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Economics of pollution control

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Abstract

This paper estimates the level of industrial pollution in Chennai City, a fast developing metropolitan city in South India. The level of industrial pollution was estimated using econometric, the analysis of data and the development and testing of theories and models. In order to study the relationship between elements of effluent the Pearson's correlation coefficient is worked out. The primary data collected through questionnaires were used in the estimation model. Measuring and valuing the pollution control measures is very complex and the available methods of economic valuation are often rudimentary. The study analyzed how the monetary value of pollution control measures could be increased by reducing the pollution level in industries, which will be useful for policy makers to reduce the incidence industrial pollution in the urban population of Chennai city. This study addresses the current status and consequences of industrial pollution, which causes concern in developing countries. The study would highlight the status of the environmental economic and pollution control used by industries.

Keywords: Industrial pollution, econometric, Pearson's correlation coefficient.

Introduction

All economic activities either impinge on or are affected by natural and environmental resources. Activities such as extraction, processing, manufacturing, transport, consumption and disposal not only change the stock of natural resources, but also add stress to the environmental system besides introducing wastes to the environment. Our world has seen essential and persistent change in the last 50 years. The increased economic growth of the developing countries has bitterly affected the quality of the environment, which becomes a menace to sustainable development. The global diversification of textile manufacturing and exports with a considerable reduction in its share in western developed countries and an increase in eastern, especially Asian developing nations has had significant implications for the Indian textile sector. Since most of the textile centers have developed as small-scale clusters, pollution management and enforcement is not at a satisfactory level. In many places the pollution load discharged into the environment has exceeded the assimilative capacity and caused severe degradation of eco-systems and ultimately affected the livelihood of the people who depend on the services provided by these eco-systems. After Stockholm Conference of 1972 even the erstwhile underdeveloped countries have realized the environmental degradation can be disproportionately more than economic development unless suitable safeguards are not provided from the beginning. The Millennium Ecosystem Assessment (2005) concluded that most of the world's ecosystems have already suffered major degradation. The most impact of pollution is on air and water resources and associated ecosystems.

Every living organism is facing environmental hazards. There is no doubt that human activities are mainly responsible for this. These include misuse of natural resources, rapid urbanization, deforestation, population exposure, shifting of surface water and ground water in massive amounts, release of heat energy from various industries, emission of particles and trace gases into the atmosphere, release of carbon dioxide into the atmosphere by combustion of fossil fuels, effect of transportation systems on land surfaces and effect of their emission upon the lower and upper atmosphere, formation of ozone holes, release of chloro fluoro carbons into the atmosphere, global warming etc.

Indian history of textile industry

The history of textiles in India dates back to the use of mordant dyes and printing blocks around 3000 BC. The diversity of fibers found in India, intricate weaving on its state-of-the art manual looms and its organic dyes attracted buyers from all over the world for centuries. India saw the building up of textile capabilities, diversification of its product base, and its emergence, once again, as an important global player. The Indian Textiles Industry has an overwhelming presence in the economic life of the country. Apart from providing one of the basic necessities of life, the textiles industry also plays a pivotal role through its contribution to industrial output, employment generation, and the export earnings of the country. The textiles sector is the second largest provider of employment after agriculture. Thus, the growth and all round development of this industry has a direct bearing on the improvement of the economy of the nation. India's textile industry comprises mostly small-scale, non-integrated spinning, weaving, finishing, and apparel-making enterprises.

India's position in global textiles & clothing industry

- India's position in the World Textiles Economy is as listed second largest producer of raw cotton.
- Second largest producer of cotton yarn.
- Second largest producer of cellulose fiber/yarn.
- Second largest producer of silk.
- Fourth largest producer of synthetic fiber/yarn.
- Largest producer of jute.

Textile Sector in Tamil Nadu

Tamil Nadu is the 3rd largest industrial state in the country. The gross output of its industrial sector is Rs.53674 crores, accounting for 13.4 per cent of the national output. Cotton textiles were prominent among the industry groups that contributed to this ranking. In terms of gross output value, cotton textiles increased from 18.80 per cent of the national share (ranked 2) in 1982-83 to 39.40 percent (ranked 1) in 2008-09. The textile industry uses vegetable fibers such as cotton; animal fibers such as wool and silk; and a wide range of synthetic materials such as nylon, polyester, and acrylics. The production of natural fibers is approximately equal in amount to the production of synthetic fibers. Polyester accounts for about 50% of synthetics. (Chemical production of the polymers used to make synthetic fiber is not covered in this document. The stages of textile production are fiber production, fiber processing and spinning, yarn preparation, fabric production, bleaching, dyeing and printing, and finishing. Each stage generates wastes that require proper management. This document focuses on the wet processes (including wool washing, bleaching, dyeing, printing, and finishing) used in textile processing.

Industrial pollution control – preferred policy instruments for medium and large-sized firms

a) Pollution charges: Pollution charges are based on 'polluter-pays' principle and it levels the economic playing field by confronting all managers with the same price for each unit of pollution generated. Under such a system, managers are free to adjust their operations until they have minimized pollution-related costs i.e., charges plus the abatement costs. On the other hand, in CAC regulation, which mandates all factories to cut back pollution by the same uniform percentage unit (though overall pollution falls to the desired level), it heavily penalizes factories with high marginal abatement cost. A pollution charge not only cuts emissions but also generates public revenue, though the second is incidental. Though pollution charges keep the ingenuity and incentive structure of the plant manager in focus, their efficacy depends on two conditions:

1. How to fix an optimum pollution charge? and
2. How to garner industry support for that charge?

Level of pollution charge: The marginal abatement cost equal to marginal damage (i.e., MAC = MSD) rule provides a good framework for determining environmental goals and pollution charges, but in the real world the valuation of damages for activities having no market leaves sufficient room for politically negotiated charges. Since pollution charges necessitate full knowledge of the pollution profile of each plant, it has been argued that this 'asymmetric information' problem can be circumvented through the use of presumptive charges based on engineering estimates of pollution from plants of different kinds.

Presumptive charges are appealing because they transfer monitoring costs to polluters, as the plants can either pay or ask for reduction in charges by proving that their pollution levels are lower than the estimates. Still regulators need to regularly verify the veracity of emissions reports. Alternatively, subcontractors can be used to solve the informational and auditing problems rather than presumptive charges e.g. as in Columbia. By subcontracting the fee collection and financial accounting to an agency, the regulator can solve the informational problem. In lieu of the services, the agent can be given a fixed percentage of the revenue flow. This solution could have the following advantages:

a) The agent has the right experience to operate such a system;
b) It knows how to collect debts; and
c) Failure to pay these debts can threaten a firm's credit rating. A good candidate to become such an agent would be a firm with knowledge of accounting and customer profile, such as commercial banks.

Even if a uniform rate is applied, actual charges collected per unit of emissions may vary widely. This is because the price a community places on pollution damage varies with a) total amount of pollution, b) the size of exposed population, c) the local income per capita, d) awareness and education level and hence the bargaining power, which again depends on local income per capita. (ii) How to garner industry support for the charge? This is even more difficult than deciding on how much charge to be levied. However with information revolution, judicial activism, globalization and growing reliance on MBI even in developing countries, it appears in the long run the industry may have to support any charge system.

The support is contingent on four factors. (i) Industry has to be convinced that the government is serious about environmental protection. (ii) Industrialists may need credible evidence that pollution control will not bankrupt them. Presenting credible information by regulator and international experts about the abatement costs can ensure this e.g., in the Philippines and Colombia. (iii) Plant managers tend to support charge systems once they appreciate that these systems give them greater flexibility. For this again, services of experts can be utilized. (iv) How the revenue from the collected pollution charge is used. To industrialists, the charge is equivalent to a tax. A financial sacrifice they have to incur for the common good and they may refuse to support it until they are assured that the revenues will be used to finance public or private waste treatment projects in their own area i.e., a kind of earmarking.

b) Public disclosure: The other alternative to traditional regulation that can be used to control industrial pollution from medium and large units is public disclosure. In the public disclosure, declaring the pollution contribution (or environmental performance) of a firm can automatically increase the marginal expected penalty for pollution. In fact, firms' may resort to abatement even before ratings are announced in anticipation of public disclosure even for the same level of regulation. Ratings or public disclosure has many benefits for different stakeholders. For instance, equipped with performance ratings, citizens are in a much stronger position to negotiate pollution control agreements in neighbouring factories. This is essential because lack of information can distort communities' perceptions. For example, emissions of metals and toxins that accumulate in organisms' tissues, but often are not seen or smelt, are likely to escape notice of residents.

The regulator may itself benefit from public disclosure. More widespread adherence to environmental standards can boost its credibility with industry, NGOs and the public. Further, the ratings allow communities to check an agency's claim against their own daily experience, thereby indirectly affecting the credibility of the agency. As mentioned earlier, all regulators need good data about firms' pollution, but non-compliant firms have a clear incentive to evade such information. However, with ratings, clean firms have an incentive to identify themselves, which makes the task of the regulatory agency easy as it can concentrate on serious polluters and expose them in public.

Rewarding good performers also insulates regulators from accusations that they are anti-business. In fact, the impact of public disclosure or ratings can be far reaching. This is because the environmental performance becomes a 'proactive' exercise rather than the 'reactive' efforts unlike in the case with CAC regulations. Under ratings, meeting standards constitute the bare minimum efforts and to acquire larger rating, the firms may have to go beyond just meeting the norms prescribed by the regulator. Public disclosure is usually a political act and a media event, so a strategy needs to be thought before releasing the results. Since large polluters may also be large employers, it may not be in the interest of the economy not to give the grace period to them before full public disclosure. In Indonesia and the Philippines the program allowed poorly rated factories a grace period before public disclosure. Targeting Enforcement: Since implementing pollution charges require regulatory reforms, besides uncertainty involved in its success, in the short-run they can still rely on traditional approaches and can flexibly target plants for monitoring and enforcement instead of regulating all factories. Targeting large pollution sources (with low abatement costs due to economies of scale in abatement) would raise their expected penalties and this might even approximate the results of a charge system. In fact, large plants usually respond more vigorously than other small and medium factories since they tend to have more skills to draw on, resources to buy and run complex equipment, and ability to spread their administrative costs over many units of activity. The paper mainly revolves around the assumption that there is no significant difference in awareness of pollution, water discharge, quantity of solid waste and effluent treatment among the different types of industrial units. Among the different industrial areas in Tamil Nadu, the Chennai has been purposively selected for the present study. Among different industrial estates in Chennai, Ambattur, Guindy, Orakadam and Gummudipoondi have been again purposively selected based on the concentration of number of industrial units. The data and information have been collected from the respondents by adopting random sampling technique. The geographical area has been selected purposively followed by industrial estates and the sample respondents have been selected randomly thus, multi-stage random sampling technique has been adopted for data collection. The data and information have been collected from the sample size of 180 through pre-tested, structured interview schedule through direct interview method. To identify the structure of organizations / companies with respect to their type, products, staff, pollution prevention plan and other features of organizations, the descriptive statistics, percentage analysis and frequency distribution are worked out.

Chi-Square test

In order to study the differences between type of units, number of employees and shifts and batches, products and awareness levels and source and consumption of energy, source and consumption of water for different type of units, the Chi-Square Test has been employed and the formula is:

$$\chi^2 = \sum \left(\frac{(O-E)^2}{E} \right)$$

Where O = Observed Frequency in each category, E = Expected Frequency in the corresponding category, d.f = Degree of Freedom" (n-1), χ^2 = Chi Square

Analysis of variance (ANOVA)

In order to examine the differences in daily consumption of raw materials, wastewater discharge, quantity of solid waste and atmospheric emission among the different types of units, the analysis of variance (ANOVA) has been employed and the formula is:

F = Variance between Samples/Variance within Samples. i.e. F = Greater variance/Smaller variance.

Correlation analysis

In order to study the relationship between elements of effluent the Person's correlation coefficient is worked out. The sample correlation coefficient is written

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{(n-1)s_x s_y},$$

Where $\bar{x}$ = Sample mean of x, y= Sample mean of y, s_x = Standard Deviation of x, s_y = Standard Deviation of y, n=Sample Size i = 1, 2... n,

This can also be written as:

$$r_{xy} = \frac{\sum x_i y_i - n\bar{x}\bar{y}}{(n-1)s_x s_y} = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n\sum x_i^2 - (\sum x_i)^2}\ \sqrt{n\sum y_i^2 - (\sum y_i)^2}}.$$

Relationship between elements of effluent in textile industry

The relationship between trace elements of effluent in textile industry was analyzed by computing correlation co efficient and the results are presented in Table 1. From the table, it is clear that the trace element such as lead-sulphate, zinc-copper and lead-zinc showed a strong positive correlation indicating that all these metals occur together as pollutants derived from effluents, possibly moving together as poly metal complexes. The correlation between zinc-sulphate, cadmium-iron, silicate-cadmium and phosphate-silicate showed a moderate positive correlation indicating that all these metals occur together as pollutants possibly moving together in moderate rates.

The correlation between iron-chloride, copper-chloride, zinc-chloride, copper-iron, zinc-iron, lead-copper and cadmium-copper showed a weak positive correlation indicating that all these metals occur together as pollutants possibly moving together in low rates. Hence, the null hypothesis is disproved. In order to study the relationship between elements of effluent the Person's correlation coefficient is worked out. In order to identify the quality characteristics of water, factor analysis has been employed. The results indicated that the parameters of effluents of textile units were greater than pollution control standards for bleaching, dyeing and washing. The pH was varying from 8.86 in dyeing to 7.50 in bleaching while Total Dissolved Solids (TDS) was varying from 83.04 mg/l in washing to 70.02 mg/l in bleaching. The Total Suspended Solids (TSS) was varying from 343mg/l in large size units to 191 mg/l in small size units while Chemical Oxygen did (COD) was ranging from 301 mg/l in large size units to 146 mg/l in small size units. The Biological Oxygen did (BOD) was ranging from 27 mg/l in large size units to 18 mg/l in small size units. The oil and Grease was varying from 7 mg/l in large size units to 3 mg/l in small size units while chloride content was varying between 4984mg/l in large size units and 2868 mg/l in small size units. The sulphate was varying from 772 mg /l in small size units to 314 mg/l in medium size units. The iron content was varying from 16 mg/l in large size units to 12 mg/l in small size units. The copper was varying from 9 mg/l in large size units to 4 mg/l in small size units while zinc content was ranging from 12 mg/l in large size units to 6 mg/l in small size units. The lead and cadmium content was varying from the maximum in large size units to minimum in small size units. The silicate content was varying from 8.1 mg/l in large size units to 6.2 mg/l in small size units while the phosphate was ranging from 5.1 mg/l in large size units to 3.2 mg/l in small size units. The (Electrical Conductivity) EC was varying from 50400 $S{\cdot}m^{-1}$ in large size units to 48000 $S{\cdot}m^{-1}$ in small size textile units. The Hydro Chloric Acid (Hcl) was varying from 25.42 liter in large size units to 18.54 liter in small size units while sulphuric acid was ranging from 11.34 liter in large size units to 7.65litre and acetic acid was varying between 3.45 liter in large size units and 1.70 liter in small size industrial units.

The results showed that the pH was 9.35 and the moisture content was 2.60 per cent. The solubility was 0.16 g/100ml and contents of copper, chromium, lead, zinc and nickel were 64.30, 55.40, 1.71, 18.20 and 22.80 mg/kg respectively. The results indicated about the quantity of solid waste was 4.79 kg/tonne in large size units followed by medium (4.47 kg/tonne) and small (3.72 kg/tonne) size textile units. The quantity of solid waste from bleaching was varying from 0.86 kg/tonne in large size units to 0.54 kg/tonne while, the solid waste from dyeing was ranging from 0.92 kg/tonne in large size units to 0.76 kg/tonne in small size units. The retained sledge was varying between 3.01 kg/tonne in large size units and2.42 kg/tonne in small size textile units.

The results showed that the Volatile Organic Compound (VOC) was varying from 24 mg/Nm^3 in small

Table 1. Inter-Elemental correlation matrix for elements of effluent in textile industry.

	Chloride	Sulphate	Iron	Copper	Zinc	Lead	Cadmium	Silicate	Phosphate
Chloride	1.00								
Sulphate	0.15	1.00							
Iron	0.20*	0.06	1.00						
Copper	0.22*	0.18	0.24*	1.00					
Zinc	0.28*	0.46*	0.21*	0.62*	1.00				
Lead	0.19	0.74*	-0.12	0.28*	0.52*	1.00			
Cadmium	-0.06	-0.04	0.48*	0.24*	0.06	0.42	1.00		
Silicate	0.04	0.13	0.12	0.20	-0.24	0.28	0.44*	1.00	
Phosphate	0.06	0.17	0.14	0.18	0.12	-0.19	0.26	0.38*	1.00

Note: * *Indicates significance at one per cent level of significance.*

size units to 21 mg/Nm^3 in large size units. The sulphur oxide was varying from 1.1 g/liter in large size units to 4 g/liter in small size units, while nitrogen oxide was varying from 2.2. g/liter in large size unit to 5 g/liter in small size textile units. The trace element such as lead-sulphate, zinc-copper and lead-zinc showed a strong positive correlation indicating that all these metals occur together as pollutants derived from effluents, possibly moving together as poly metal complexes. The correlation between zinc-sulphate, cadmium-iron, silicate-cadmium and phosphate-silicate showed a moderate positive correlation indicating that all these metals occur together as pollutants possibly moving together in moderate rates. The correlation between iron-chloride, copper-chloride, zinc-chloride, copper-iron, zinc-iron, lead-copper and cadmium-copper showed a weak positive correlation indicating that all these metals occur together as pollutants possibly moving together in low rates.

Conclusion

Indian Textile Industry plays a pivotal role through its contribution of about 14 per cent to industrial production, four per cent to GDP and 19.63 per cent to export earnings. Its share in global textiles and apparel is 3.90 per cent and three per cent respectively. It provides direct employment to over 38 million people. Textile sector is the second largest provider of employment after agriculture. The close linkage of the industry to agriculture and the ancient culture and tradition of the country make the Indian textiles sector unique in comparison with the textile industry of other countries. This industry is growing by 9-10 per cent and the pace would be to increase it to 16 per cent in the coming years. The mood in the Indian textile industry given the phase-out of the quota regime of the Multi-Fiber Arrangement (MFA) is upbeat with new investment flowing in and increased orders for the industry as a result of which capacities were fully booked up to April 2005. As a result of various initiatives taken by the government, there has been new investment of Rs.500 billion in the textile industry in the last five years. Nine textile majors invested Rs.26 billion and plan to invest another Rs.64 billion. Further, India's cotton production increased by 57 per cent over the last five years; and 3 million additional spindles and 30000 shuttle-less looms were installed. The industry expects investment of Rs.1400 billion in this sector in the post-MFA phase. A Vision 2010 for textiles formulated by the government after intensive interaction with the industry and Export Promotion Councils to capitalize on the upbeat mood aims to increase India's share in the world textile trade from the four per cent in 2005 to eight per cent by 2010 and to achieve export value of US $ 50 billion by 2010 Vision 2010 for textiles envisages growth in Indian textile economy from the current US $ 37 billion to $ 85 billion by 2010; creation of 12 million new jobs in the textile sector, modernization and consolidation for creating a globally competitive textile industry.

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