Impact of Environmental Regulation on Small Scale Industries - Cost-Benefit Approach for Secondary Lead Smelting Units

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Abstract

For protecting the global environment, the adoption of abatement technology and improved production process is almost mandatory now in the industrial sector. As a consequence, one finds various environmental regulations being implemented. However, the small scale industry components of the industrial sectors, which contributes significantly to total pollution, are yet to adopt such abatement technology on a wide scale. A major cause for such a situation may be the difficulties that the small units encounter in being able to calculate correctly the net benefits of investing in abatement related. An empirical exercise on estimation of socio-economic and environmental impact of environmental regulation implemented in Secondary Lead Smelting industry suggests that the Cost-benefit Analysis may be the most appropriate method for comparative assessment of the decisions of the investors regarding additional investment in this respect. It also helps to identify the exact factor(s) influencing their decision making.

Key words: Cost-Benefit Analysis, Environmental Regulation, Small-scale industry, Abatement Technology and Secondary lead smelting units.

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Impact of Environmental Regulation on Small Scale Industry -Cost-Benefit Approach Applied in the Secondary Lead Smelting Units[1]

1.Introduction:

To control the emission from production process, air quality regulation lays downs stringent equipment specification that require to be implemented by the polluting industries. The adoption of production and abatement technology is mandatory now with respect to global environmental problem. However while relevant technology and control equipment may be developed and available for use, the important question is whether they may be adopted or by-passed by the firm. Obviously, the decision to adopt is largely determined by a proper assessment or comparison of cost and benefits of such devices. Thus from the regulatory authority's point of view the improvement of air quality is very important. While such improvement would be beneficial to the environment and to the overall societies welfare, from the polluting firm's point of view investment in equipment /technology that enhance air quality, would be worthwhile when the effective rate of return from such investment may exceed the cost of adoption. In other words, the two alternative course of action before the firm, namely, the decision to produce by regulating emissions or to opt for closure of operations is influenced by an assessment of the comparative cost and benefits of these alternative options. One thus realizes that the objective function of the regulator and regulated, so far as air pollution abatement is concerned, may not necessarily converge. While social planner are more concerned with the overall social welfare, the private investors' decision regarding the additional investment for the adoption of the controlling technology may be guided by their own profit maximization motives.

This paper is an attempt in exploring the way in which optimal decisions relating to air pollution control technology are reached in a particular industry belonging to the small-scale sector. Now the small-scale sector in India which contributes to more than 40per cent of the value added in manufacturing and more than 35per cent of the exports (both direct and indirect)[2], occupies an important place in India's industrial structure. With this sector's desirable features in terms of labour intensity, distributional implications, flexibility, decentralization potential and entrepreneurship development[3], the overall growth of this sector has been quite impressive. The 1999-2000 figures put the growth rate achieved at 8.33per cent over the previous year, which is a higher rate than the 6.4per cent growth of the overall industrial sector. Under the present liberalized regime and the transition of the industrial sector towards greater market orientation, the future growth prospects of this sector (SSI) appears to be bright. With subcontracting emerging to be an important strategy of large multinationals under the economic reforms[4], productive activities are expected to gravitate towards the small and the unorganized

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[2] Approach to the Ninth Five Year Plan (1999-2000)
[3] Hussain (1997)
[4] Janardhan (1997); Ramaswamy (1999)

sector. With the considerable employment potential of the small enterprises, investment and technology upgradation is of much importance under the present scenario.

However, in the literature on development and environment, one finds emphasis on two controversial characteristics of small-scale enterprises. On the one hand, from the point of view of sustainable development, small industries are valued in developing countries[5], on the other hand, from the environment point of view, since they add to the pollution problem, are considered to be relatively hazardous. One thus encounters a dilemma in this respect. It is here that the search of the policy makers is towards the development of appropriate pollution control technology specific to the type of industry, such that the paradoxical situation may not persist. The development and availability of such technology is now a reality. While a few units in the small sector have been able to adopt such abatement devices, most others have failed to install them. Operating with unskilled labour, under highly competitive unregulated market, the willingness and ability to control the level of pollution effectively, have generally been found to be missing. Also the actual knowledge about the economic, social and environmental feasibility of such abatement technology may be difficult to acquire or calculate on the part of such small producers. Thus it becomes clear that pollution abatement in small-scale enterprises requires two pre-conditions. First is the development of clean technology and second is the calculation of economic, social and environmental significance of such technology in clear terms of actual benefits that may be accrued.

In this regard now the widely used and popular analysis that is generally adopted in economics for such comparative assessment of decisions is the Cost-Benefit Analysis. This paper deals with an exercise on the Cost – Benefit approach for calculating the impact of environmental regulation applying to the Secondary Lead Smelting units of the small-scale enterprise, that are located in and around Calcutta metropolitan area. This study also helps to identify the relevant factors that may be crucial in explaining the flexibility and viability of technology adoption. On the basis of a case study of the few firm which have been able to install the abatement device, it will be objective to understand the constraints that may operate with respect to the other firms that are yet to install the technology for air pollution abatement

The report has been organized as follows. In the next section, a review of the secondary lead smelting units within our study area, details regarding their activities and role in pollution control have been discussed in brief. The production process, developed abatement technology and its use in these units has been described there. The next section is devoted to a detailed discussion about the data set and methodology that has been used in the study. The analysis of the data is reported in section four. Conclusions have been presented in the final section.

2. Secondary Lead Smelting Units and Air Pollution: A Review

In Calcutta over the last 40 to 50 years, a number of secondary lead smelting factories have been continuing production. As evidence shows almost all the owners of such units came from the adjoining state of Bihar and Uttar Pradesh. The reason for the location of such units in the state of West Bengal may perhaps be traced to the weather of the state, which along with other factors was conducive to the production of battery (wet), for which the major input is lead. The battery industry is both the

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[5] Schumacher (1989)

major consumer of lead as also the generator of hazardous industrial waste containing lead. Quite a substantial amount of lead is being recovered from lead sheathings, waste lead, acid batteries and so on together making up for about 50 per cent of the total supply of lead used in various industrial applications. This share may be expected to increase further in the coming years.

While Secondary Lead smelting units play significant role in recycling of hazardous wastes, at the same time, on account of their emission of flue gas and dust, they are a source of air pollution. It is largely on account of the intensity of their contribution to air pollution, that such units have been classified by the authorities as belonging to the "red category" of industry. In recent years, these units, being located within or in close proximity to residential areas, have been subjected to much community pressure for improved environmental program. Such pressures are in addition to the stringent regulations that have been introduced by the Pollution Control Board. The regulator has also involved the services of, scientists, engineers and technologists to evolve appropriate technology, the adoption of, which may be both feasible and viable to the firms.

In these units the production process is simple where smelting operation is carried out in an oven, called 'vatti', where charcoal is used as fuel and waste lead as input. Liquid melted lead along with slag comes out after a period of time. The slag is first separated out from the liquid lead and then final output, called lead ingot, is made by pouring the liquid into moulds. Two or three charges are required to extract maximum amount of lead from the lead waste, and after that the slag containing about 2 per cent lead is finally disposed of. The entire production process is carried out by three labourers. At the time of operation a flue gas and lead dust are generated which are hazardous in nature and have to be cleaned. The purpose of the control device is to clean and de-dust the flue gas containing chemical components and lead dust particles that are generated in the process of smelting operation, before it is released to the atmosphere. A diagram of the production process and controlling system has been shown in Appendix 1. The flue gas and dust are trapped in the control device with the help of ID fan(induced draught fan) and pass through (i) a cyclone/impact separator, (ii) bag filter and (iii) a scrubber. While cyclone / impact separators are designed for the collection of bigger sized particles, bag filters in the bag house arrest almost all the dust from the dust and allow only cleaned gas to pass through.

3. Data and methodology:

3.1 Methodology

The use of air pollution control technology is one such measure, which obviously has two sides, it creates values and it imposes costs. To a producer in a smelting unit the investment for the installation of any abatement technology along with its operation and maintenance cost is an additional one over and above the cost of production which is relatively lower. On the other hand, benefit may be obtained from the use of device in two ways, by preserving heat for the use of improved 'vatti'(production process) required for operating the device which saves the consumption of fuel and by reusing the dust collected with the help of control device. A profit maximizing producer or private investor takes the investment decision regarding control technology by taking into account the net profit at the margin. From his point of view, it is the involved cost and the generated profit that are crucial variables in determining the choice of control technology.

Let

K_0 = investment cost for installing an air pollution control device (inclusive of related construction work) in the current year.

c_{mt} = maintenance cost in t^{th} year.

c_{ot} = operation cost in t^{th} year consisting of cost of electricity and cost of bags used in Bag house for filtering of green house gases coming out at the time of operation of the device.

i.e., $c_{0t} = p_t^e.E_t + p_t^{bf} bf_t$ **............................(1)**

where, E_t = consumption of electricity units at time t,

bf_t = number of bags replaced at time t and

p_t^j = price of j^{th} input at time t

Then, $c_t = i * K_0 + c_{mt} + c_{ot}$ **.......................(2)**

where c_t = total running cost,

i = rate of interest on the capital investment.

On the benefit side, additional facilities obtained from the introduction of controlling system include the following: (i) saving of coal, an important input, due to the preservation of heat and (ii) collection of dust on account of the device, which may again be used as input, leading to cost economy. Lesser quantity of inputs needs to be purchased, for some lead can be recovered from the waste dust that accumulates.

b_t^p = Benefit obtained directly from production at time t for the use of the device by reducing the consumption of charcoal and reusing the dust collected through bag house.

i.e., $b_t^p = p_t^f .f_t + p_t^d .d_t$ **...................................(3)**

where f_t = Consumption of charcoal at time t,

d_t = Amount of dust at time t, and

p_t^j = Price of j^{th} input at time t.

In contrast, a social planner or policy maker is interested more with social cost and benefits of any action i.e. the cost a society bears and the benefits accruing from the relevant activity. The ultimate objective should be to maximize the social welfare associated with any action. As it is related to the social welfare problem, the adoption of any abatement technology may not be successful unless it is acceptable to the polluters and sufferers. The use of controlling device, instead, may help the society by offering a clean environment. As a result, the productivity of human being may increase through reduction in loss of mandays due to the containment of health hazards that unclean technology creates. The benefit of this increased productivity of human being would be enjoyed also by the producers. In addition, the production of the controlling device and its related accessories may generate more employment. The environ mental and social benefit may then be written as

b_t^{ev} = benefit for reduction in loss of mandays due to adverse environmental impact on human health; and

b_t^s = benefit from generating income from new economic activities.

Therefore, the total benefit obtained is

$$b_t = b_t^p + b_t^{ev} + b_t^s$$

The Cost-benefit approach is intended to compare the net present value of the present and future flow of costs and benefits.

Hence, the net present value total costs is

$$C = K_0 + \sum_{t=0}^{L-1} \frac{c_t}{(1+r)^t} \text{ ....}\textbf{(4)}$$

and total benefit is

$$B = \sum_{t=0}^{L-1} \frac{b_t}{(1+r)^t} \text{ ....}\textbf{(5)}$$

Where r = rate of discount,
L= life of the device.

The positive net benefit, i.e, (B/C) > 1 indicates the justification of any investment.

For this industry at the present year price level the corresponding net present value of cost and benefit would be

$$\overline{C} = K_0 + \sum_{t=0}^{L-1} \frac{\bar{c}}{(1+r)^t} \text{ ....}\textbf{(6)} \text{ and}$$

$$\overline{B} = \sum_{t=0}^{L-1} \frac{\bar{b}}{(1+r)^t} \text{ ....}\textbf{(7)}$$

as $c_0 = c_1 = c_2 = ... = c_{L-1}$ and $b_0 = b_1 = b_2 = ... = b_{L-1}$.

The break-even period T is that time point where NPV of cost and benefit would be equal, i.e., $K_0 + \sum_{t=0}^{T-1} \frac{\bar{c}}{(1+r)^t} = \sum_{t=0}^{T-1} \frac{\bar{b}}{(1+r)^t}$ ....**(8)**

If the price of inputs changes, i.e., inflation is allowed at (say) π rate per unit of time these relation would become then

$$K_0 + \sum_{t=0}^{T-1} \frac{(1+\pi)^t.\bar{c}}{(1+r)^t} = \sum_{t=0}^{T-1} \frac{(1+\pi)^t.\bar{b}}{(1+r)^t} \text{ ....}\textbf{(9)}.$$

The payback period ***l***, which is that period of time when cumulative expenditure incurred for the installation of the device will be equal to the cumulative benefit earned from this.

i.e., $k_0 + \sum_{i=1}^{l} \bar{c} = \sum_{i=1}^{l} \bar{b}$ .... **(10)**

3.2 Data

The evaluation of costs incurred by and benefit obtained from the adoption of controlling measure with respect to engineering and technological specification is simple because the goods are marketed goods. But the evaluation of social and environmental costs and benefit cannot be done easily due to the fact that most of them are non- marketed goods. Various indirect methods are used for estimation of such benefits.

Our attempted cost - benefit analysis of such decision making to evaluate the efficiency of the adopted technology was based on primary and secondary information that were collected from many sources namely from the owners themselves, the workers of such units, WBPCB and the producer of the device. The primary data were collected through field enquiry.

As has been mentioned earlier, due to the very small size of the secondary lead smelting units, which belong to the unorganized informal sector, well maintained and compiled data set were difficult to come by. Records regarding the production system, output produced, input used, the cost and price figures, from all the producers were not available to the extent desirable[6]. For such information the study had to depend on secondary sources also.

The required information regarding production level, input used, emission levels etc, for the respective units could therefore be obtained from the reports submitted to the WBPCB. However, in order to enrich the data set, since no single source of data was considered sufficient for the analysis, further information collected from technologists, scientists, engineers, local people, doctors as also from other records, reports and books, were supplemented.

4.Results: Measurement of Costs and Benefits.

4.1 Financial Aspect

As mentioned earlier, due to non-availability of information about the level of expenditure, revenue earned and other such data it is the additional benefit derived as a result of additional expenditure incurred on account of the installation of control device, that has been sought to be compared, instead of comparing the benefits obtained 'before' and 'after' the installation of abatement device.

For the actual estimation purpose, the information collected from both secondary sources and primary sources have been used. As a complete series of information is not available, both cost and benefit have been sought to be estimated by taking a number of alternative values. Table 1 depicts the range of values for each of cost and price variables that have been collected from different sources. In addition, following assumptions have been made on the basis of primary and secondary sources of information.

(i) It may be mentioned that the oldest device has been operating for the past six years since 1994, without any major shortcoming. Except for some unnatural causes, it may be expected to run another few years in its present condition. The expected life of the device may be assumed to be at least 10 years.

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[6] Though the questionnaire was prepared to enquire about all such information, ultimately that questionnaire could not be followed strictly. Instead, based on that questionnaire the information have been collected through discussion.

(ii)The costs of electricity, bags etc. are directly related to the volume of production and the total hours of operation. Though the consumption of electricity increases with the hours of operation, the cost of replacement of bags increases at decreasing rate with the number of shifts operated. For the estimation of total cost, it is assumed that if the unit runs only one shift, the replacement of bags become sufficient for once a year only. However, if the unit runs either two or three shifts, the bags require to be replaced twice a year[7].

(iii) As no additional labour is required for operating the device, additional expenditure on labour use is assumed to be zero here.

(iv) The quantity of dust collected also varies due to the difference in the quality of inputs. For the inputs purchased from the market, the average amount of dust is 40 kg / ton of lead waste ranging from 35 to 45 kg / ton (see Table 2). But this amount is lower, about 23 kg. / ton of lead waste from generator of said wastes. Again experiments on the collected bag house dust, conducted at different times, show that at least 30 per cent of lead may be recovered by using the device[8].

(v) According to the information supplied by the technologist from the experiment, the gas that comes out from the vatti at the entrance point of the device contains SPM on an average 19000 mg / nm^3 where the amount of lead is 7000 mg / nm^3 i.e., the proportion of lead in dust is about 37 per cent. But quantity of SPM and lead is very low, far below the permissible level, at the releasing point or at the end point of the chimney[9]. This is further supported by the information obtained from the record of the WBPCB collected from one unit in 1996 before the imposition of the regulatory measure to stop pollution, where it was shown that at the vatti top the air contained SPM of about 12000 mg / nm^3 SPM of which lead was 6240.02 mg / nm^3. These figures indicate that the proportion of lead comprised about 50 per cent of the total dust initially, which has now become possible to be collected through the device - a part of which comes out at the end of the bag house and remaining part becomes deposited in the sedimentation tank used for the cleaning of gas from where it may again be re-used as input. This study has used 30 per cent dust recovery rate in general, which may underestimate the benefit.

(vi) As regards charcoal it was found that its price, as reported in the primary data collected from the different units under consideration, varies from Rs. 4 / kg. to Rs. 6 / kg. depending on its quality. In order to be able to estimate the value of the charcoal saved, on account of the introduction of the device, two alternative average values of charcoal, Rs. 4.5 / kg. and Rs. 5.0 / kg., were assumed.

(vii) If the input contains 60 - 70 per cent of lead, the price of input may vary from Rs. 16 to Rs. 20. But in case of the 25 – 30 per cent recovery rate, the price comes down to Rs. 8 / kg. . The price of dust which is not a marketed product, may be considered at Rs. 8 / kg. when it contains lead around 30 per cent of the total dust, which may be reused in the production process .

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[7] The price of electricity for industrial units is considered as Rs.3 per unit, which is charged by the supplying authority. The number of bags is taken as 28, which is the standard number in such a unit.
[8] Chatterjee et al (1998).
[9] The level of SPM, released in the air, is between 3 – 13 μg/nm^3 of which amount of lead is maximum .02 – 1.2 μg/nm^3. These are far below the permissible ranges, which are 50μg for SPM and 10μg for lead per nm^3.

The estimation of additional cost and benefit realised by a firm of a given size has been done for different alternative values of fixed costs, maintenance cost, number of shifts operated, rate of interest and rate of recovery of dust. The social rate of discounting, which is a national parameter generally adopted by the policy makers in India[10], has been taken as 12 per cent for the estimation of the present value of costs and benefit. Alternatively a 10 per cent rate of discount, based on the market rate of interest, has also been tried.

But, the results have been presented finally for a set of alternative values, given in Table 2, of investment, maintenance cost, amount of dust generated for the different quality of inputs used, price of charcoal and for the number of shifts operated for a given level of price of electricity, raw material and bag in tables 4 to 6. All the costs and benefits have been estimated at the 1999 price level.

It had been mentioned earlier that previously the secondary lead smelting units were allowed to run at night. But the installation of the device now enables them to operate also during the day time. However, the results show that after the introduction of the device the running of the units in only one shift, i.e., for 6 to 7 hours per day using only 1 MT of lead waste for 300 days per year does not appear to be economically viable, as expected, if sufficient amount of dust is not being recovered. (see Table 3). On the other hand, the increase in the amount of dust makes, though marginally, the net benefit positive irrespective of the rate of interest, level of investment. But it is evidenced that the operation of the units only for two shifts per day (around 6-7 hours with 1 MT of lead waste per shift) and on an average of a total of 300 days per year generates quite a significant amount of additional benefit over the additional expenditure for the device as result of collection of more dust. The internal rate of return is also significantly high. The pay back period could be achieved within two to five years just after the installation of the machine (see Table 4). Hence, amount of dust collected through the control device, which would save the purchase of raw material, is a crucial factor in achieving the net benefit from this additional investment. It is mentioned earlier that the dust collected from the bag house is a portion of the total dust generated. Therefore, the use of total amount of dust generated may help to obtain positive benefit even by running one shift per day.

In general the recycling industry is constrained by the lack of guaranteed demand and lack of assured supply of waste. But as the demand for lead is significantly high for its various uses and more than about 50 per cent of total lead supplied in the market comes from the secondary lead smelting units, operation of two shifts, which is possible under such the situation, should be taken. However, belonging to the informal sector and being small in size their control in the input market may not be smooth. Under such circumstances expected benefit may not be realised. Provided there exists assured supply of lead waste, the results then show that the introduction of the device, which involves expenditure, is financially gainful from the producer's point of view if it is properly maintained and operated.

Tables 5 depicts the values of break-even point, on which the firms investment decision depends, for different alternative values of investment cost, price of charcoal, rate of interest, recovery rate, and for the number of shifts operated for a given level of operation and maintenance costs and benefits. It is observed from the tables that at a given level of benefits and costs the firm may achieve the break-even point earlier by operating more number of shifts per day. But no change is observed as such in the achievement of break-

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[10] Murthy et al (1998).

even point even if the inflation is allowed up to 10 per cent in the estimation of benefit or cost or both except in few cases.

4.2 Environmental Aspect

It is well known that the secondary lead smelting industries contribute to environmental degradation. There is no reason to deny that air pollution due to the emission from these units containing considerable amount of lead in the suspended particulate matter (SPM) and some gaseous components have serious negative impacts on human health and various economic goods and services both in and outside the production place. The external effects lead to the reduction of productivity of human resources and also of natural resources and imposes important economic and social costs on the society.

The situation, therefore, makes it imperative that the measures have to be taken to reduce the negative environmental impact for the sake of industry and society. Hence along with comparison of financial benefits and costs achieved due to the introduction of such measures, the evaluation of health impact associated with it, is also essential for setting priority of action in this respect. The estimation of net environmental benefits quantitatively (if not possible, then qualitatively) helps the society to make more rational decision for allocating scarce financial resources.

The numerical estimation of environmental impacts, though these are non-marketed goods, is not impossible if proper information is available. In one method, valuation is done before the installation to assess the feasibility of technology in this context by estimating the willingness to pay to avoid the degradation of the environment and to be able to live in a pure environment. But difficulty may arise due to the existing population distribution. The willingness to pay may be much higher in case of rich people compared to that of poor, as being wealthier, they turn their attention increasingly to the quality of their living environment. Hence the estimation may become biased.

Alternatively, the estimation of change in the health effect due to the change in components of pollutants in the air, either qualitatively or quantitatively, may give an idea about the impact of air pollution on human health and environment.

In the secondary lead smelting industry the most important pollutant is lead coming out with SPM. Lead poisoning may cause a great variety of diseases: a specific syndrome does not exist[11].

It has both short and long term effects on human health. Most important short- term effect of lead on human health is the abdominal pain, loss off appetite, metallic taste in the mouth etc. The long-term effects are renal problems affecting kidney function, hypertension, effects on bone, fatigue, joint pain, anemia etc.

The deposition of lead on the root, leaf and surface of the plant has the lead toxic effect causing a problem in photosynthesis, growth and other parameters[12].

The focus may be made on the estimation of the short run impacts on human health both in and outside of the factory premises and environment, compared to that of the long run. This is because it is difficult to isolate the impacts of particular type of effluent in the

[11] Sue et al (1983)
[12] WHO (1989)

long run. It has to be mentioned that the measurement of the impact on environment due to the change in the level of pollution is possible only if the required information is available. In the present case of secondary lead smelting units, no information on the components of air pollution 'prior' to the introduction of control device were recorded properly either by the WBPCB or by the factory owners. The only available information from the survey of the units is the amount of dust collected through the device, which were previously being released in the air. It is, however, possible to reconstruct the level of pollution that would prevail in the absence of control device in the factories from the current information on the emission of pollutants recorded by WBPCB officers and the survey data on the dust collected through the device. The two together would indicate the potential for pollution of the factory concerned.

The lead dust is absorbed into human health by inhalation and ingestion through food.
The change in the human health and in the surroundings within the factory premises due to the installation of the device were recorded from the survey by interviewing the older workers, if any, who were found to be working since the 'no-device' period. According to these workers, the abdominal pain, loss of appetite, metallic tastes in the mouth - all the immediate effects of lead absorption, which were the regular health features experienced by them previously, were reported to be totally absent at present.

One possible method of estimation of the damage to health in monetary terms of this lead - related health hazards would be to estimate the total expenditure made by the affected persons towards curing such diseases. However, due to the very nature of the employment pattern observed in these small-scale industries such estimation could not be attempted. The labourers employed in such units were mostly temporary workers, who migrated from neighboring places. It has been reported that they were used to working for short spans in these jobs in the pre - device period. However, in the post - device period the quit - rate or the frequency of leaving jobs had declined significantly. Due to the better work environments in the present context the workers are willing to continue with their jobs in these units. Alternatively an attempt may be made to estimate the loss of labour hours due to absentism in the job, as a result of ill health, as a proxy of health impact. For example, if it is assumed that a labour may loose minimum two years from his total service period of thirty two years[13], the loss of earning then may be estimated as about Rs. 937 per year at the rate of Rs. 50 per day for 300 days in a year for a labour within the tenure of his working age. Then for the introduction of device in an unit employing three labours per shift, it may be possible to earn at least Rs. 5622.0 more per year from operating two shifts by saving the loss of working period as a result of improved environment. The net present value of this flow of benefit at 10 per cent rate of discount is about Rs. 28000.0 during the life years of the device. It would also be considered as the additional income generated in the society and should be added to the social benefit obtained from the introduction of the device.

The growth of fruits and flowers, the absence of any trace of lead dust on the leaves of trees, in the pond or water bodies inside the factory premises may also be taken as an indicator of cleaner environment experienced in the post device period.

The benefits from the change in the air quality may be realized in terms of (i) increasing productivity of the labour on account of improvement in the quality of health and (ii) increased efficiency on account of being able to remain in the same occupation and unit for a greater length of his working life.

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[13] The working age of a hard working labour is assumed as 18 to 50 years.

These benefits taken together lead to the (a) savings of input for optimum and efficient use and (b) saving of money resources in terms of paying same wage rate to the most efficient workers. These benefits are obtained by the producers, which may be deducted from their actual cost of production.

The growth of fruits and flowers, the absence of any trace of lead dust on the leaves of trees, in the pond or water bodies inside the factory premises may also be taken as an indicator of cleaner environment experienced in the post device period.

The measurement of impact of controlling air pollution on the neighboring locality would also be possible through a survey similar to the present study. But it was beyond the scope of the present study. Observation from a secondary source is instructive in this respect, however[14]. From such source it is known that all the short-term effects of lead poisoning, commonly experienced in the pre - installation period, were found to have been removed in the post - device period. Similarly the positive changes and growth, observed in the natural environment now, were not observed previously. The value of the benefits enjoyed by the previously sufferers on account of the improvement in the environment can similarly be estimated in terms of the expenditure estimated for caring the related diseases and the value of production obtained from natural environment. Thus the estimated obtained in and outside the production unit together, by cleaning the adjoining environment, is significantly high and have to be adjusted with the cost of production.

4.3 Social Aspect

In estimating the social cost with respect to any activity, the investment of capital made should be assigned some premium as a result of sub - optimal level of saving and investment patterns. The price in this case is termed as shadow price, which is defined as the present value of consumption, which an additional unit of investment fetches to the economy. But with respect to this particular project like installation of control device, the best alternative use of capital would be the investment made in this project for carrying out the production as against the complete closure of it for non - compliance with pollution control.

The social benefits obtained from this project in particular, are manifold. The clean environment due to the reduction of dust, which was initially released in the air, has increased the productivity of human beings as well as of nature.

Another significant social benefit of the introduction of pollution control measure is the creation of new activity in the form of the indigenously developed pollution control devices. This new activity is obviously providing job opportunities to the society, not only in these producing units, but also in the production of components such as bags and other spare parts and as also in maintenance related activities by locally trained people. In a developing country with high level of unemployment, the opportunity cost of labour may be taken to be zero. Then, the income earned through employment, in such new activities, is obviously an addition to the national income. For example from a single unit operating two shifts per day, society may earn Rs.31200.0 per year or discounted total

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[14] A study 'Dushan Niyantraner Prayas', a Bengali article based on a survey conducted in the nearby locality to study the effects of control device by WBPCB in 1996.

income about Rs. 2.0 lakhs over 10 years period in the first round only by rendering maintenance services and producing bags[15].

Therefore, addition of the value of benefits obtained from cleaning environment, creating new job opportunities with the net physical benefit puts overall net benefit of the introduction of controlling device to a much higher level. As a result, operation of one shift may be viewed as viable from the point of view of society and environment. The aggregate, therefore, indicates the significance of the abatement technology at the social, environmental and commercial levels.

5. Summary and conclusion

At the beginning of this decade the sole regulatory measure that was adopted by the pollution control authority of West Bengal was to stop the production of lead by the secondary lead smelting units as this production entailed the disposal of 'hazardous substance' which polluted the environment. However, the policy makers realized that the recycling of hazardous wastes which these Secondary Lead Smelting units undertook and consequent recovery of lead on their part, which was an important intermediate input for various productive activities, could not be ignored. Hence, the WBPCB, with the help of local scientists developed an air pollution control device, which might be installed by these units. Hence, as against 'closure option', there was now before the firms, another alternative, namely, the adoption of such control device.

However, what was puzzling was that, despite this available alternative, there appeared to be few takers. In other words, while many firms chose the closure option, only a few opted for the control device that had been developed. Why were there such a few takers? A possible explanation may either be that there was not much awareness relating to the utility or disutility of adopting such device as because it is difficult to estimate the accrued benefits from adopting the control device, or the high installation cost, or both. This study was an attempt in estimating the net benefits that was achieved by the units and society at large, from the adoption of control device, even though it involves additional installation costs.

The necessary information to carryout such a study have been collected from different secondary sources along with the primary source by survey of the existing units within Calcutta that adopted the technology.

A cost-benefit method was applied to the data collected and supposed to be the most appropriate method for the comparison of costs incurred for and the benefits obtained from the installation of the control device from economic, social and environmental points of view to study the appropriateness of the investment in this regard.

It has been observed from the cost–benefit analyses that as against confining the production only to the night shift as was the practice earlier, the use of the device enabled the secondary lead smelting units to operate the factories throughout the day or to utilize their full productive capacity to meet the existing demand for their products. The lack of assured supply of inputs would be the only constraint in this respect. The results show that the amount of dust collected is a crucial factor to determine the level of net benefit obtained from the installation of the device. It is further observed that if dust is collected properly, then for all combination of costs and prices, each of the units may be operated

[15] It is the sum of earnings of Rs.20000.0 per year by providing maintenance services and Rs.11200.0 (28x2x200) for the sale of bags.

profitably even if it runs one shift only. However, it will be highly profitable if the units run two shifts per day using one MT of raw materials per shift for 300 days per year. These findings may be crucial from the point of view of other units in introducing similar investment decisions regarding the adoption of the developed technology.

Apart from the financial profitability considerations the system developed by the WBPCB and the scientists involves also considerable social and environmental significance for the workers and the immediate neighborhood surrounding these units. Therefore, efforts to increase the awareness of the owners of the respective units regarding the financial viability of technology and the judiciousness of their investment decisions relating to it are of crucial importance. For the benefit of industry from the socio-economic and environmental points of view financial assistance could also be considered.

The detailed analysis of the productivity of the device indicates that it is not only beneficial from the point of view of the private producers, but it also benefits the environment and the society at large. As against the closure option, from the society point of view, it is meaningful to continue the productive activity, which is possible by adopting this technology. Hence, since the initial investment costs which the firms are required to bear is quite significant, it may be captured if financial assistance by way of loans for installation of device could be provided to these small units. Lastly, it is also to be mentioned that a proper maintenance of the device through regular checking of the pollution level by the regulatory authority is an important component to ensure the expected air pollution abatement results.

Table 1: Financial and Other Information of the Secondary Lead Smelting Units

Item of Information	Values		
	Maximum	Minimum	Average
(1)	(2)	(3)	(4)

Cost of Air Pollution Control Device Cost of civil construction works Cost of maintenance(yearly) (Rs. Lakh in 1996)	2.5 0.15	2.0 0.25	2.25 0,60 0.20
Number of Filter Bags used	36	24	
Price of Raw Materials(Rs. / kg.) (i) Battery scrap (ii) Slag (iii) Slag containing 25-30per cent lead	 20 3 8	 14 2.5	 17 2.75 8
Price of coal(Rs. / kg)	6	4	5
Price of Bag (Rs. / bag)	225	175	200
Price of lead ingot (Rs. / kg)	36	30	33
Collection of dust from bag house(kg./kg of raw material) (i) Output/Input Ratio-25per cent (ii) Output/Input Ratio-30per cent	 0.045 0.027	 0.035 0.019	 0.040 0.023

Source: Reports from WBPCB, Survey data.

Table 2: Alternative values of Items Used in the Estimation of Cost and Benefit.

Items	Alternative Values		
(1)	(2)		
Price of device including construction cost (Rs. Lakh)	4.00	4.50	
Average maintenance cost / year(Rs. Lakh)	0.15	0.20	0.25
Per unit price of electricity (Rs.)	3.00		
Price of bag / piece (Rs.)	200.00		
Price of charcoal / kg (Rs.)	4.50	5.00	
Price of dust / kg (Rs.)	8.00		
Life of the device(years)	10		
Rate of interest (per cent)	12		
Rate of discount (per cent)	12	10	
Proportion of lead in dust(per cent)	30		
No. of bag used	28		
Working day per year	300		

Source: See Table 1

Table 3: Estimated Physical Benefit-Cost Ratio (B/C ratio), Internal Rate of Return (IRR), and Pay Back Period (at 1999 price level) for a Given Level of Investment and Rate of Recovery of Dust in a Unit Operating One Shift.

A Level of investment –Rs.4.0 lakhs and rate of recovery of dust – 0.023 kg per kg of input.

Investment (Rs. Lakh)	Recovery rate of dust/kg of input(kg)	Rate of interest (per cent)	Maintenance cost /year (Rs. Lakh)	Price of charcoal					
				Rs. 4.5 per kg			Rs. 5.0 per kg.		
				B/C ratio	IRR	Pay back period (years)	B/C ratio	IRR	Pay back period (years)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rate of discount = 10 percent									
4.0	0.023	12	0.15	0.82			0.87		
			0.20	0.79			0.84		
			0.25	0.77			0.81		

B : Level of investment – Rs. 4.0 lakh and rate of recovery of dust – 0.040 kg /ton of input.

Rate of discount = 10 per cent									
4.0	0.040	12	0.15	1.09	0.16	6	1.14	0.19	6
			0.20	1.05	0.14	6	1.10	0.17	6
			0.25	1.02	0.11	7	1.07	0.14	6

C : Level of investment – Rs.4.5 lakh and rate of recovery – 0.023kg/kg of input

Rate of discount = 10 percent									
4.5	0.023	12	0.15	0.75			0.80		
			0.20	0.73			0.77		
			0.25	0.71			0.75		

D : Level of investment – Rs. 4.5 lakh and rate of recovery – 0.040 kg per kg of input.

Rate of discount = 10 per cent									
4.5	0.040	12	0.15	1.00	0.09	7	1.04	0.13	7
			0.20	0.97	0.07	8	1.02	0.11	7
			0.25	0.94	0.05	8	0.98	0.09	8

Source : Estimation

Table4 :Estimated Physical Benefit-Cost Ratio (B/C ratio), Internal Rate of Return (IRR), and Pay Back Period (at 1999 price level) for a Given Level of Investment and Rate of Recovery of Dust in a Unit Operating Two Shifts.

A: Level of investment – Rs.4.0 lakhs and rate of recovery of dust – 0.023 kg per kg of input.

Investment (Rs. Lakh)	Recovery rate of dust/kg of input(kg)	Rate of interest (per cent)	Maintenance cost /year (Rs. Lakh)	Price of charcoal					
				Rs. 4.5 per kg			Rs. 5.0 per kg.		
				B/C ratio	IRR	Pay back period (years)	B/C ratio	IRR	Pay back period (years)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rate of discount = 10 percent									
4.0	0.023	12	0.15	1.38	0.44	4	1.46	0.52	3
			0.20	1.34	0.41	4	1.42	0.49	3
			0.25	1.30	0.38	4	1.38	0.46	4
B: Level of investment – Rs.4.0 and rate of recovery of dust – 0.040 kg per kg of input.									
Rate of discount = 10 percent									
4.0	0.40	12	0.15	1.83	1.05	2	1.92	1.22	2
			0.20	1.74	1.00	2	1.86	1.15	2
			0.25	1.74	0.94	3	1.82	1.10	2
C : Level of investment – Rs.4.5 and rate of recovery of dust – 0.023 kg per kg of input.									
Rate of discount = 10 per cent									
4.5	0.023	12	0.15	1.28	0.33	4	1.36	0.40	4
			0.20	1.25	0.31	4	1.29	0.38	4
			0.25	1.22	0.28	5	1.29	0.35	4
D: Level of investment – Rs.4.5 and rate of recovery of dust – 0.040									
Rate of discount = 10 per cent									
4.5	0.040	12	0.15	1.71	0.79	3	1.78	0.90	3
			0.20	1.66	0.75	3	1.74	0.86	3
			0.25	1.62	0.72	3	1.69	0.82	3

Source : Estimation

Table 5 : Estimated Break-even Point Achieved by the firm Operating Two Shifts

A : Rate of recovery of dust –0.023 kg per kg of raw material

Investment (Rs. Lakh)	Rate of change of price (per cent)		Price of charcoal											
			Rs.4.5 per kg						Rs.5.0 per kg					
			Rate of interest per year						Rate of interest per year					
	O & M cost	Benefit obtained	12 per cent		13 per cent		15 per cent		12 per cent		13 per cent		15 per cent	
			Discount rate (per cent)		Discount rate (per cent)		Discount rate (per cent)		Discount rate (per cent)		Discount rate (per cent)		Discount rate (per cent)	
			10	12	10	12	10	12	10	12	10	12	10	12
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
4.0	0	0	3.67	3.77	3.82	3.93	4.16	4.30	3.20	3.27	3.31	3.39	3.56	3.66
	0	5	3.25	3.32	3.35	3.43	3.57	3.65	2.91	2.96	2.99	3.05	3.16	3.23
	0	10	2.99	3.04	3.06	3.12	3.22	3.28	2.71	2.75	2.77	2.82	2.91	2.95
	5	0	3.87	3.99	4.05	4.18	4.46	4.64	3.32	3.40	3.45	3.54	3.74	3.85
	5	5	3.36	3.44	3.47	3.55	3.71	3.80	2.98	3.04	3.07	3.13	3.26	3.33
	5	10	3.06	3.11	3.14	3.19	3.31	3.37	2.76	2.80	2.83	2.87	2.97	3.02
	10	0	4.15	4.31	4.38	4.57	4.99	5.27	3.47	3.57	3.62	3.73	3.98	4.12
	10	5	3.49	3.58	3.61	3.71	3.89	4.00	3.07	3.13	3.16	3.23	3.37	3.45
	10	10	3.14	3.20	3.22	3.29	3.41	3.48	2.82	2.86	2.89	2.94	3.04	3.10
4.5	0	0	4.51	4.68	4.73	4.93	5.26	5.52	3.88	4.00	4.05	4.18	4.43	4.59
	0	5	3.83	3.93	3.96	4.07	4.25	4.38	3.41	3.39	3.52	3.61	3.76	3.85
	0	10	3.44	3.51	3.53	3.61	3.73	3.82	3.12	3.18	3.20	3.26	3.37	3.44
	5	0	4.87	5.09	5.17	5.43	5.92	6.31	4.09	4.23	4.29	4.45	4.77	4.98
	5	5	3.99	4.11	4.14	4.27	4.48	4.63	3.52	3.16	3.64	3.74	3.90	4.01
	5	10	3.53	3.61	3.64	3.72	3.86	3.95	3.19	3.25	3.28	3.34	3.46	3.53
	10	0	5.52	5.90	6.06	6.59	8.33	-	4.39	4.58	4.66	4.88	5.36	5.70
	10	5	4.20	4.34	4.38	4.53	4.79	4.98	3.66	3.76	3.79	3.90	4.10	4.23
	10	10	3.65	3.74	3.76	3.86	4.01	4.11	3.27	3.34	3.86	3.44	3.56	3.65

B : Rate of recovery of dust – 0.040 kg per kg of raw material

4.0	0	0	2.04	2.06	2.09	2.11	2.18	2.21	1.89	1.90	1.93	1.94	2.01	2.03
	0	5	1.96	1.98	2.00	2.02	2.08	2.10	1.83	1.84	1.86	1.88	1.93	1.95
	0	10	1.90	1.91	1.93	1.95	2.00	2.02	1.78	1.79	1.81	1.82	1.87	1.88
	5	0	2.06	2.08	2.11	2.13	2.21	2.24	1.90	1.92	1.94	1.96	2.03	2.05
	5	5	1.98	2.00	2.02	2.04	2.10	2.12	1.84	1.85	1.87	1.89	1.95	1.96
	5	10	1.91	1.93	1.95	1.96	2.02	2.04	1.79	1.80	1.82	1.83	1.88	1.90
	10	0	2.09	2.11	2.13	2.16	2.24	2.27	1.92	1.94	1.96	1.98	2.05	2.07
	10	5	2.00	2.02	2.04	2.06	2.12	2.15	1.85	1.87	1.89	1.90	1.96	1.98
	10	10	1.93	1.94	1.96	1.98	2.04	2.06	1.80	1.81	1.83	1.84	1.89	1.91
4.5	0	0	2.40	2.44	2.47	2.50	2.60	2.64	2.22	2.24	2.27	2.30	2.38	2.41
	0	5	2.28	2.30	2.33	2.36	2.44	2.47	2.12	2.14	2.16	2.18	2.25	2.28
	0	10	2.18	2.20	2.22	2.25	2.31	2.34	2.04	2.06	2.08	2.10	2.16	2.18
	5	0	2.44	2.48	2.51	2.54	2.65	2.69	2.24	2.27	2.30	2.33	2.42	2.45
	5	5	2.30	2.33	2.36	2.39	2.47	2.50	2.14	2.16	2.18	2.21	2.28	2.31
	5	10	2.20	2.22	2.24	2.27	2.34	2.37	2.05	2.07	2.09	2.11	2.18	2.20
	10	0	2.48	2.52	2.55	2.59	2.70	2.75	2.27	2.30	2.33	2.36	2.45	2.49
	10	5	2.33	2.36	2.39	2.42	2.51	2.54	2.16	2.18	2.21	2.23	2.31	2.33
	10	10	2.22	2.25	2.27	2.29	2.36	2.39	2.07	2.09	2.11	2.13	2.20	2.22

Source : Estimation

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APPENDIX 1

Diagram of the production process and control device

A.

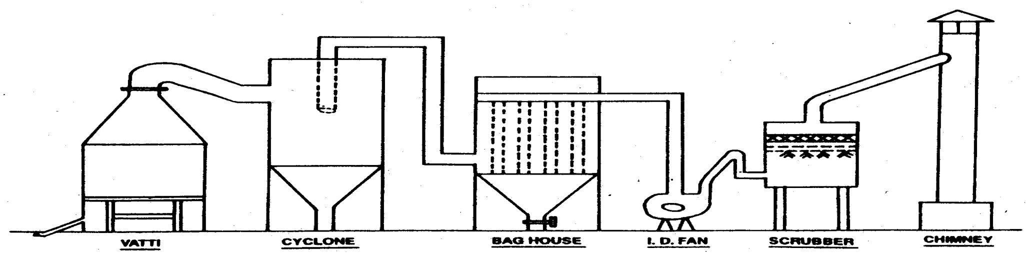

FIGURE - 2

B.

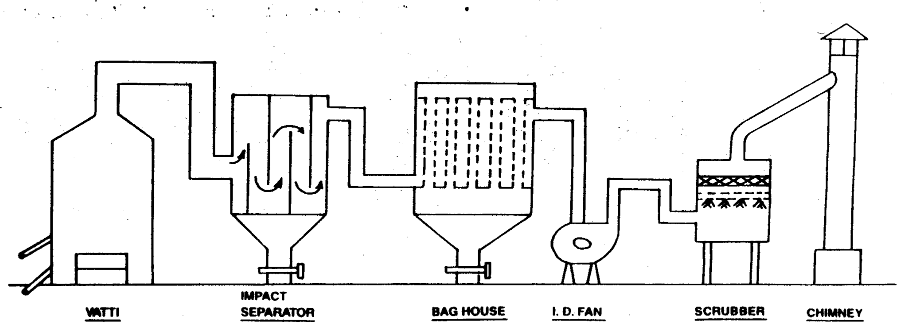

FIGURE - 3