ISIC code. Table 3 presents the results of this exercise. It would be seen from Table 3 that for some industries in the NIC list, the match with ISIC data is poor. For instance ISIC code 3511, industrial chemical except fertiliser would also include chemicals other than those listed under NIC 3001. Similarly, NIC code 3160, manufacture of other petroleum products (obtained from products or residues from petroleum refining), would also include products other than those listed under ISIC code 3513. Also, while NIC classifies fertilisers and pesticides as two different industries, ISIC code 3512 includes both fertilisers and pesticides. Pollution intensity for ISIC code 3512 is used for fertiliser (NIC codes 3011 to 3013) and pesticides (NIC codes 3014 and 3019). Four industries in the CPCB and NIC list were not found in the ISIC list. These industries are: aluminium manufacturing (NIC code 3350), copper manufacturing (NIC code 3330), zinc manufacturing (NIC code 3360) and generation and transmission of electric energy (NIC code 4000). Pollution intensity for ISIC code 3720, non-ferrous metals, has been used for NIC codes 3350, 3330 and 3360. Industry corresponding to NIC code 4000 had to be dropped.

4.2 Defining IPPS Pollution Intensities in Indian Rupees

IPPS pollution intensities obtained using value of output as a measure of industrial activity, hereafter output intensities, are available for the year 1987 in pounds per million US dollar of output value. Since value of industrial output in India is available in Indian rupees, either industrial output had to be defined in US dollars or the IPPS pollution intensities had to be defined in Indian rupees. We prefered the latter to the former. One way of defining pollution intensities in Indian rupees would be to use the official Indian/US exchange rate prevailing in 1987.

It may, however, be noted that the use of the official exchange rate may result in under-estimation (over-estimation) of the real output produced and thus under-estimation (over-estimation) of pollution load because difference in the prices of manufactured goods in India and US may be greater (lower) than that suggested by the official exchange rate. A measure of Purchasing Power Parity (PPP) is often recommended and used for the purpose of comparison of GDP across countries. The expenditure PPPs of the UN do not reflect relative price levels in the manufacturing sector. We have used alternative PPPs which have been developed using the industry-of-origin approach based on comparisons of prices of manufacturing goods (which include both tradables and non-tradable) across countries. These PPPs are also referred to as unit value ratios (UVRs) (Marcel P. Timmer 1999). IPPS pollution intensities have been applied to 1994-95 data[5] on value of output at 1987 prices.

4.3 Sectoral and Geographical Distribution of Industrial Activity in India: An Overview

As noted earlier, the study focuses on the CPCB notified most polluting industries except thermal power plants. These industries account for 28.11 per cent of total value of industrial production in India, and 19.52 per cent of total employment.

These industries are mostly concentrated in 7 states namely; Maharashtra, Gujarat, Uttar Pradesh, Tamil Nadu, Bihar, Andhra Pradesh and Madhya Pradesh which together account for more than 70 per cent of their total value of production (Table 4). Among these states, while iron and steel industry dominates in Bihar and Madhya Pradesh, oil refinery is largely concentrated in Maharashtra and Tamil Nadu, fertiliser in Gujarat, Maharashtra and Uttar Pradesh, sugar in Uttar Pradesh and Maharashtra, and cement industry dominates in Madhya Pradesh and Andhra Pradesh.

In 1994, among the 16 most polluting industries in terms of both value of production and employment, the largest industry was the iron and steel industry. The five largest industries contributing 74 per cent of the total value of industrial production and nearly 67 per cent of total employment in these industries were: iron and steel, oil refinery, fertiliser, sugar, and cement (Table 5).

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[5] Latest year for which ASI data is available.

4.4 Nature and Distribution of Industrial Pollution in India

In order to examine the nature and magnitude of industrial pollution in India, estimates of industrial pollution load have been obtained using the industrial value of production and employment as a measure of industrial activity. Pollution loads are estimated according to the nature of pollutants; water, air, toxic and metal and also by medium (air, water, land) for the toxic and metal pollutants. From the estimates of pollution load, two points are worth noting. First, estimates of pollution load are generally much larger by a factor ranging between 1 and 20, when employment is used as a measure of industrial activity (Appendix 3A). Second, ranking of industrial sectors changes depending on whether employment or value of production is used as the unit of measurement (Appendix 3B and 3C). Two factors may explain these results. First, most enterprises in India are overstaffed, thereby leading to higher estimates of pollution load with employment as a unit of measurement of industrial activity. Second, the extent of overstaffing and the adoption of capital intensive technology vary across industrial sectors and this may introduce a bias in relative ranking of industries in terms of pollution intensity. Hence, it is appropriate to use output intensities in estimating pollution load.

4.4.1 Major Polluting Industrial Sectors: by Nature of Pollutants

Relative contribution to total pollution load of each industry at the all India level is presented in Table 6. It can be seen from Table 6 that the iron and steel industry is the highest polluting in terms of all four pollutants except air where it ranks second to cement. Iron and steel is the largest water polluting industry in India with 87.5 per cent of the total pollution load. Pulp and paper and aluminium industries rank second and third respectively with their contribution to total water pollution load at 4.6 and 2.5 per cent. Sugar and distillery industries rank fourth and fifth, respectively.

Cement industry is the biggest air polluter emitting nearly 34 per cent of the total air pollution load. Iron and steel stands second, emitting 32 per cent, while oil refinery ranks third contributing 7.5 per cent to the total industrial air pollution load.

Iron and steel industry is also the largest metal polluter accounting for more than 71 per cent of the total metal pollution load. Aluminium industry is the second highest contributor (nearly 16 per cent) to metal pollution. In the toxic pollution

category also, iron and steel industry is the highest polluter contributing 39 per cent of the total pollution load. The second most polluting industry in this category is leather with about 14 per cent share in total toxic load. Iron and steel, leather, petrochemical and oil refinery industries together account for 70 per cent of the total toxic pollution load.

The main implication of these results is that substantial reduction in total pollution loads can be achieved by focusing pollution control efforts in a limited number of industrial sectors.

4.4.2 Major Polluting States

The contribution of each state to the total industrial pollution load of the country according to the medium of pollution are contained in Tables 7A to 7D. Total pollution load in any medium refers to the pollution generated by the sixteen industry categories notified by the CPCB as the most polluting industries in India. In toxic pollution, there are seven states which account for about 70 per cent of the total toxic industrial pollution. Maharashtra, the largest contributor, accounts for about 15.93 per cent of the total toxic pollution in the country followed by Gujarat at 15.51 per cent and Tamil Nadu at 8.47 per cent. Bihar is at the fourth place with a share of 8.38 per cent followed by Uttar Pradesh with 7.92 per cent of the total toxic pollution load. Madhya Pradesh and Orissa contribute 7.03 and 6.24 per cent respectively to this category of pollution.

68 per cent of the total industrial metal pollution load of the country is contributed by six states. Bihar ranks first with a share at 15.08 per cent followed by Maharashtra at 14.15 per cent. 12.13 per cent of the total metal pollution load is generated by Orissa. Madhya Pradesh's contribution to this category of pollution is 12.09 per cent followed by West Bengal at 7.39 per cent. Uttar Pradesh with a metal pollution load of 6.54 per cent of the total load ranks sixth.

The ranking of states in water pollution is somewhat similar to that of metal pollution. The four largest water polluting states are the same as in the case of metal pollution. Bihar with 17.10 per cent of the load leads the group and is followed by Madhya Pradesh with 12.93 per cent, Maharashtra with 12.47 per cent and Orissa with 10.86 per cent of the total water pollution load. Andhra Pradesh and West Bengal respectively have a share of 6.99 and 6.94 per cent of the total water pollution

load. Uttar Pradesh with a share of 5.49 per cent of the total pollution load puts the cumulative share of these 7 states at about 73 per cent.

As in the case of toxic pollution, Maharashtra is the largest polluter of air with a share of 14.96 per cent of the total industrial air pollution followed by Madhya Pradesh at 11.19 per cent. Gujarat ranks third with a share of 9.25 and is followed by Andhra Pradesh and Bihar at 8.83 and 8.62 per cent share, respectively. Tamil Nadu and Uttar Pradesh contribute 7.86 and 7.46 per cent of air pollution load, respectively. Orissa with a share of 6.58 per cent, takes the cumulative contribution of these 8 states to 74.81 per cent of total industrial air pollution load.

4.4.3 Major Polluting Industries and their Contribution to Pollution Load across States

Since the relative ranking of these industries varies considerably in terms of their contribution to the total industrial pollution load at the all India level vis-a-vis the state level, the policy implications that will emerge in terms of setting priorities for intervention for pollution control are likely to be different for the country as a whole from that for the individual states. For instance in all the states except Goa, iron and steel is the major water polluting industry in terms of contribution to the total water pollution load in the state (Table 8). In fact, in all the states excepting Goa and Kerala, iron and steel industry contributes more than fifty per cent to the states' total water pollution load. However, in Goa, distillery industry which ranks 5th at the all India level in terms of its contribution to total pollution load, is the only water polluting industry. Pulp and paper industry is the second largest contributor (5 to 20 per cent) to state's water pollution load in Andhra Pradesh, Haryana, Karnataka, Tamil Nadu, Gujarat and Uttar Pradesh. Aluminium, fertiliser and drugs and pharma are the other major water polluting industries besides iron and steel in the state of Kerala.

In terms of discharge of toxic pollutants, iron and steel industry is the largest contributor to states' total toxic pollution load in all states' excepting Assam, Gujarat, Goa, Kerala, Rajasthan and Tamil Nadu. In this category, petrochemical and fertiliser industries are major contributors in Gujarat, distilleries in Goa, fertiliser and aluminium industries in Kerala, oil refinery in Assam, leather in Tamil Nadu and fertiliser industries in Rajasthan.

For metal pollutants, iron and steel is the largest polluting industry in all the states except Goa. Oil refinery industry contributes substantially to states' total toxic pollution load in Assam, copper industry in Delhi, Maharashtra and Rajasthan, petro-chemical in Gujarat, aluminium industry in Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Uttar Pradesh and West Bengal and leather industry in Tamil Nadu.

For air pollutants, iron and steel industry is again the major polluting industry in all states except Assam, Goa and Kerala. Oil refinery, paper and cement are the major air polluting industries in Assam. While distillery is the single most polluting industry in Goa, cement and aluminium are the major air polluting industries in Kerala. Cement is a major air polluting industry for the states of Andhra Pradesh, Assam, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Rajasthan and Tamil Nadu. Among other industries, paper industry in Assam, Haryana and Karnataka; oil refinery industry in Assam, Gujarat, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal; aluminium industry in Kerala, Orissa, Uttar Pradesh and West Bengal; copper industry in Delhi; petrochemical in Gujarat; distillery in Jammu and Kashmir and sugar industry in Uttar Pradesh contribute significantly to the states' total air pollution load.

5. Cost of Pollution Abatement in Indian Industries

This section aims at estimating the pollution abatement cost in sixteen industries in India for major air and water pollutants. From the estimates of pollution abatement cost, an attempt is made to draw some inferences about the following:

(i) Extent of variance in abatement cost of a pollutant across industries;

(ii) appropriateness of the current legislation which mandates that each polluter must observe the uniform discharge/emission standards; and

(iii) introduction of an effluent charge on Biological Oxygen Demand (BOD).

5.1 Data and Estimation

Estimates of pollution abatement cost in Indian industries have been obtained using the abatement costs available for various pollutants by industrial sectors in

World Bank (1994). These abatement costs have been computed from the industry specific pollution abatement cost functions which, in turn, have been estimated using the data of US manufacturing facilities (Hartman *et.al.*, 1994, and Appendix 3A). The abatement cost coefficients for various pollutants by industries are presented in Table 9. The coefficients are in US dollars per ton of pollutant abated.

Estimates of abatement costs for Indian industries can be obtained by multiplying the World Bank estimates of abatement cost for a pollutant with its estimated load. To obtain the estimates of abatement cost in Indian rupees, World Bank coefficients which are available in US $ have been converted into rupees at Rs. 31.37 for US dollar at the 1994 exchange rate.

It may be recalled that in computation of pollution load we have used UVRs for defining IPPS pollution load coefficients in terms of rupees. As noted earlier (see page 7), unit value ratios (UVRs) indicate the relative producer price of goods in two countries. That is, UVR is the ratio of ex-factory unit output values for a particular good in two countries. Since, pollution abatement is a capital intensive activity the import component of its capital cost is likely to be high in a developing country like India. Use of UVRs may therefore result in under-estimation of the cost of abatement. We have thus used the official Indian/US exchange rate prevailing in 1994 for defining the World Bank abatement costs in rupees. These are presented in Table 10.

5.2 Estimates of Cost of Abatement

It can be seen from Table 10 that the average costs of abatement per unit of pollutant abated vary significantly across industries. The average costs of abatement of conventional water pollutants viz; BOD, total suspended solids (TSS), and oil and grease are substantially higher for fertiliser, pesticide, petro-chemical, drugs and oil refinery industries as compared to abatement costs of these pollutants for sugar, dye and dyes intermediate, leather and cement industries. It can also be seen from this table that abatement costs for a pollutant vary widely across different industries by a factor as much as 1 to 150[6]. These results reaffirm the result of the earlier studies

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[6] Variation in abatement costs can be attributed to factors such as the scale of production, the average operating efficiency of the firm, the available process technologies, and the efficiencies of waste treatment technologies.

on abatement costs (Mehta, Mundle, Sankar 1994; Pandey, 1998) in India which show large variations in abatement costs not only across the industrial sectors but also across firms within an industry. The most important observation that can be made on the basis of these results is that the current legislation, which requires that all polluters meet the same discharge standards, is highly inefficient. If firms can reduce pollution by different amounts, while collectively achieving the target aggregate reduction, then abatement costs can be reduced substantially. This is, because under the current regulations firms equate the amount of pollution generated, whereas under the market based instruments such as effluent charge they will equate their marginal abatement costs. Clearly, these results point towards the need to review the current regulation which is attempting to abate pollution at a very high cost.

It is important to note that abatement cost estimates based on US-based abatement cost coefficients are likely to be upper-bound estimates of pollution control costs in India for two reasons. First, US-based abatement cost estimates are based on high mandated levels of pollution control in the US. Second, cost of services - an important input in pollution abatement - is higher in the US vis-a-vis India. Moreover, in India substantial subsidies are available on installation of pollution control equipments both indigenously produced and imported (Pandey 1998).

5.3 Abatement Costs: IPPS Estimates vs. Estimates using Data Reported by Indian Firms

In this section we compare the estimated abatement costs in Table.10 with the estimates of abatement costs obtained from the data reported by a select number of firms in sugar and pulp and paper industries in India. We have estimated the abatement cost functions as given in Appendix 3A using the firm level data of Indian firms. The estimated abatement costs for the above mentioned industries are presented in Table 11.

It would be seen from Tables 11 and 10 that for sugar industry, the average cost per 100 gms of BOD removed is Rs. 0.78 as per the data obtained from Indian firms and Rs. 0.81 as per the estimates from US based data. For paper industry, similarly the estimated abatement costs per 100 gms of BOD are Rs. 0.83 and Rs. 0.96, respectively. These results support the hypothesised relationship between the abatement costs in US and Indian industries. Another important observation that can be made from Tables 10 and 11 is that the relative rank of sugar and paper industries

in terms of cost of abatement is same for both US data-based and Indian data-based estimates.

6. Determining the Rate of Effluent Charge

An important aspect of designing an effluent charge is to determine the right rate of charge. Theoretical literature provides the following prescription: the rate of charge should be set such that the marginal gains from the pollution reduced equals the marginal cost of reducing it. In other words, a rate of charge equal to the marginal pollution abatement cost at the socially optimum level of pollution will induce the polluter to reduce his/her pollution to the socially efficient level.

However, given the practical difficulties in measuring the damage due to pollution and also gains from reduction in pollution at the margin, the above approach is difficult to put in practice. Economists have suggested an alternative approach which is popularly known as 'standards and taxes' approach. This approach involves a pre-specified emission/discharge standard for each pollutant, together with a charge that is levied on the polluter if he/she exceeds the prescribed norms. Ideally, the rate of charge should be set so as to induce just the desired amount of pollution abatement. If it is set too low, firms will abate less than the targeted amount, and *vice versa*. It has been argued that the rate of charge should be set equal to the average marginal costs of abatement (MCA) for a given standard. Effluent charge should be levied on discharges exceeding the specified standards. Firms with abatement costs higher than the rate of charge, will abate upto a point where rate of charge equals their marginal abatement costs and will pay the effluent charge on the remaining discharges liable to be charged. Firms with abatement costs lower than the rate of charge will abate till the standards since there is no incentive for them to abate more even when the additional incremental cost of abatement is lower than the rate of charge. While this system would achieve the target pollution reduction at a lower cost *vis-a-vis* the current command and control (CAC) type system it does not lead to equalisation of abatement costs across the firms at the margin. This is because under the 'standards and taxes' approach, the marginal abatement costs of those firms which have MAC higher than the rate of charge will be equated, whereas the firms with MAC lower than the rate of charge will continue to have different MACs. The latter is mainly due to the absence of incentives to abate more than what is required

by the specified standards. In this context, a full charge[7] system seems more appropriate. Results of a recent simulation study (Dasgupta *et. al.*, 1996) provide support in favour of this view point. The study shows that a shift from the existing tax and standard system in China, to a full charge system would result in substantial reduction in overall costs of abatement.

However, we feel that in a country where discharge standards are in force for more than two decades and firms have adjusted their abatement activities to the discharge standards, a full charge system may not be acceptable to industries. There may also be resistance because of factors such as non-availability of technology for meeting more stringent targets and economic viability of meeting such targets. Since efficiency is by no means the only factor in designing a pollution control instrument, we may take an approach in which efficiency may have to be sacrificed marginally for the gain in its acceptability hence, implementation and enforcement ease.

Another issue pertains to setting the rate of charge. What level of abatement cost should it reflect? In this context, it may be mentioned that since the effect of BOD when discharged into water bodies is the same irrespective of its origin, the main objective of the regulators is to realise the overall target pollution level. The rate of effluent charge based on the high abatement cost industry will provide incentive to industries with equal or lower abatement cost for clean up. This would also provide an incentive to low abatement cost industries to abate beyond the prescribed standards provided there is a mechanism to reward this extra effort on the part of the firm[8]. This can be done through a system of providing clean-up credits[9] to those firms which reduce pollution beyond the required levels. Revenues collected from the non-complying firms should be used to fund projects for water quality management, to strengthen the capabilities of monitoring and enforcement agencies, and to assist firms in their efforts in pollution control. Such earmarking of funds may also serve as a kind of second best measure where the likely costs due to effluent charge make their introduction difficult without some form of earmarking assistance.

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7 In full charge system, pollution charge is levied on all the units of pollutants discharged by a polluter. In other words under this system there are no discharge standards or the discharge standards for pollutants are zero.

8 It was noted before that this would result in realising the same pollution target at lower costs.

9 These credits can be sold to those not complying fully. Initially the system of providing credit may be used selectively in one or two regions. These steps would not only lay the foundation for its extention to other regions but would generate valuable information on the actual cost.

It is suggested that an effluent charge at the rate of Rs. 1.86 per 100 grams of BOD discharged[10], in excess of the prescribed amounts, be levied on all polluting firms. Revisions in effluent charges could be affected on the basis of response of the industry.

6.1 Who Should Administer the Effluent Charge?

In introducing a pollution tax, the issue of who should administer it is an important one. Ideally, the design and locus of administration of the pollution tax should reflect both environmental and taxation objective. The pollution tax should be viewed as a tool to realise the joint gains from pollution control and a reduced reliance on distorting taxes. While in practice, such an integrated approach to tax policy is not very simple, this should not undermine the importance of this approach. However, until this is done, the environmental regulators must be given a dominant role in the design and administration of pollution taxes, rather than assigning this responsibility to a taxing authority.

6.2 Revenue Potential of Effluent Charge on discharge of BOD

Estimates of revenue potential of an effluent charge at Rs. 1.86 per 100 gms of BOD discharged are obtained for four alternative scenarios of abatement response from the industries: no abatement, 50 per cent, 70 per cent and 90 per cent abatement. Estimated revenue when there is no abatement is Rs. 224.86 crores. In other three scenarios it is Rs. 112.35, 67.46 and 22.49 crores respectively.

7. Main Findings and Recommendations

1. As the relative ranking of industries considered in the study varies considerably in terms of their contribution to the total industrial pollution load at the all India level vis-a-vis the state level, the policy implications that emerge in terms of setting priorities for intervention for pollution control are likely to be different for the country as a whole from that for the individual states (Section 4.4.3).

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[10] Though standards are specified for other pollution parameters also such as COD and suspended solids, generally only the BOD standards are enforced by the regulating agencies.

2. Estimates of abatement costs of pollutants show wide variation across different industries by a factor as much as 1 to 150 (section 5.2). This shows that the current legislation, which requires that all polluters meet the same discharge standards, is highly inefficient. Introduction of economic instruments is thus imperative for cost effective industrial pollution control.

3. For controlling industrial water pollution, an effluent charge should be levied on a common indicator of water pollution, namely, BOD. The charge could initially be set at Rs. 1.86 per 100 grams of BOD discharged in excess of the prescribed standards on all polluting firms. Revisions in affluent charges could be affected on the basis of response of the industry.

4. The average costs of abatement of conventional water pollutants viz; BOD, TSS and oil and grease are substantially higher for fertiliser, pesticides, petro-chemical, drugs and oil refinery industries as compared to abatement costs of these pollutants for sugar, dye and dye intermediate, leather and cement industries (Section 5.2 and Table 10). Results show that the iron and steel industry is the largest water, metal and toxic substance polluter whereas cement industry is the biggest air polluter. Regulator should therefore prioritise their monitoring effort and allocate their monitoring resources more efficiently by targeting the industries characterised by relatively high effluent discharges and low costs of pollution abatement (Sections 4.4.1 and 5.2).

5. Revenue collected from the non-complying firms should be put in a separate fund. This fund could be used to finance projects for water quality management, to strengthen the capabilities of monitoring and enforcement agencies, and to accelerate the innovation and spread of technologies to prevent and control pollution.

Table 1. Pollution Intensities in IPPS

1.	**Toxic and Bio-Accumulative Pollution Intensities by Medium:**
	1. Toxic Pollution to Air
	2. Toxic Pollution to Water
	3. Toxic Pollution to Land
	4. Bio-Accumulative Metal Pollution to Air
	5. Bio-Accumulative Metal Pollution to Water
	6. Bio-Accumulative Metal Pollution to Land
2.	**Air Pollution Intensities:**
	7. Sulphur Dioxide (SO_2)
	8. Nitrogen Dioxide (NO_2)
	9. Carbon Monoxide (CO)
	10. Volatile Organic Compounds (VOC)
	11. Particulates less than 10 μm in diameter (PM_{10})
	12. Total Particulates (TP)
3.	**Water Pollution Intensities:**
	13. Biological Oxygen Demand (BOD)
	14. Total Suspended Solids (TSS)

Table 2: Mapping of CPCB industry categories to NIC Codes

S.No.	CPCB category	NIC	3 digit NIC description	NIC	4 digit NIC description
1.	Aluminium smelter	335	Aluminium manufacturing.	3350	Aluminium manufacturing.
2.	Caustic soda	300	Manufacture of industrial organic and inorganic chemicals other than for laboratory and technical uses.	3001	Manufacture of nitric acid, ammonia, commercial ammonium chloride, nitrates of potassium and other basic chemicals of nitrogenous fertiliser industry.
3.	Cement	324	Manufacture of cement lime and plaster.	3241 3242 3243 3244	Manufacture of cement in the form of clinkers. Manufacture of portland cement, aluminious cement, slag cement and similar hydraulic cements except in the form of clinkers. Manufacture of quicklime, slacked lime and hydraulic lime. Manufacture of plaster (but not plaster products).
4.	Copper smelter	333	Copper manufacturing.	3330	Copper manufacturing.
5.	Distillery	220 221 222	Distilling, rectifying and blending of spirits, ethyl alcohol production from fermented materials. Manufacture of wine. Manufacture of malt liquors and malt.	2200 2210 2220	Distilling, rectifying and blending of spirits; ethyl alcohol production from fermented materials. Manufacture of wine. Manufacture of malt liquors and malt.
6.	Dyes and dye intermediate	236 243 246 248 257	Bleaching-dyeing and printing of cotton textiles. Bleaching and dyeing of woolen textiles. Bleaching-dyeing and printing of textiles. Bleaching-dyeing and printing of artificial/ synthetic textile fabrics. Bleaching-dyeing and printing of jute and mesta textiles.	2360 2430 2460 2480 2570	Bleaching, dyeing and printing of cotton textiles. Bleaching and dyeing of woolen textiles. Bleaching, dyeing and printing of silk textiles. Bleaching, dyeing and printing of artificial/synthetic textile fabrics. Bleaching, dyeing and printing of jute and mesta textiles.

S.No.	CPCB category	NIC	3 digit NIC description	NIC	4 digit NIC description
7.	Fertiliser	301	Manufacture of fertilisers and pesticides.	3011	Manufacture of straight inorganic fertilisers.
				3012	Manufacture of urea and other organic fertilisers.
				3013	Manufacture of mixed, compound or complex fertilisers.
8.	Integrated iron and steel	330	Manufacture of iron and steel in primary/self-fmished forms.	3301	Manufacture of iron and steel in primary/semi-finished forms in the integrated steel plants and in mini steel plants (including re-rolling or iron and steel scraps).
		331	Manufacture of semi-finished iron and steel products in re-rolling mills, cold-rolling mills and wire-drawing mills.	3303	Manufacture of direct reduced iron and other spongy ferrous products in primary forms; other than in the integrated steel plants.
		332	Manufacture of ferro-alloys.	3304	Manufacture of pig-iron other than in the integrated steel plants.
		337	Casting of metals.	3309	Manufacture of iron and steel in primary forms n.e.c.
				3314	Manufacture of tin free steel, tin plates, galvanised/zinc-aluminium coated/organic coated/laminated plates, sheets and stripe of iron and steel.
				3320	Manufacture of ferro-alloys.
9.	Leather	290	Tanning, curing, finishing, embossing and japanning of leather.	2900	Tanning, curing, finishing, embossing and japanning of leather.
10.	Pesticide	301	Manufacture of fertilisers and pesticides.	3014	Pesticides (fungicides, weedicides and insecticides).
				3019	Fertiliser and pesticides n.e.c.

S.No.	CPCB category	NIC	3 digit NIC description	NIC	4 digit NIC description
11.	Petrochemical	316	Manufacture of other petroleum products n.e.c. (obtained from products or residues from petroleum refining).	3160	Manufacture of other petroleum products n.e.c. (obtained from products or residues from petroleum refining).
12.	Basic drugs and pharma	304	Manufacture of drugs, medicines and allied products.	3043	Manufacture of ayurvedic/unani pharmaceutical preparations.
				3044	Manufacture of homeopathic/bio-chemic pharmaceutical preparations.
				3049	Manufacture of other pharmaceutical products n.e.c. (including heparin and its salts, substances for therapeutic or prophylactic uses, blood fractions, vaccines, toxins, sterile surgical cat-guts etc. blood grouping re-agents, dental cements or fillings, chemical contraceptive preps. etc.
13.	Pulp and paper	280	Manufacture of pulp, paper and paper board including manufacture of newsprint.	2801	Manufacture of pulp (machine made).
				2802	Manufacture of paper (machine made).
		283	Manufacture of special purpose paper whether or not printed n.e.c.	2804	Manufacture of packaging paper (machine made).
				2805	Manufacture of paper board and straw board (machine made).
				2830	Manufacture of special purpose paper whether or not printed n.e.c.
14.	Oil refinery	314	Manufacture of refined petroleum products (e.g. liquid or gaseous fuel illuminating oils, lubricating oils, greases and similar products).	3140	Manufacture of refined petroleum products (e.g. liquid or gaseous fuel illuminating oils, lubricating oils, greases and similar products).

S.No.	CPCB category	NIC	3 digit NIC description	NIC	4 digit NIC description
15.	Sugar	206	Manufacture and refining of sugar (vacuum pan sugar factories).	2060	Manufacture and refining of sugar (vacuum pan sugar factories).
		207	Production of indigenous sugar, boora, khandsari, gur etc. from sugarcane, palm juice etc.	2071	Manufacture of gur from sugarcane and gur other than from sugar-cane.
				2073	Manufacture of khandsari sugar from sugar-cane and manufacture of khandsari other than from sugar-cane.
				2079	Manufacture of 'boora' a candy from sugarcane or others (e.g. palm juice or date juice) and manufacture of other indigenous products from sugarcane, sugarbeet or palm juice etc.
16.	Zinc smelter	336	Zinc manufacturing.	3360	Zinc manufacturing.

Note: n.e.c. - not elsewhere classified.

Table 3: Mapping of NIC Codes to ISIC Codes

S.No.	NIC	4 digit NIC description	ISIC	Industry description
1.	3330 3340 3350 3360 3390	Copper manufacturing. Brass manufacturing. Aluminium manufacturing. Zinc manufacturing. Other non-ferrous metal industries.	3720	Nonferrous metals. (includes Aluminium, Copper and Zinc smelters)
2.	3001 3002 3003 3004 3005 3006 3007 3008 3009	Manufacture of nitric acid, ammonia, commercial ammonium chloride, nitrates of potassium and other basic chemicals of nitrogenous fertiliser industry. Manufacture of industrial gases (incl. elemental gases, liquid or compressed air, acetylene and mixed industrial gases). Manufacture of inorganic acids excl. manufacture of nitric acid. Manufacture of industrial monocarboxilic fatty acids, acid oils and industrial fatty alcohols; manufacture of glycerine. Manufacture of tanning/dyeing extracts: tannings and their derivatives and colouring matter n.e.c. Manufacture of turpentine and resins of vegetable origin (e.g. terpenic oils, crude dipentene and para-cymene, pine oil, rosin and acids, rosin spirit and resin oils, wood tar, wood naptha etc.). Manufacture of organic acids, alcohols, methanol and higher alcohols (excl. ethyle alcohol). Manufacture of other basic inorganic chemicals (e.g. roasted iron pyrites, oxides of non-metals, halogen or sulphur compounds of non-metals, halogen or sulphur compounds of non-metals, fluorides, chlorides etc. and their oxides etc. excl. radioactive elements. Manufacture of other basic organic chemicals (e.g. animal black, animal or vegetable fats and oils edible or inedible, hydrocarbons and their derivatives, enzymes etc. but excl. vitamins and hormones, provitamins, esters, sugars and their salts, glycocides etc.	3511	Industrial chemical except fertiliser.

S.No.	NIC	4 digit NIC description	ISIC	Industry description
3.	3241	Manufacture of cement in the form of clinkers.	3692	Cements, lime and plaster.
	3242	Manufacture of portland cement, aluminious cement, slag cement and similar hydraulic cements except in the form of clinkers.		
	3243	Manufacture of quicklime, slacked lime and hydraulic lime.		
	3244	Manufacture of plasters (but not plaster products).		
	3270	Manufacture of asbestos cement and other cement products.		
4.	3330	Copper manufacturing.	3720	Nonferrous metals.
5.	2200	Distilling, rectifying and blending of spirits; ethyl alcohol production from fermented materials.	3131	Distilled spirits.
			3132	Wine industries.
			3133	Malt liquors and malt.
	2210	Manufacture of wine.		
	2220	Manufacture of malt liquors and malt.		
6.	2360	Bleaching, dyeing and printing of cotton textiles.	3211	Spinning, weaving and finishing textiles.
	2430	Bleaching and dyeing of woolen textiles.		
	2460	Bleaching, dyeing and printing of silk textiles.		
	2480	Bleaching, dyeing and printing of artificial/synthetic textile fabrics.		
	2570	Bleaching, dyeing and printing of jute and mesta textiles.		
	2580	Bleaching, dyeing and printing of coir textiles.		
	2590	Bleaching, dyeing and printing of other vegetable fibre textiles n.e.c.		
7.	3011	Manufacture of straight inorganic fertilisers.	3512	Fertilisers and pesticides.
	3012	Manufacture of urea and other organic fertilisers.		
	3013	Manufacture of mixed, compound or complex fertilisers.		

S.No.	NIC	4 digit NIC description	ISIC	Industry description
8.	3301	Manufacture of iron and steel in primary/semi-finished forms in the integrated steel plants and in mini steel plants (including re-rolling or iron and steel scraps).	3710	Iron and steel.
	3303	Manufacture of direct reduced iron and other spongy ferrous products in primary forms; other than in the integrated steel plants.		
	3304	Manufacture of pig-iron other than in the integrated steel plants.		
	3309	Manufacture of iron and steel in primary forms n.e.c.		
	3313	Manufacture of wire-drawings of steel, alloy steel or stainless steel.		
	3314	Manufacture of tin free steel, tin plates, galvanised/zinc-aluminium coated/organic coated/laminated plates, sheets and stripe of iron and steel.		
	3319	Manufacture of semi-finished iron and steel products n.e.c., hot-rolled semi-finished iron and steel products in cold rolling mills.		
	3320	Manufacture of ferro-alloys.		
	3370	Casting of metals.		
9.	2900	Tanning, curing, finishing, embossing and japanning of leather.	3231	Tanneries and leather finishing.
	2910	Manufacture of footwear (excluding repair) except vulcanized or moulded rubber or plastic.		
	2920	Manufacture of wearing apparel of leather and substitute of leather.		
	2960	Manufacture of fur and skin rugs and other similar articles.		
	2990	Manufacture of leather and fur products not elsewhere classified (nec).		
10.	3014	Pesticides (fungicides, weedicides and insecticides).	3512	Fertilisers and pesticides.
	3019	Fertiliser and pesticides n.e.c.		
11.	3140	Manufacture of refined petroleum products (e.g. liquid or gaseous fuel illuminating oils, lubricating oils, greases and similar products).	3513	Synthetic resins, plastic materials
	3160	Manufacture of other petroleum products n.e.c. (obtained from products or residues from petroleum refining).		

S.No.	NIC	4 digit NIC description	ISIC	Industry description
12.	3043	Manufacture of ayurvedic/unani pharmaceutical preparations.	3522	Drugs and medicines
	3044	Manufacture of homeopathic/bio-chemic pharmaceutical preparations.		
	3049	Manufacture of other pharmaceutical products n.e.c. (including heparin and its salts, substances for therapeutic or prophylactic uses, blood fractions, vaccines, toxins, sterile surgical cat-guts etc. blood grouping re-agents, dental cements or fillings, chemical contraceptive preps. etc.		
13.	2801	Manufacture of pulp (machine made).	3411	Pulp, paper, and paperboard.
	2802	Manufacture of paper (machine made).	3419	Pulp, paper, and paperboard.
	2804	Manufacture of packaging paper (machine made).		
	2805	Manufacture of paper board and straw board (machine made).		
	2930	Manufacture of special purpose paper whether or not printed n.e.c.		
14.	3140	Manufacture of refined petroleum products (e.g. liquid or gaseous fuel illuminating oils, lubricating oils, greases and similar products).	3530	Petroleum refineries.
			3540	Misc. petroleum and coal products.
	3160	Manufacture of other petroleum products n.e.c. (obtained from products or residues from petroleum refining).		
15.	2060	Manufacture and refining of sugar (vacuum pan sugar factories).	3118	Sugar factories and refineries.
	2071	Manufacture of gur from sugarcane and gur other than sugar-cane.		
	2073	Manufacture of khandsari sugar from sugar-cane and manufacture of khandsari other than from sugar-cane.		
	2079	Manufacture of 'boora' a candy from sugarcane or other (e.g. palm juice or date juice) and manufacture of other indigenous products from sugarcane, sugarbeet or palm juice etc.		
16.	4000	Generation and transmission of electric energy.		
17.	3360	Zinc manufacturing.	3720	Nonferrous metals.

Note: n.e.c. - not elsewhere classified.

Table 4. Statewise Distribution of Value of Output of 16 Most Polluting Industries

S.No.	States	Per cent of Total Output	Cumulative Share (per cent)
1.	All India	100	100
2.	Maharashtra	18.25	18.25
3.	Gujarat	12.59	30.84
4.	Uttar Pradesh	10.41	41.25
5.	Tamil Nadu	8.44	49.69
6.	Others	7.31	57.00
7.	Bihar	6.95	63.95
8.	Andhra Pradesh	6.95	70.90
9.	Madhya Pradesh	6.81	77.72
10.	Orissa	4.76	82.48
11.	West Bengal	4.17	86.65
12.	Karnataka	2.93	89.58
13.	Punjab	2.87	92.46
14.	Rajasthan	2.64	95.10
15.	Haryana	1.59	96.69
16.	Assam	1.22	97.92
17.	Kerala	0.92	98.83
18.	Delhi	0.38	99.21
19.	Himachal Pradesh	0.29	99.50
20.	Pondicherry	0.19	99.69
21.	Chandigarh	0.18	99.87
22.	Jammu & Kashmir	0.06	99.92
23.	Daman & Diu	0.06	99.98
24.	Goa	0.02	100.00

Table 5. Value of Output and Total Employment in the Most Polluting Industries in India

S.No.	ISIC Code	Industry	Total Value of Production (Rs.'000)	Total no. of emplyees	% of Total Output	%of Total Employees	Cumulative % Output
1.	3710	Iron and Steel	424037387	381536	29.12	28.04	29.12
2.	3530	Oil refinery	230571289	24553	15.84	1.80	44.96
3.	3512	Fertiliser	173220325	76576	11.90	5.63	56.86
4.	3118	Sugar	161150448	327252	11.07	24.05	67.93
5.	3692	Cement	88380698	93229	6.07	6.85	74.00
6.	3411	Pulp and paper	67829121	114952	4.66	8.45	78.66
7.	3513	Petrochemical	65843544	29630	4.52	2.18	83.18
8.	3720	Aluminium	55241176	38906	3.79	2.86	86.97
9.	3211	Dyes and dye intermediates	42563168	112528	2.92	8.27	89.90
10.	3512	Pesticide	39022534	27234	2.68	2.00	92.58
11.	3131	Distillery	34566292	41098	2.37	3.02	94.95
12.	3231	Leather	25005813	42488	1.72	3.12	96.67
13.	3720	Copper smelter	18595348	11037	1.28	0.81	97.94
14.	3522	Drugs and pharma	15900251	27626	1.09	2.03	99.04
15.	3720	Zinc smelter	9437615	5686	0.65	0.42	99.69
16.	3511	Caustic soda	4581879	6552	0.31	0.48	100.00

Table 6. Ranking of Industries by Relative Pollution Levels and by Medium

S.No.	ISIC Code	Industry	Water		Air		Toxic		Metal	
			Rank	% share	Rank	% share	Rank	% share	Rank	% share
1.	3720	Aluminium	3	2.53	6	3.84	5	7.58	2	15.82
2.	3720	Copper	6	0.85	10	1.30	8	2.56	3	5.34
3.	3720	Zinc	8	0.41	12	0.62	10	1.23	4	2.58
4.	3710	Iron and steel	1	87.43	2	32.18	1	38.98	1	71.41
5.	3692	Cement	7	0.47	1	33.55	15	0.34	9	0.30
6.	3530	Oil Refinery	10	0.18	3	7.42	4	7.83	8	0.42
7.	3522	Drugs	9	0.25	15	0.07	14	0.75	14	0.02
8.	3513	Petrochemicals	14	0.06	7	2.52	3	9.80	6	0.74
9.	3512	Pesticide	11	0.13	9	1.49	7	5.81	7	0.44
10.	3512	Fertiliser	13	0.04	16	0.06	13	1.09	11	0.17
11.	3511	Caustic Soda	15	0.03	14	0.14	9	1.29	12	0.14
12.	3411	Pulp and paper	2	4.61	5	6.62	6	6.17	13	0.08
13.	3231	Leather	12	0.11	13	0.41	2	14.16	5	2.24
14.	3211	Dyes and dye intermediates	16	0.026	11	0.89	12	1.13	10	0.26
15.	3131	Distillery	5	1.29	8	1.80	16	0.07	16	0
16.	3118	Sugar	4	1.55	4	7.07	11	1.20	15	0.01
		Total		100		100		100		100

Table 7A. Water Pollution Load (tons) Using Output Intensities

S.No.	States	Pollution Load	Per centage Share	Cumulative Share (per cent)
1.	All India	1879140.31	100	
2.	Maharashtra	234360.17	12.47	42.52
3.	Gujarat	78354.11	4.17	90.78
4.	Uttar Pradesh	103205.63	5.49	72.82
5.	Tamil Nadu	84384.41	4.49	82.42
6.	Others	78698.45	4.19	86.61
7.	Bihar	321494.75	17.11	17.11
8.	Andhra Pradesh	131536.27	7.00	60.39
9.	Madhya Pradesh	243125.24	12.94	30.05
10.	Orissa	204240.25	10.87	53.39
11.	West Bengal	130444.33	6.94	67.33
12.	Karnataka	58705.67	3.12	93.90
13.	Punjab	96050.21	5.11	77.93
14.	Rajasthan	23530.82	1.25	97.12
15.	Haryana	36939.58	1.96	95.87
16.	Assam	7861.10	0.42	99.21
17.	Kerala	6549.88	0.35	99.56
18.	Delhi	12387.18	0.66	97.78
19.	Himachal Pradesh	5709.87	0.30	99.86
20.	Pondicherry	9655.95	0.51	98.29
21.	Chandigarh	9294.02	0.49	98.79
22.	Jammu & Kashmir	2378.90	0.13	99.99
23.	Daman & Diu	115.33	0.01	100
24.	Goa	118.17	0.01	99.99

Table 7B. Air Pollution Load (tons) Using Output Intensities

S.No.	States	Pollution Load	Per centage Share	Cumulative Share (per cent)
1.	All India	11416931.88	100	
2.	Maharashtra	212063.08	14.97	14.97
3.	Gujarat	131189.65	9.26	35.41
4.	Uttar Pradesh	105790.62	7.47	68.23
5.	Tamil Nadu	111460.81	7.87	60.76
6.	Others	68925.14	4.86	79.68
7.	Bihar	122241.04	8.63	52.89
8.	Andhra Pradesh	125412.60	8.85	44.27
9.	Madhya Pradesh	158559.68	11.19	26.16
10.	Orissa	93368.37	6.59	74.81
11.	West Bengal	60730.68	4.29	88.30
12.	Karnataka	61477.80	4.34	84.02
13.	Punjab	38518.90	2.72	94.86
14.	Rajasthan	54414.87	3.84	92.14
15.	Haryana	24251.66	1.71	96.57
16.	Assam	17347.94	1.22	97.80
17.	Kerala	7864.164	0.55	99.07
18.	Delhi	4828.08	0.34	99.41
19.	Himachal Pradesh	10141.21	0.71	98.51
20.	Pondicherry	3405.32	0.24	99.65
21.	Chandigarh	3230.58	0.23	99.88
22.	Jammu & Kashmir	870.81	0.06	99.94
23.	Daman & Diu	689.87	0.05	99.99
24.	Goa	148.97	0.01	100

Table 7C. Toxic Pollution Load (tons) Using Output Intensities

S.No.	States	Pollution Load	Per centage Share	Cumulative Share (per cent)
1.	All India	161234.34	100	
2.	Maharashtra	25686.59	15.93	15.93
3.	Gujarat	25009.71	15.51	31.44
4.	Uttar Pradesh	12771.18	7.92	64.26
5.	Tamil Nadu	13664.40	8.47	39.92
6.	Others	12953.58	8.03	56.34
7.	Bihar	13522.33	8.39	48.30
8.	Andhra Pradesh	9280.99	5.76	83.29
9.	Madhya Pradesh	11342.00	7.03	71.29
10.	Orissa	10063.31	6.24	77.53
11.	West Bengal	8748.45	5.42	88.72
12.	Karnataka	3198.20	1.98	93.54
13.	Punjab	4581.51	2.84	91.56
14.	Rajasthan	3134.86	1.94	95.49
15.	Haryana	2270.70	1.41	96.89
16.	Assam	1348.98	0.84	98.65
17.	Kerala	1481.77	0.92	97.81
18.	Delhi	805.05	0.50	99.15
19.	Himachal Pradesh	304.88	0.19	99.81
20.	Pondicherry	403.85	0.25	99.40
21.	Chandigarh	362.60	0.22	99.62
22.	Jammu & Kashmir	82.39	0.05	100
23.	Daman & Diu	216.48	0.13	99.95
24.	Goa	0.50	0.00	100

Table 7D. Metal Pollution Load (tons) Using Output Intensities

S.No.	States	Pollution Load	Per centage Share	Cumulative Share (per cent)
1.	All India	46658.47	100	
2.	Maharashtra	6606.38	14.16	29.24
3.	Gujarat	1935.10	4.15	83.11
4.	Uttar Pradesh	3055.13	6.55	67.42
5.	Tamil Nadu	1897.97	4.07	87.18
6.	Others	2674.72	5.73	78.97
7.	Bihar	7038.47	15.08	15.08
8.	Andhra Pradesh	2711.32	5.81	73.23
9.	Madhya Pradesh	5642.93	12.09	53.47
10.	Orissa	5663.17	12.14	41.38
11.	West Bengal	3452.59	7.40	60.87
12.	Karnataka	1330.99	2.85	94.02
13.	Punjab	1858.23	3.98	91.16
14.	Rajasthan	801.52	1.72	95.73
15.	Haryana	642.78	1.38	97.11
16.	Assam	107.14	0.23	99.86
17.	Kerala	320.09	0.69	98.50
18.	Delhi	329.68	0.71	97.82
19.	Himachal Pradesh	116.19	0.25	99.63
20.	Pondicherry	196.42	0.42	99.38
21.	Chandigarh	210.49	0.45	99.96
22.	Jammu & Kashmir	46.97	0.10	99.96
23.	Daman & Diu	20.18	0.04	100
24.	Goa	0	0	100

Table 8. Major Polluting Industries and their Contribution to Pollution Load Across States

S.No	States	Major Polluting Industries	Contribution of Industry in terms of Pollution Load					
			50% and above	31 - 49%	21 - 30%	11 - 20%	5 - 10%	below 5%
1.	Andhra Pradesh							
	Water	Iron and Steel	Iron and Steel				Pulp and Paper	Rest
	Toxic	Iron and Steel, Fertiliser, Oil refinery		Iron and Steel		Fertiliser, Oil refinery	Pulp and Paper	Rest
	Metal	Iron and Steel	Iron and Steel				Aluminium	Rest
	Air	Cement, Iron and Steel		Cement, Iron and Steel			Pulp and Paper, Oil refinery	Rest
2.	Assam							
	Water	Iron and Steel, Pulp and Paper	Iron and Steel	Pulp and Paper				Cement, Drugs, Oil refinery
	Toxic	Oil refinery, Pulp and Paper, Iron and Steel	Oil refinery		Pulp and Paper	Iron and Steel		Drugs
	Metal	Iron and Steel, Oil refinery	Iron and Steel			Oil refinery		Rest
	Air	Oil refinery, Pulp and Paper, Cement	Oil refinery		Pulp and Paper	Cement	Iron and Steel	Rest
3.	Bihar							
	Water	Iron and Steel	Iron and Steel					Rest
	Toxic	Iron and Steel	Iron and Steel					Rest
	Metal	Iron and Steel	Iron and Steel				Copper	Rest
	Air	Iron and Steel	Iron and Steel				Cement	Rest

S.No	States	Major Polluting Industries	Contribution of Industry in terms of Pollution Load					
			50% and above	31 - 49%	21 - 30%	11 - 20%	5 - 10%	below 5%
4.	Delhi							
	Water	Iron and Steel	Iron and Steel					Rest
	Toxic	Iron and Steel, Copper, Pesticide	Iron and Steel			Copper, Pesticide	Drugs, Leather, Petro-chemical	Aluminium, Dyes
	Metal	Iron and Steel, Copper	Iron and Steel		Copper			Rest
	Air	Iron and Steel, Copper	Iron and Steel			Copper		Rest
5.	Gujarat							
	Water	Iron and Steel	Iron and Steel				Fertiliser, Pulp and Paper	Rest
	Toxic	Petro-chemical, Fertiliser		Petro-chemical		Fertiliser	Pesticide, C-soda, Iron and Steel, Oil refinery	Rest
	Metal	Iron and Steel, Petro-chemical	Iron and Steel			Petro-chemical	Aluminium	Rest
	Air	Cement, Petro-chemical, Iron and Steel, Oil refinery			Cement, Petro-chemical	Iron and Steel, Oil refinery	Pulp and Paper	Rest
6.	Goa							
	Water	Distillery	Distillery					
	Toxic	Distillery	Distillery					
	Metal							
	Air	Distillery	Distillery					

S.No	States	Major Polluting Industries	Contribution of Industry in terms of Pollution Load					
			50% and above	31 - 49%	21 - 30%	11 - 20%	5 - 10%	below 5%
7.	Haryana							
	Water	Iron and Steel, Pulp and Paper	Iron and Steel			Pulp and Paper		Rest
	Toxic	Iron and Steel, Pulp and Paper		Iron and Steel, Pulp and Paper			Pesticide	Rest
	Metal	Iron and Steel	Iron and Steel					Rest
	Air	Iron and Steel, Pulp and Paper, Cement		Iron and Steel, Pulp and Paper		Cement	Sugar	Rest
8.	Himachal Pradesh							
	Water	Iron and Steel	Iron and Steel					Rest
	Toxic	Iron and Steel, Petro-chemical	Iron and Steel	Petro-chemical				Rest
	Metal	Iron and Steel	Iron and Steel					Rest
	Air	Cement, Iron and Steel	Cement			Iron and Steel		Rest
9.	Jammu & Kashmir							
	Water	Iron and Steel	Iron and Steel					Distillery
	Toxic	Iron and Steel	Iron and Steel					Distillery
	Metal	Iron and Steel	Iron and Steel					
	Air	Iron and Steel, Distillery	Iron and Steel			Distillery		

S.No	States	Major Polluting Industries	Contribution of Industry in terms of Pollution Load					
			50% and above	31 - 49%	21 - 30%	11 - 20%	5 - 10%	below 5%
10.	Karnataka							
	Water	Iron and Steel, Pulp and Paper	Iron and Steel			Pulp and Paper		Rest
	Toxic	Iron and Steel, Pulp and Paper, Aluminium	Iron and Steel		Pulp and Paper	Aluminium		Rest
	Metal	Iron and Steel, Aluminium	Iron and Steel		Aluminium			Rest
	Air	Cement, Iron and Steel, Pulp and Paper		Cement	Iron and Steel	Pulp and Paper	Aluminium, Sugar	Rest
11.	Kerala							
	Water	Iron and Steel, Aluminium, Fertiliser, Drugs		Iron and Steel	Aluminium	Fertiliser, Drugs	Distillery	
	Toxic	Fertiliser, Aluminium, Drugs	Fertiliser		Aluminium	Drugs	Iron and Steel	Rest
	Metal	Aluminium, Iron and Steel	Aluminium			Iron and Steel		Rest
	Air	Cement, Aluminium		Cement	Aluminium		Fertiliser, Distillery, Iron and Steel	Rest

S.No	States	Major Polluting Industries	Contribution of Industry in terms of Pollution Load					
			50% and above	31 - 49%	21 - 30%	11 - 20%	5 - 10%	below 5%
12.	Madhya Pradesh							
	Water	Iron and Steel	Iron and Steel					Rest
	Toxic	Iron and Steel, Aluminium	Iron and Steel			Aluminium	Fertiliser, Leather	Rest
	Metal	Iron and Steel, Aluminium	Iron and Steel			Aluminium		Rest
	Air	Iron and Steel, Cement		Cement, Iron and Steel				Rest
13.	Maharashtra							
	Water	Iron and Steel	Iron and Steel				Pulp and Paper	Rest
	Toxic	Iron and Steel, Oil refinery, Petro-chemical			Iron and Steel	Oil refinery, Petro-chemical	Aluminium, Copper,Fertiliser, Pesticides, Pulp and Paper	Rest
	Metal	Iron and Steel, Copper, Aluminium	Iron and Steel		Copper	Aluminium		Rest
	Air	Iron and Steel, Oil refinery			Iron and Steel, Oil refinery		Copper, Cement, Pulp and Paper, Sugar, Petro-chemical	Rest

S.No	States	Major Polluting Industries	Contribution of Industry in terms of Pollution Load					
			50% and above	31 - 49%	21 - 30%	11 - 20%	5 - 10%	below 5%
14.	Orissa							
	Water	Iron and Steel	Iron and Steel				Aluminium	Rest
	Toxic	Iron and Steel, Aluminium	Iron and Steel		Aluminium		Pulp and Paper	Rest
	Metal	Iron and Steel, Aluminium	Iron and Steel	Aluminium				Rest
	Air	Iron and Steel, Aluminium	Iron and Steel			Aluminium	Cement, Pulp and Paper	Rest
15.	Pondicherry							
	Water	Iron and Steel	Iron and Steel					Rest
	Toxic	Iron and Steel, C-soda	Iron and Steel			Caustic soda		Rest
	Metal	Iron and Steel	Iron and Steel					Caustic soda
	Air	Iron and Steel	Iron and Steel					Rest
16.	Punjab							
	Water	Iron and Steel	Iron and Steel					Rest
	Toxic	Iron and Steel, Fertiliser	Iron and Steel			Fertiliser	Pulp and Paper	Rest
	Metal	Iron and Steel	Iron and Steel					Rest
	Air	Iron and Steel	Iron and Steel			Pulp and Paper	Distillery	Rest

S.No	States	Major Polluting Industries	Contribution of Industry in terms of Pollution Load					
			50% and above	31 - 49%	21 - 30%	11 - 20%	5 - 10%	below 5%
17.	Rajasthan							
	Water	Iron and Steel	Iron and Steel				Copper, Fertiliser	Rest
	Toxic	Fertiliser, Copper, Iron and Steel		Fertiliser		Copper, Iron and Steel	Aluminium, Petro-chemical	Rest
	Metal	Iron and Steel, Copper, Aluminium		Copper, Iron and Steel		Aluminium		Rest
	Air	Cement, Iron and Steel	Cement			Iron and Steel	Copper	Rest
18.	Tamil Nadu							
	Water	Iron and Steel	Iron and Steel				Pulp and Paper	Rest
	Toxic	Leather, Iron and Steel, Oil refinery, Petro-chemical		Leather		Iron and Steel, Oil refinery, Petro-chemical	Fertiliser, Pulp and Paper	Rest
	Metal	Iron and Steel, Leather	Iron and Steel			Leather	Aluminium	Rest
	Air	Cement, Iron and Steel, Oil refinery		Cement		Iron and Steel, Oil refinery	Pulp and Paper, Sugar	Rest

S.No	States	Major Polluting Industries	Contribution of Industry in terms of Pollution Load					
			50% and above	31 - 49%	21 - 30%	11 - 20%	5 - 10%	below 5%
19.	Uttar Pradesh							
	Water	Iron and Steel, Pulp and Paper	Iron and Steel			Pulp and Paper	Aluminium	Rest
	Toxic	Aluminium, Fertiliser, Iron and Steel, Leather, Oil refinery				Aluminium, Fertiliser, Iron and Steel, Leather, Oil refinery	Pulp and Paper	Rest
	Metal	Iron and Steel, Aluminium		Aluminium, Iron and Steel				Rest
	Air	Iron and Steel, Aluminium, Pulp and Paper, Sugar, Oil refinery			Iron and Steel	Aluminium, Pulp and Paper, Sugar, Oil refinery	Cement	Rest
20.	West Bengal							
	Water	Iron and Steel	Iron and Steel					Rest
	Toxic	Iron and Steel, Aluminium	Iron and Steel			Aluminium	Leather, Oil refinery, Petro-chemical	Rest
	Metal	Iron and Steel, Aluminium	Iron and Steel		Aluminium			Rest
	Air	Iron and Steel, Aluminium, Oil refinery	Iron and Steel			Aluminium, Oil refinery		Rest

Table 9. Abatement Cost Coefficients (US $, 1994) per ton of Pollutant Abated

S.No.	Industry	ISIC	PT	SO_2	NO_2	VOC	PB	TXAIR	AOTH	WCON	WNON	WTXMT	WTXOG
1.	Sugar	3118	57.50	234.92	330.51	195.35	236.93	1277.21	387.36	5.92	71.68	671.93	286.71
2.	Distillery	3131	176.39	622.54	2963.14	195.35	236.93	1277.21	387.36	183.49	319.26	671.93	286.71
3.	Dye	3211	243.80	270.85	2670.28	819.34	1362.29	544.18	387.36	83.58	319.26	785.63	167.83
4.	Leather	3231	329.64	300.13	300.13	366.79	300.13	300.13	300.13	148.50	442.17	2753.81	167.83
5.	Pulp & Paper	3411	40.74	106.22	136.26	157.42	236.93	544.18	62.94	84.17	185.36	671.93	286.71
6.	Caustic Soda	3511	2.42	222.48	146.34	133.38	444.34	22.46	39.87	175.72	281.69	671.93	205.95
7.	Fertiliser & Pesticide	3512	69.01	183.94	510.55	295.79	79.32	1352.11	159.73	954.46	487.03	671.93	448.19
8.	Petrochemical	3513	71.23	222.48	120.66	81.70	1413.43	70.04	51.05	592.01	369.16	671.93	532.80
9.	Drugs	3522	260.47	1311.88	706.55	141.26	354.34	81.94	387.36	452.89	397.00	671.93	1793.01
10.	Oil Refinery	3530	23.50	187.83	65.71	188.38	3.84	3.84	3.84	269.27	724.01	671.93	1016.51
11.	Cement	3692	13.00	14.08	330.51	327.03	236.93	544.18	387.36	11.73	2741.22	671.93	286.71
12.	Iron & Steel	3710	167.8	40.69	106.03	2420.94	2176.47	667.97	387.36	91.25	279.01	486.93	87.32
13.	Aluminium, Copper & zinc	3720	199.42	151.14	116.75	1326.9	874.22	2021.18	387.36	85.09	78.46	671.93	100.74

ISIC - International Standard Industrial Classification
PT - Particulates
SO_2 - Sulphur di-oxide
NO_2 - Nitrogen dioxide
VOC - Volatile organic compounds
PB - Lead
TXAir - Toxic air pollutants
AOTH - Others air pollutants
WCON - Conventional water pollutants
WNON - Non-conventional water pollutants
WTXMT - Toxic metal water pollutants
WTXOG - Toxic organic water pollutants

Table 10. Abatement Cost (Rs., 1994) per 100 gms. Pollutant Abated

S.No.	Industry	ISIC Code	PT	SO_2	NO_2	VOC	PB	TXAIR	AOTH	WCON	WNON	WTXMT	WTXOG
1.	Sugar	3118	0.18	0.74	1.04	0.61	0.74	4.01	1.22	0.02	0.22	2.11	0.90
2.	Distillery	3131	0.55	1.95	9.30	0.61	0.74	4.01	1.22	0.58	1.00	2.11	0.90
3.	Dye and Dyes intermediate	3211	0.76	0.85	8.38	2.57	4.27	1.71	1.22	0.26	1.00	2.46	0.53
4.	Leather	3231	1.03	0.94	0.94	1.15	0.94	0.94	0.94	0.47	1.39	8.64	0.53
5.	Pulp & Paper	3411	0.13	0.33	0.43	0.49	0.74	1.71	0.20	0.26	0.58	2.11	0.90
6.	Caustic Soda	3511	0.01	0.70	0.46	0.42	1.39	0.07	0.13	0.55	0.88	2.11	0.65
7.	Fertiliser & Pesticide	3512	0.22	0.58	1.60	0.93	0.25	4.24	0.50	2.99	1.53	2.11	1.41
8.	Petrochemical	3513	0.22	0.70	0.38	0.26	4.43	0.22	0.16	1.86	1.16	2.11	1.67
9.	Drugs	3522	0.82	4.12	2.22	0.44	1.11	0.26	1.22	1.42	1.25	2.11	5.62
10.	Oil Refinery	3530	0.07	0.59	0.21	0.59	0.01	0.01	0.01	0.84	2.27	2.11	3.19
11.	Cement	3692	0.04	0.04	1.04	1.03	0.74	1.71	1.22	0.04	8.60	2.11	0.90
12.	Iron & Steel	3710	0.53	0.13	0.33	7.59	6.83	2.10	1.22	0.29	0.88	2.11	0.27
13.	Aluminium, Copper & zinc	3720	0.63	0.47	0.37	4.16	2.74	6.34	1.22	0.27	0.25	2.11	0.32

Exchange rate (1994): $ 1 = Rs. 31.37.

Table 11. Abatement Cost Per 100 grams of BOD

S.No.	Industry	Rupees
1.	Sugar	0.78
2.	Pulp and Paper	0.83

Table 12. Revenue Potential of a Charge BOD

S.No.	States	Total BOD Load (tonnes)	No Abatement (Rs. Lacs)	90% Abatement (Rs. Lacs)	95% Abatement (Rs. Lacs)
1.	All India	1208978.04	9188.23	918.82	459.41
2.	Andhra Pradesh	29175.32	221.73	22.17	11.09
3.	Assam	755.89	5.74	0.57	0.29
4.	Bihar	39502.26	300.22	30.02	15.01
5.	Goa	24877.00	189.07	18.91	9.45
6.	Gujarat	4375.22	33.25	3.33	1.66
7.	Haryana	1948.19	14.81	1.48	0.74
8.	Himachal Pradesh	48.74	0.37	0.04	0.02
9.	Jammu & Kashmir	46768.32	355.44	35.54	17.77
10.	Karnataka	37995.29	288.76	28.88	14.44
11.	Kerala	112437.94	854.53	85.45	42.73
12.	Madhya Pradesh	216103.92	1642.39	164.24	82.12
13.	Maharashtra	250296.14	1902.25	190.23	95.11
14.	Orissa	1749.34	13.30	1.33	0.66
15.	Punjab	35967.03	273.35	27.33	13.67
16.	Rajasthan	15989.10	121.52	12.15	6.08
17.	Tamil Nadu	207807.09	1579.33	157.93	78.97
18.	Uttar Pradesh	121858.41	926.12	92.61	46.31
19.	West Bengal	572.99	4.35	0.44	0.22
20.	Chandigarh	5825.66	44.28	4.43	2.21
21.	Daman & Diu	3.78	0.03	0.00	0.00
22.	Delhi	6.06	0.05	0.00	0.00
23.	Pondicherry	51740.48	393.23	39.32	19.66
24.	Others	3173.79	24.12	2.41	1.21

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APPENDIX 1A. Water Pollution Intensity for Selected Pollutants
(Pounds/1987 US $ Million Output Value)

S.No.	Four digit ISIC description	ISIC	BOD	TSS
1.	Sugar factories & refineries	3118	2130.73	3054.97
2.	Distilled spirits	3131	5451.00	9797.25
3.	Wine industries	3132	24.37	13.37
4.	Malt Liquors and malt	3133	28.92	66.84
5.	Spinning, weaving & finishing textiles	3211	98.18	152.47
6.	Tanneries and leather finishing	3231	607.39	1147.01
7.	Pulp, paper, & paperboard	3411	13751.16	46704.84
8.	Industrial chemical except fertiliser	3511	3988.90	6165.59
9.	Fertilisers & pesticides	3512	44.88	8732.58
10.	Synthetic resins, plastics materials	3513	211.78	684.35
11.	Drugs & medicines	3522	61.09	15314.74
12.	Petroleum refineries	3530	158.28	794.37
13.	Cement, lime and plaster	3692	1.18	2587.58
14.	Iron and Steel	3710	13.22	194732.90
15.	Nonferrous metals	3720	2963.03	42830.90

APPENDIX 1B. Air Pollution Intensity for Selected Pollutants
(Pounds/1987 US $ Million Output Value)

S.No.	Four digit ISIC description	ISIC Code	SO_2	NO_2	CO	VOC	PM_{10}	TP
1.	Sugar Factories & refineries	3118	6428	6171	3306	1094	135	4258
2.	Distilled spirits	3131	3887	1351	253	13355	170	325
3.	Wine industries	3132	462	70	6	1	0	48
4.	Malt liquors and malt	3133	2146	1690	105	176	3	118
5.	Spinning, weaving & finishing textiles	3211	2422	3342	448	917	65	433
6.	Tanneries and leather finishing	3231	1299	343	126	3819	41	157
7.	Pulp, paper and paperboard	3411	25585	13349	29203	4043	1453	5028
8.	Industrial chemical except fertiliser	3511	11656	8658	6687	6766	395	1873
9.	Fertilisers and pesticides	3512	1106	1065	212	1008	47	307
10.	Synthetic resins, plastics materials	3513	5185	13477	1993	9862	4	792
11.	Drugs & medicines	3522	1825	775	91	908	13	345
12.	Petroleum refineries	3530	12664	7285	6579	6705	128	1117
13.	Cement, lime and plaster	3692	128688	59751	7273	340	107003	62238
14.	Iron and Steel	3710	17867	7761	27843	2392	4938	4140
15.	Nonferrous metals	3720	38646	1259	17977	1406	355	3246

APPENDIX 1C. Toxic Pollution Intensity by Medium
(Pounds/1987 US $ Million Output Value)

S.No.	Four digit ISIC description	ISIC	Water	Air	Land
1.	Sugar factories & refineries	3118	1.54	55.35	264.45
2.	Distilled spirits	3131	48.94	1.43	14.92
3.	Wine industries	3132	0.00	61.06	154.87
4.	Malt liquors and malt	3133	6.23	109.91	59.29
5.	Spinning, weaving & finishing textiles	3211	178.85	350.96	326.21
6.	Tanneries and leather finishing	3231	220.02	4733.22	12687.84
7.	Pulp, paper & paperboard	3411	1209.31	3627.03	1671.80
8.	Industrial chemicals except fertilisers	3511	2992.90	5923.99	20577.03
9.	Fertilisers & pesticides	3512	110.89	2362.89	3204.00
10.	Synthetic resins, plastics materials	3513	416.18	5692.07	4718.77
11.	Drugs & medicines	3522	56.08	1451.39	2172.40
12.	Petroleum refineries	3530	45.84	607.86	2574.07
13.	Cement, lime and plaster	3692	43.17	27.95	79.76
14.	Nonmetallic mineral products, N.E.C	3699	2.08	417.88	687.98
15.	Nonferrous metals	3720	116.07	2988.29	7920.98

APPENDIX 1D. Toxic Metal Pollution Intensity by Medium
(Pounds/1987 US $ Million Output Value)

S.No.	Four digit ISIC description	ISIC	Water	Air	Land
1.	Wine industries	3132	0.00	0.00	0.67
2.	Spinning, weaving & finishing textiles	3211	0.20	2.89	58.52
3.	Tanneries and leather finishing	3231	1.30	1.61	854.36
4.	Pulp, paper & paperboard	3411	7.84	0.34	17.19
5.	Industrial chemical except fertiliser	3511	27.23	29.32	929.58
6.	Fertilisers & pesticides	3512	0.68	3.96	276.53
7.	Synthetic resins, plastics materials	3513	5.14	1.58	245.86
8.	Drugs & medicines	3522	0.14	0.25	28.16
9.	Petroleum refineries	3530	1.96	4.95	45.76
10.	Cement, lime and plaster	3692	0.00	0.98	40.25
11.	Iron and Steel	3710	25.57	169.11	3728.58
12.	Nonferrous metals	3720	4.12	206.75	6849.73

APPENDIX 2A. IPPS: Water Pollution Intensity for Selected Pollutants
(Kg. per Thousand Employees)

S.No.	ISIC Code	BOD	TSS
1.	3118	273259.87	391791.09
2.	3131	959717.58	1724930.09
3.	3211	4172.55	6479.70
4.	3231	43317.39	81801.66
5.	3411	1497824.42	5087181.90
6.	3511	569462.00	880209.19
7.	3512	7120.45	1385540.58
8.	3513	25343.20	81895.87
9.	3522	6433.39	1612919.67
10.	3530	113721.23	570735.23
11.	3692	109.31	239708.05
12.	3710	954.99	14069644.07
13.	3720	260854.30	3770670.33

BOD - Biological Oxygen Demand
TSS - Total Suspended Solids.

APPENDIX 2B. IPPS: Air Pollution Intensity for Selected Pollutants
(Kg. per Thousand Employees)

S.No.	ISIC Code	SO_2	NO_2	CO	VOC	FP	TSP
1.	3118	824363.31	791392.59	424029.94	140276.61	17250.57	546035.85
2.	3131	684381.53	237860.21	44458.86	2351233.24	29910.33	57277.83
3.	3211	102928.73	142019.77	19059.95	38959.50	2755.12	18418.57
4.	3231	92670.73	24472.67	9016.05	272385.85	2915.24	11185.59
5.	3411	2786784.88	1454032.98	3180859.13	440341.58	158224.36	547678.77
6.	3511	1664092.97	1236065.52	954671.78	965855.55	56418.73	267411.30
7.	3512	175508.95	169049.34	33646.57	159973.41	7399.90	48772.97
8.	3513	620504.38	1612754.93	238458.04	1180191.55	500.76	94791.73
9.	3522	192246.05	81580.40	9573.52	95633.15	1333.56	36291.92
10.	3530	9098911.90	5234020.95	4726810.33	4817329.23	91881.03	802731.94
11.	3692	11921335.08	5535165.92	673731.18	31511.97	9912531.87	5765586.76
12.	3710	1290916.63	560745.86	2011713.91	172804.63	356790.77	299100.62
13.	3720	3402209.03	110815.79	1582625.06	123771.30	31258.86	285735.07

FP - Fine Particulates
TSP - Total Suspended Particulates

APPENDIX 2C. IPPS: Toxic Pollution Intensity by Medium
(Kg. Per Thousand Employees)

S.No.	ISIC Code	WATER	AIR	LAND
1.	3118	198.22	7098.27	33914.65
2.	3131	8616.89	252.65	2626.30
3.	3211	7600.85	14915.48	13863.60
4.	3231	15691.12	337560.27	904863.25
5.	3411	131720.96	395063.53	182096.02
6.	3511	427270.40	845717.98	2937610.24
7.	3512	17594.85	375062.83	508358.20
8.	3513	49803.99	681167.83	564693.02
9.	3522	5906.23	152857.45	228792.90
10.	3530	32933.53	436734.61	1849407.22
11.	3692	3999.32	2589.56	7389.02
12.	3710	25299.11	71178.17	408005.88
13.	3720	10218.07	263077.68	697333.40

APPENDIX 2D. Toxic Metal Pollution Intensity by Medium
(Kg. Per Thousand Employees)

S. No.	ISIC Code	WATER	AIR	LAND
1.	3118	-	-	141.27
2.	3211	8.29	122.90	2487.05
3.	3231	92.54	114.70	60930.65
4.	3411	854.49	37.26	1872.83
5.	3511	3887.76	4185.68	132708.84
6.	3512	108.26	628.22	43874.81
7.	3513	615.33	188.96	29421.76
8.	3522	14.97	26.16	2965.81
9.	3530	1410.78	3556.17	32876.01
10.	3692	0.18	90.71	3728.47
11.	3710	1847.36	12218.42	269393.30
12.	3720	362.34	18201.60	603023.93

APPENDIX 3A

IPPS abatement cost coefficients for various pollutants presented in Table 1. The abatement cost function has been assumed to be separable from the firm's production cost function, reflecting purely end-of-pipe activity. The abatement cost function has been specified as:

$$C_{ij} = \beta_{oj} + \Sigma_i \beta_{jk} A_{ijk} + \Sigma_i \beta_{jjk} A^2_{ijk} + \Sigma_{ij} \quad (1)$$

where,

C_{ij} = Total cost of abatement for end-of-pipe pollution control by plant i in sector j.

A_{ijk} = Quantity of pollutant abated by plant i.

Σ_{ij} = A random disturbance term.

The quadratic specification of the cost function has been estimated which allows for testing possible pollutant - specific scale economies.

Sectoral marginal and average costs have been computed as follows:

$$MC_{jk} = \beta_{jk} + 2\beta_{jjk} A_{ijk} \quad (2)$$

$$AFC_{jk} = \beta_{oj}/\Sigma_k A_{ijk} \quad (3)$$

where A_{ijk} = plant-level mean abatement of K.

$$AC_{jk} = MC_{jk} + AFC_{jk} = \beta_{jk} + 2\beta_{jjk} A_{ijk} + \beta_{oj}/\Sigma_{ik} A_{ijk} \quad (4)$$

All costs have been expressed in US 1994 dollars; and quantity of pollutants are in tons. The regression equations have been estimated using ordinary least squares.

Appendix 3B: Estimated Pollution Load (tons)

S.No.	ISIC Code	Industry	Estimates using Output Intensities				Estimates using Employment Intensities			
			Water	Air	Toxic	Metal	Water	Air	Toxic	Metal
1.	3720	Aluminium	47469.13	65189.56	11428.66	7318.88	0	215399.8	37763.3	24183.5
2.	3720	Copper	16035.36	22021.43	3860.67	2472.36	44495.9	61105.41	10712.83	6860.46
3.	3720	Zinc	7737.01	10625.27	1862.76	1192.91	22923.2	31480.06	5519.00	3534.35
4.	3710	Iron and Steel	1639368.5	546671.9	58777.44	33025.88	8093409	2698880	290178.7	163045.7
5.	3692	Cement	5168.89	336636.83	301.28	82.32	27999.9	3950973	1631.99	445.93
6.	3530	Oil Refinery	4340.40	157086.39	14706.15	239.98	16805.5	608219.2	56940.26	929.16
7.	3522	Drugs	5889.71	1515.73	1409.57	10.94	44736.2	11510.61	10706.64	83.07
8.	3513	Petrochemicals	1818.81	63553.80	21974.82	512.64	3805.38	132969.4	45976.67	1072.57
9.	3512	Fertiliser	31480.99	13431.71	20367.38	1008.43	106644	45513.03	68996.19	3416.15
10.	3512	Pesticide	7366.96	3143.19	4766.23	235.99	37927.7	16186.56	24538.27	1214.94
11.	3511	Caustic Soda	836.05	2966.86	2428.31	81.19	135691	481531.8	394116.2	13177.36
12.	3411	Pulp and paper	86245.45	112216	9284.38	36.21	801764	1043196	86310.45	336.59
13.	3231	Leather	894.42	2949.28	8993.68	437.05	5316058	17532.51	53454.79	2597.63
14.	3211	Dyes and dye intermediate	0.59	18.12	2.03	0.15	1198.68	36475.01	4093.81	294.62
15.	3131	Distillery	7740.12	9817.63	33.14	0	110334	139943.7	472.46	0
16.	3118	Sugar	16747.87	69088.16	1037.81	3.56	217639	897766.4	13486.43	46.23

Appendix 3C: Ranking of Industrial Sectors by Estimated Pollution Load (tons)

S.No.	ISIC Code	Industry	Estimates using Output Intensities				Estimates using Employment Intensities			
			Rank	Water	Rank	Air	Rank	Water	Rank	Air
1.	3720	Aluminium	3	47469.13	6	65189.56	16	0	7	215399.77
2.	3720	Copper	6	16035.36	8	22021.43	9	44495.94	10	61105.41
3.	3720	Zinc	8	7737.01	10	10625.27	12	22923.25	13	31480.06
4.	3710	Iron and Steel	1	1639368.54	1	546671.90	1	8093408.58	2	2698880.06
5.	3692	Cement	11	5168.89	2	336636.82	11	27999.88	1	3950973.2
6.	3530	Oil Refinery	12	4340.40	3	157086.39	13	16805.46	5	608219.19
7.	3522	Drugs	10	5889.71	15	1515.73	8	44736.25	16	11510.61
8.	3513	Petrochemicals	13	1818.81	7	63553.80	14	3805.38	9	132969.44
9.	3512	Fertiliser	4	31480.98	9	13431.71	7	106644.41	11	45513.03
10.	3512	Pesticide	9	7366.96	12	3143.19	10	37927.73	15	16186.56
11.	3511	Caustic Soda	15	836.05	13	2966.86	5	135690.67	6	481531.83
12.	3411	Pulp and paper	2	86245.44	4	112216.00	3	801764.03	3	1043195.9
13.	3231	Leather	14	894.42	14	2949.28	2	5316058.43	14	17532.51
14.	3211	Dyes and dye intermediate	16	0.59	16	18.12	15	1198.68	12	36475.01
15.	3131	Distillery	7	7740.12	11	9817.63	6	110333.65	8	139943.7
16.	3118	Sugar	5	16747.87	5	69088.15	4	217639.26	4	897766.41

Appendix 3D: Ranking of Industrial Sectors by Estimated Pollution Load (tons)

S.No.	ISIC Code	Industry	Estimates using Output Intensities				Estimates using Employment Intensities			
			Rank	Toxic	Rank	Metal	Rank	Toxic	Rank	Metal
1.	3720	Aluminium	5	11428.66	1	7318.88	8	37763.30	2	24183.50
2.	3720	Copper	9	3860.67	2	2472.36	11	10712.83	4	6860.46
3.	3720	Zinc	11	1862.76	3	1192.91	13	5519.00	5	3534.35
4.	3710	Iron and Steel	1	58777.44	4	33025.88	2	290178.72	1	163045.66
5.	3692	Cement	14	301.28	5	82.32	15	1631.99	11	445.93
6.	3530	Oil Refinery	4	14706.15	6	239.98	5	56940.26	10	929.16
7.	3522	Drugs	12	1409.57	7	10.94	12	10706.64	14	83.07
8.	3513	Petrochemicals	2	21974.82	8	512.64	7	45976.67	9	1072.57
9.	3512	Fertiliser	3	20367.38	9	1008.43	4	68996.19	6	3416.15
10.	3512	Pesticide	8	4766.23	10	235.99	9	24538.27	8	1214.94
11.	3511	Caustic Soda	10	2428.31	11	81.19	1	394116.24	3	13177.36
12.	3411	Pulp and paper	6	9284.38	12	36.21	3	86310.45	12	336.59
13.	3231	Leather	7	8993.68	13	437.05	6	53454.79	7	2597.63
14.	3211	Dyes and dye intermediate	16	2.03	14	0.15	14	4093.81	13	294.62
15.	3131	Distillery	15	33.14	15	0	16	472.46	16	0
16.	3118	Sugar	13	1037.81	16	3.56	10	13486.43	15	46.23