CHAPTER TWO
THEORETICAL AND CONCEPTUAL BACKGROUND

2.1 Introduction

This chapter provides theoretical and conceptual framework of the present study. The chapter deals with the concept of environment and environmental pollution, industry and environmental connections, production of paper, impact of paper production on human health, property value and quality of life. Apart from these this chapter also discussed the concept of profitability and socio-economic benefit.

By environment we mean the biosphere, the thin skin on the earth’s surface on which life exists, the atmosphere, the geo-sphere (that part of the earth lying below the biosphere) and all flora and fauna (Nisbet, 1991). According to the section 2 (a) of the environment (protection) Act under Article 48-A, environment (a) includes water, air, and land and (b) the interrelationship which exists among and between - (i) water, (ii) air, (iii) land, (iv) human beings, (v) living creatures, (vi) plants, (vii) microorganisms, (viii) property. Therefore environment includes animate and inanimate objects and their relationships.

Rapid growth and application of science and technology to economic activities naturally leads to modern industrialisation which accompanied with or without some other factors, results among other things in urbanisation and environmental pollution. There is a dilemma. On the one hand, expansions of economic activities are indispensable and in other, growths of economic activities
are showing environmental degradation. Therefore, one normative aspect of research is – ‘what should be the optimum economic growth rate which is environmentally sustainable?’

Relating economic growth and environment degradation many thinkers believe that economy can grow their way out of the environmental problems. Wilfred Beckerman (1992) exemplifies this position - the only way to attain a decent environment in most countries to become rich. This view is accepted by World Bank (World Development Report, 1992) and is often called Environmental Kuznet Curve (EKC) theory after the name Simon Kuznet who in 1955 hypothesised an inverted U shaped relationship between the growth of income level and environmental degradation. The environmental Kuznet curve hypothesis, first identified empirically by Grossman and Krueger (1993), seeks to establish a relationship between income levels and environmental quality. The EKC hypothesis states that as per capita income grows, environmental impact rise, hit a maximum and then decline.

Climate change has been the great concern over the few decades. A resolution of the UN general Assembly in 1989 led to the unprecedented UN conference on environment and development (UNCED) – popularly known as the Earth Summit- which was held at Rio-de-Janerio in June 1992. The earth summit succeeded in attracting the largest number of government heads. This was a clear sign of environmental and resource concern all over the world. The signatories to the convention committed themselves to the goal of achieving ‘stabilisation of greenhouse gases concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.
2.2 Industrialisation and Externalities:

By externality we mean the effect of production or consumption activities of one individual or firm or group on other individual(s) or firm(s) or group(s) without paying for the effect. Marshall (1898) was the first to define external economies as external to the firm but internal to the society. If the consumption or production activity of one individual or firm affects another person’s utility or firm’s production function so that the conditions of a Pareto optimal resource allocation are violated, an externality exist. Externalities are of two types, production and consumption externality. Again externality may be positive or negative. When production or consumption activities of one firm or consumer benefit other(s), it is the case of positive externality. On the contrary, when production or consumption activities of one firm or individual affect other(s), then it is the case of negative externality. Thus in case of positive externality activity of one economic agent increases the utility of other economic agent who need not pay for that additional benefit. And in the case of negative externality, activity of one economic agent reduces utility or welfare of other economic agent who remains unpaid. If externality exists, market fails to work efficiently. For efficient working of the market, price should be equal to the social marginal cost and not on the basis of conventional neo-classical law i.e. price = MC.

Industry creates negative externality when its production activities create some disutility to society and which is not paid to the suffering class. When industry discharges its wastes in to river, water of the river gets polluted.
Similarly industry emerges some kinds of toxicant elements into the air which like polluted water affects human health.

Industry also creates some sorts of positive externality. Many other industries and business enterprises are built up based on the former industry. It stimulates economic activities and thus generates positive impact in the economy which is not paid to the industry.

In each case actual output of industry is not equal to the social optimal output. In case of negative externality e.g. when it pollutes environment, actual output of industry is greater than social optimal output.

2.3 Environmental Kuznets Curve:

Grossman and Krueger (1995) and the World Bank (1992) first popularized the concept of environmental Kuznets curve using an empirical work. They ran a regression equation where dependent variable is ambient air and water qualities in cities worldwide and polynomial in GDP per-capita and other city and country characteristics as independent variable. They then plotted the filled values of pollution levels as a function of GDP per-capita, and demonstrated that many of the plots appeared inverted U-shaped, first rising and after a point falling. The study found that peaks of these predicted pollution-income paths vary across pollutants, but in most cases they come before a country reaches a per-capita income of $ 8000 in 1985 dollars (Grossman and Krueger, 1995).
Pollution often appears to worsen at the initial state of income growth and later to improve as countries’ income grows beyond a limit. Because of its resemblance to the pattern of inequality and income described by Simon Kuznets. This is referred as ‘Environmental Kuznets Curve’ (EKC).

This EKC concept is also applicable to individual firm. A newly firm initially concentrates more on growth. At that time its cost of production does not support adoption of environment friendly technology. With the assumption of weak monitoring of environmental regulation a firm concentrates more on production efficiency. As time passes, firm’s average cost starts falling by virtue of falling average fixed cost with output. It is also natural propensity of a small firm not to comply with environmental pollution limit because its scale of production does not support. However, a growing firm in the long run, due to acquisition of some advantage of returns to scale and also due to increasing pressure from environmental protection authority, invests in the green technology. Therefore, pollution level per output level comes down. This we address as the down phase of EKC.
In the above figure Output is measured along horizontal axis and pollution along vertical axis. It is apparent from the figure that before reaching O* level of output pollution increases directly with output. However, rate of increase in pollution continually falls with the level of output and after crossing O* level of output pollution rate increases negatively. The implication of this is that at the initial level of output firm concentrates only on growth of output and do not like to spend on pollution reducing technology or invests a small amount on that. Therefore there is a direct or positive relationship between pollution and level of output where there is no or limited application of green technology.

Karvonen (2001) studied emission status of 14 individual mills. He found that oldest mills are the most polluting. He also graphically presented cumulative pulp production in Finland in thousand metric tons and biological oxygen demand (BOD) emission per metric ton. The figure reflects emission increases at an increasing rate with the level of output. However, the presentation does not
give any hints regarding the adoption of green technology. As adoption of effluent treatment technology can reduce pollution level.

According to an estimate cost of installing air and water cleaning equipment adds an extra 15 percent to the investment costs of a modern pulp mill (Metsateollisuus, 1995) and running the equipment is a sizable and increasing cost to the mill. Therefore, it is very irksome task for a small firm which yet to enjoy scale efficiency, to adopt such kind of cleaning technology. Even large firms also try to skip in adopting clean technology if they realise slack in monitoring.

There are some literatures which define emission (E) as some function of output or \( E = f( Q) \) (Clift et al, 1999). However, this approach is too much restrictive as in this process the reduction of environmental wrongs is only possible through the simultaneous reduction in the desired outputs (Chung et al, 1997).

### 2.4 Health and Industrial Environment Pollution:

Health and environment are well linked. An estimate indicates that the proportion of the global burden of disease associated with environmental pollution hazards ranges from 23 percent (WHO 1997) to 30 percent (Smith, Corvalan and Kjellstram, 1999). This estimate includes infectious diseases related to drinking water, sanitation and food hygiene. More importantly environmental pollution is of two types: air and water pollution.
2.4.1 Water pollution:

Rapidly increasing urbanisation and industrial count, day by day, are inviting future jeopardy of fresh water crisis. Industries are the major source of pollution. Based on the type of industry, various levels of pollutants can be discharged into the environment directly or indirectly through public sewer lines. Waste water from industry includes employees' sanitary waste, process wastes from manufacturing, wash waters and relatively uncontaminated water from heating and cooling operations. High level of pollutants in river water systems causes an increase in biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS), toxic metals such as Cd, Cr, Ni and Pb and fecal coliform and hence make such water unsuitable for deinking, irrigation and aquatic life (Kanu, Ijeoma and Achi, 2011)

Generally industry discharges its wastes into water body and if the discharged water not treated properly it disturbs water characteristics. This harms ecosystem of water body. Also due to flow of chemical wastes people's health gets harm. Gobindaajalu (2003) conducted a water pollution study covering 31 villages and 600 households. It was evident from the study that almost all the 31 villages were affected by the industrial effluent. Health problems such as skin allergy, respiratory infections, general allergy, gastritis and ulcers were the common diagnosis by the medical team. Industrial pollution and human health can be presented as follows:
The above figure explains the channel through which industrial effluent can impair human health. When industry discharges large volume of wastes into water body the characteristics of water alters. However, if waste water is properly treated before discharging, there will be fewer impacts on water body. The consequence of untreated or poorly treated waste water may have many adverse impacts on aquatic ecosystem. Human being can be victim of water pollution through three main paths: a) by drinking polluted water, b) by consuming agricultural food grains which is produced by using harmful chemical mixed water and c) by consuming aquatic organisms like fish which lives on hazardous chemical water.
2.4.2: Air Pollution:

The effects of atmospheric pollution on human health are the result of a chain of events starting on the pollutants emission, going through transportation, dispersion in the atmosphere and by the individual inhalation (inhaled dose). The evaluation of those effects implies the knowledge of the several chain links:

![Chain of events](image)

**Figure 2.3: Chain of events associated with atmospheric pollution, from emission to health effects**

Human exposure can be defined as an event that occurs when an individual is in contact with a pollutant (Duan, 1982, Ott, 1982). European legislation recognises and recommends using human exposure as an assessment indicator of health impact. To have exposure it is required that the concentration of a pollutant (a physical environmental characteristic) in a certain location is not Zero, and simultaneously, an individual is present in that location (Sexton and Ryan, 1988). The definition of exposure refers to an instantaneous occurrence between a people i and a concentration pollutant c, for a certain period of time. Exposure does not necessarily imply a pollutant inhalation of ingestion; it is only related with the pollutants levels in the environment. On the other hand dose concept is used when a pollutant crosses the physical barrier (body). When analysing the exposure to atmospheric pollutants, the inhaled dose is referred as the amount of pollutants inhaled by an individual in a determined time.
Therefore, person who works in a polluted industry is highly exposure to air pollutants and he is also subject to inhalation of higher doses compared to person stays outside or away from industry. Similarly, persons living near a polluted industry are more exposure to air pollutants and subject to inhalation of higher doses of pollutants in contrast to people living outside the industrial region. From the above statements logically we can say that probability of ill health effect of poisonous emission of an industry will be more for the person who lives closer to the source of emission compared to the person who lives at a higher distance place provided that both persons have same resistance power against that particular emission.

Now it becomes very interesting to concentrate the role of distance in pollution study. From the above analysis we can make further advancement in the concept of distance such as ‘if we move away continually from a polluting source or in other words if distance from a polluting source continues to increase health impact of that source specific pollution will be lessen. In an alternative way if it is evident that living closer to an emission source reveals more health symptoms then we can say that emission source is the cause of such health impairment.

2.5: Property Value and Industrial Set Up:

Industry can be recognised as one of the agent of economic development. It generates employment in the economy both in direct and indirect way. People who get employment in the industry enjoy the direct benefit in terms of income whereas indirect benefit implies the benefit accrued from the built market. How
does it work? There is infiltration of people from outside regions to industrial region for seeking employment. This raises the demand for goods and services in the local market creating a favourable business environment. Due to the impact of such positive economic aspect demand for land and housing in the locality boost up. As a result price of land and rent of house also goes up.

This is the just half of the whole scenery. Industry is also associated with generation of certain negative impact such as environmental pollution. Environmental pollution can exert some sorts of disutility among individuals. Moreover, excessive pollution has some negative impact on human health. Other sorts of disutility associated with industry are poor vision due to fog, flow of dust, odorous smell etc. The impact of such negative aspect on property value will depend on how people value them.

The interaction of positive and negative aspects with other characteristics determines property value of the locality. Property value will be more if positive impact is stronger than negative impact and vice versa.

2.5.1 Individuals’ Preference in Choosing a Location:

While choosing a location individual is guided by many factors or attributes such as availability of market, school, bank, post-office, hospital or nursing home, transport & communication, crime factor etc. Apart from these factors environment also plays a significant role in individual utility function. Suppose, an individual want to purchase a house. There are two locations A and B. while A and B have same attributes. The only difference between these two locations is that in location B, a large scale industry has been built up. The
establishment of that industry results in higher level of activity in the local market. Individual wants to maximise its profit or minimise its cost. If he locates at B, he maximises his income. But environmental cost in locating at B is also maximum. Now, consider location A which is far away from B. At location A opportunity cost of losing income is maximum. However, environmental cost is zero. Therefore, we have two extreme locations and two types of costs. Now, what is the feature of mid-places between A and B? If the individual moves forward towards location A, opportunity cost will continually fall and environmental cost will continually rise.

The assumptions are:

1. Hypothetical individual wants to maximise his gain or minimise his cost.
2. There is no possibility of moving from one location to another location to capture benefit.
3. Location B has highest environment cost and it falls continually moving away from B to A.
4. Location A has highest income earning scope and this scope comes down continually moving from location B towards A and vanishes at location A.

Now the question comes forth, where does our rational individual would prefer to locate? In one side he wants to maximise his income. But this involves high environmental cost. Ideal location for individual will be the place where total cost is minimum. Let us explain the simplified system as follows:
Table II.1

Hypothetical Relationship Between Distance and Cost

<table>
<thead>
<tr>
<th>Distance (K.M.)</th>
<th>Opportunity cost (Rs)</th>
<th>Environmental cost/Health cost (Rs)</th>
<th>Total cost (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>150</td>
<td>75</td>
<td>225</td>
</tr>
<tr>
<td>4</td>
<td>200</td>
<td>50</td>
<td>250</td>
</tr>
<tr>
<td>5</td>
<td>250</td>
<td>0</td>
<td>250</td>
</tr>
</tbody>
</table>

We can see the opportunity cost is zero at distance 1 K.M. from industry. Opportunity cost increases as distance from industry increases. This is because spread effect of industry gets weaker while moving away from industry. On the other hand, we assumed industry emerges toxic pollutants which impairs health. Therefore, at location distance 1 K.M. (d1) environmental cost is highest and it continually falls as distance from industry increases and at a certain distance (say 5 K.M.) this cost disappears. It will be profitable for the concerned individual if he choose such location which minimises his total cost, i.e., cost of losing income if one stays at centre and environmental cost. The fourth column of the table shows that at distance 2 K.M. total cost is minimum. Therefore, a rational individual will locate at a distance of 2 K.M. from industry.

To put this in different fashion we assume opportunity cost increases at a rate ‘r’ at each successive distances where at distance 1 K.M. ‘r’ is kept zero. Therefore, at distance d opportunity cost(C_{opp}) will be:
\[ C_{\text{opp}} = (d - 1)r, \text{ where } d = 1, 2, 3, \ldots, n \] .......................... (2.1)

Now again we assume, environmental cost or health cost decreases at a rate ‘\( h \)’ in each successive distance where at distance \( n \), ‘\( h \)’ is kept zero showing zero environmental cost. Then, environmental cost or health cost in distance \( d \) will be as follows:

\[ C_{\text{env}} = (n - d)h, \text{ where } d = 1, 2, 3, \ldots, n \] .......................... (2.2)

If we add opportunity cost and environmental cost we find total cost at each distance. This can be written as:

\[
C = C_{\text{opp}} + C_{\text{env}}
\]

\[
= (d - 1)r + (n - d)h ........................................ (2.3)
\]

Total cost \( C \) at initial distance \( d1 \) is very high as revealed by table 1 due to excessive environmental cost. However, \( C \) starts declining at successive distances till a point after that \( C \) again moves upward due to increasing opportunity cost. This gives a U shaped cost curve.

Thus in quadratic form we express our cost function as:

\[
C = (d - 1)^2r + (n - d)^2h + (d - 1)r + (n - d)h ........................................ (2.4)
\]

To find out optimum distance of location we differentiate \( C \) with \( d \) and setting it equal to zero we find:

\[
\frac{dC}{dd} = 2(d - 1)r - 2(n - d)h + r - h = 0
\]

\[ \Rightarrow d = \frac{(r + 2nh + h)}{2(r + h)} ........................................ (2.5) \]

25
However, an individual will prefer to locate within the distance of 1 K.M. from industry if we suppose environmental cost is zero. This is because he can maximise his income benefit.

Now let us introduce rent as a function of economic development or economic benefit of industrial set up or positive income impact of industry and environmental cost.

\[
Rent(R) = f(\text{economic development(ED)}, \text{environmental cost(E)})
\]

\[......................... (2.6)\]

Such that, \( \frac{dR}{dED} > 0 \) and \( \frac{dR}{dE} < 0 \)

Implication of this is that rent is positively related with economic development of industrial set up. The second case indicates a negative relationship between rent and environmental pollution. Environmental pollution is one sort of negative attribute. Hence it affect house price negatively.

Alternatively we can also say that rent is function of cost i.e. opportunity cost of losing income and environmental cost such as:

\[R = f(Cost(C)) = f(C_{opp}, C_{env}) \] .......................... (2.7)

Let us write Rent function as...

\[R = a - \beta C \] .......................... (2.8)

\[R = a - \beta[ (d - 1)r + (n - d)h] \] .......................... (from equation 2.3), .......................... (2.9)

Now differentiate equation (2.9) with respect to d and get,

\[\frac{dR}{dd} = - \beta r + \beta h \] .......................... (2.10)
From equation (10) we can not say \( \frac{dR}{dd} > 0 \); if \( h > r \) then \( \frac{dR}{dd} > 0 \) and vice versa.

If however cost function is in quadratic form,

From equation (2.8) and (2.4) we write rent function as,

\[
R = a - \beta[(d - 1)^r + (n - d)^h + (d - 1)r + (n - d)h] \quad \text{..........}(2.11)
\]

Now, differentiating equation (2.11) with respect \( d' \), we find,

\[
\frac{dR}{dd} = -2\beta(d-1)r + 2\beta(n-d)h - \beta r + \beta h \quad \text{...............}(2.12)
\]

Again looking at equation (12) we cannot clearly say that \( \frac{dR}{dd} \) is greater than zero or less than zero. The sign of \( \frac{dR}{dd} \) depends on relative strength of \( r' \) and \( h' \). In our forthcoming session we have empirically verified the impact of CPM on house rent.

2.5.2: Rent as Property Value:

From the above discussion we find that in absence of environmental pollution, an individual will always prefer to stay closer industrial site to cope benefit from built market. Therefore, demand in the industrial site rise up. Due to this increasing demand price of house (rent) also pushes up. However, if the industry emits toxic pollutants environmental cost in staying that region goes up and reasonably individual who gives value to health will disperse his location from industrial site. Though he moves away from industrial site to minimise environmental cost but at the same time he will try to capture the benefit from
market. Therefore, he will choose such location where environmental cost and opportunity cost is minimum.

Many empirical works (Saphore and Benílez, 2005; Hanna, 2007; Beron et al, 2001) found that pollution affects house price (rent) negatively. They confirmed that house price is a blend of number of attributes. Environmental quality is one among these attributes.

2.6: A Brief Explanation of Production of Paper and Sources of Pollution:

Pulp and paper are manufactured from raw materials containing cellulose fibers, generally wood recycled paper and agricultural residues. In developing countries about 60% of cellulose fibers originate from non-wood raw-materials such as bagasse (sugarcane and fibers), cereal straws, bamboo, reeds, esparto grass, jute, flax and sisal. (World Bank Group, 1998)

Production of paper involves the following two major processes:-

1. The wood/ bamboo and allied materials are digested with chemicals to convert them into pulp.

2. The pulp is washed, refined and passed over a fine screen to form paper.

Production of paper requires a range of various materials. The following table shows materials requisition per ton of paper.
## Table II.2

**Consumption of Raw-materials (per ton of paper)**

<table>
<thead>
<tr>
<th>Per ton of paper</th>
<th>Unit</th>
<th>Require / ton of paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellulosic Raw materials</td>
<td>Tons</td>
<td>2.5 – 3.0</td>
</tr>
<tr>
<td>Cooking Chemicals</td>
<td>Tons</td>
<td>0.34 -0.38</td>
</tr>
<tr>
<td>Chlorine for bleaching</td>
<td>Tons</td>
<td>0.160-0.138</td>
</tr>
<tr>
<td>Caustic soda for bleaching</td>
<td>Tons</td>
<td>0.02-0.035</td>
</tr>
<tr>
<td>Lime for bleaching</td>
<td>Tons</td>
<td>0.07-0.14</td>
</tr>
<tr>
<td>Salt cake</td>
<td>Tons</td>
<td>0.06-0.078</td>
</tr>
<tr>
<td>Lime for Chemical Recovery</td>
<td>Tons</td>
<td>0.360- 0.40</td>
</tr>
<tr>
<td>Alum (paper makers alum)</td>
<td>Tons</td>
<td>0.05 – 0.10</td>
</tr>
<tr>
<td>Rosin (in stock preparation unit)</td>
<td>Tons</td>
<td>0.006 – 0.009</td>
</tr>
<tr>
<td>Talcum</td>
<td>Tons</td>
<td>0.17 – 0.20</td>
</tr>
<tr>
<td>Steam</td>
<td></td>
<td>8 – 9</td>
</tr>
<tr>
<td>Power</td>
<td>Kwh</td>
<td>1200 – 2000</td>
</tr>
<tr>
<td>Water</td>
<td>Cum</td>
<td>200 -220</td>
</tr>
</tbody>
</table>

Source: Pollution Abatement in Large Pulp and Paper Industry (Choudhury, 1993)

### 2.6.1 Steps of Paper Production:

**a)** Raw-materials preparation involves chipping of bamboo / hardwood or other fibrous materials to suitable size using dry and wet process. Chips are washed in chip washers before feeding them into digester.

**b)** Second step is pulp manufacturing and fiber recycling. Wood consists of two primary components: cellulose and lignin. Cellulose, which is the fibrous component of wood is used to make pulp and paper.
Pulping is the process which reduces wood to a fibrous by separating the cellulose from lignin.

Pulping process is generally classified as chemical, mechanical or semi-mechanical. The three chemical pulping methods are known as kraft, sulfite and soda, (EPA, 1997). In India, kraft pulping are extensively used at all mills (Choudhury, 1993) and Cachar Paper Mill is also not exceptional. Figure 2.4 is a simplified process diagram for a kraft mill.

Figure 2.4: Process of Paper Production (Soskolne and Sieswerda, 2010)
Kraft pulping is carried out in an alkaline medium and release fibres from wood chips by dissolving the lignin in a caustic solution of sodium hydroxide and sodium sulphide. Spent digester fluid is concentrated in evaporators and fed into the recovery furnace, which recycles solid sodium sulphide and combusts the organic component as a source of energy. A lime klin recovers calcium oxide for regeneration of the caustic component of the digester fluid (Soskolne and Sieswerda, 2010). The process generates several air and water pollution.

c) After the wood is pulped, pulp is washed to remove the dissolved lignin and chemicals. In the washing process, the pulp is passed through a series of washers and screens. The washing process occurs at high temperature which generates a large volume of exhaust gases containing hazardous air pollutants which are released to the atmosphere.

d) After washing, if a white product is desired the pulp must be bleached to remove colour associated with remaining residual lignin.

e) Bleached pulp is then sent to stock preparation plant for refining and addition of chemicals, fillers, dyes in required quantities. The sheet of paper formed on the wire mesh is picked up by driers and the finished paper with 2 – 6% moisture is taken on roller and is sent to rewinding and cutter section where it is cut to desired size and then dispatch to market.
The entire process of paper production starting from raw-materials preparation unit generates various kinds of water and air pollutants. Choudhury (1993) has mentioned following sources of effluents:

1. Raw materials preparation arises by washing, cleaning and cheaping.
2. Spent liquor or black liquor from blow pit,
3. Effluent from brown stock washers
4. Effluents from chlorination
5. Effluent from caustic extraction
6. Effluents from caustic chlorine effluents plant
7. Chemical recovery effluents
8. Spills and leakages, floor washes etc.

2.6.2 Paper Industry and Kinds of Pollutants:

Paper spreads all walks of human activity and thus pulp and paper industry has been responsible for important social and economic impacts of a country. India ranks nineteenth among all paper producing countries in the world. Pulp and paper industry is one of the largest polluters of the water and accordingly releases back a large quantity of pollutants. The waste water from the industry consists of substances, mainly of organic in nature, which on decomposition and/or putrefaction consumes oxygen depleting the dissolved oxygen content of the water body. Besides it is a source of suspended solids and colour and it affects other physic-chemical characteristics of the water resources receiving the waste water.
While producing paper, paper industry emerges some effluents which if not controlled responds in generating pollution. There are two major kinds of pollution which can be concerned with paper industries. These are air and water pollution.

**Air pollutants:** the common air pollutants generated from paper mill are carbon monoxide (CO2), sulphur dioxide (SO2), oxide of nitrogen (NOx), hydrogen sulphide (H2S), suspended particulate matters (SPM) etc. Pollutants have permissible limits. These air pollutants are human carcinogenic depending on the level of exposure. Let us introduce with probable impact of these gases on human health:

SO2: sulphur dioxide cause breathing problems and promotes cancer. It also harms plants, animals and the ecosystem in which they live.

NOx: Oxides of nitrogen can cause lung damage, burning of throat and sore throat with other symptoms.

SPM: Suspended particulate matter like dust, unburnt fuel carbon etc. may be the cause of symptoms like cough, cold, respiratory diseases and eye disorder.

H2S: Hidrogener sulphide is a harmful and toxic compound. It is a flammable colourless gas and odourous like rotten egg. Depending on its concentration in the air it can be fatal for human. H2S can cause irritation of eyes, nose and throat; asthma and bronchitis, headache, dizziness, nausea, vomiting, coughing, difficulty breathing, olfactory paralysis, respiratory tract irritation etc.
**Water pollutants**: water pollutants can be considered in terms of pH, BOD, COD and SS. Over concentration of these can affect water characteristics and may directly or indirectly harm human health. These pollutants are defined as below:

**pH**: pH is defined as the negative logarithms Hydrogen ion concentration. pH is measured by pH scale ranges from 0-14. pH value less than 7 is acidic and pH value above 7 is alkaline. pH of pure water is 7. Permissible limit of pH is from 6.5 to 8.5.

**Dissolved Oxygen**: Dissolved Oxygen is important for survival of aquatic plants and animals. In natural and waste water DO level depend on the physical, chemical and biological activities of the water body. DO limit as prescribed by pollution control board (CPCB) is 4mg/l.

**Chemical oxygen demand**: this is a satisfactory method for determining the organic load of a water body, which is preferable to the biochemical oxygen demand (BOD) mentioned below. It is rapidly measurable parameter for stream and industrial wastes studies and control of water treatment plants. The method is based on chemical oxidation of material in the presence of catalyst by Cr207 in 50% H2SO4. Discharged effluent permissible COD value is 350 mg/l.

**Biochemical Oxygen Demand**: this is an empirical, semi-quantitative method, based on oxidation of organic matter by suitable microorganisms during a 5 day period. There is nothing sacrosanct about 5 days but the test originates in England where the maximum steam flow is 5 days. The degree of microbial mediated oxygen consumption in water is known as Biochemical Oxygen Demand. This
parameter is commonly measured by the quantity of oxygen utilised by suitable aquatic microorganisms during 5 day period.

2.7 Standard Guideline of Limits of Air and Water Pollutants:

Government of India enacted the Air (Prevention and Control of Pollution) Act 1981 to arrest the deterioration in the air quality. Under the provisions of various acts, pollution of the environment is proposed to be prevented and controlled at the source itself. As per the Act, there are State Boards for each state of India, besides the Central Board being in apex body is responsible for formulation of policies, looking after union territories and overall co-ordination and supervision of all pollution regulating agencies. State Boards look after the interest of their states and Central Board has no control over them except in the advisory capacity (Jivendra 1995). Now, we would go through the main functions of the Central and State Pollution Control Board as mentioned in Jivendra (1995). The main functions of Central Pollution Control Board are as follows:

- To advise the Central Government on any matter concerning the improvement of the quality of the air and the prevention, control and abatement of air pollution.
- To plan and cause to be executed a nation-wide programme for the prevention, control and abatement of air pollution.
- To provide technical assistance and guidance to the State Pollution Control Board.
• To carry out and sponsor investigations and research related to prevention, control and abatement of air pollution.
• To collect, compile and publish technical and statistical data related to air pollution; and
• To lay down and annul standards for the quality of air.

The main functions of the State Pollution Control Boards are as follows:

• To plan a comprehensive programme for prevention, control and abatement of air pollution and to secure the execution thereof;
• To advise the State Government on any matter concerning prevention, control and abatement of air pollution.
• To collect and disseminate information related to air pollution.
• To collaborate with Central Pollution Control Board in programme related to prevention, control and abatement of air pollution; and
• To inspect air pollution control areas, assess quality of air and to take steps for prevention, control and abatement of air pollution in such areas.

2.7.1 Water Pollution Guideline:

In order to achieve the objectives, the Central Board does monitor the progress in respect of upgradation of the environment. Minimum National Standard for industrial waste water discharge guided by Central Pollution Control Board is given in the following table:
Table II.3

Minimum National Standard for Waste Water Discharge

(Indian Pulp and Paper Industry)

<table>
<thead>
<tr>
<th>Water Characteristics</th>
<th>Unit</th>
<th>Large paper Mill</th>
<th>Small Paper Mill</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td>7-8</td>
<td>6-9</td>
</tr>
<tr>
<td>SS</td>
<td>Mg/l</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>BOD5</td>
<td>Mg/l</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>COD</td>
<td>Mg/l</td>
<td>350</td>
<td>*</td>
</tr>
</tbody>
</table>

Source: Jivendra (1995)

* For small paper mill no COD limit is set as there is no technology for small paper mill to control COD.

The central Board evolves minimum national standard for a specific category of industries after looking into practical difficulties, limitations and economic impact on the industry. It is based on the concept of best practicable technology currently available and general environmental acceptability. Its acceptability is very much linked to techno-economic acceptability of suggested stage of treatment (Jivendra, 1995). However, I.S. 2490 has provided a guideline which is little bit different from guideline provided by Central Board. Tolerance limits for industrial effluence according to IS 2490 is given in the table II.4.
Table II. 4


<table>
<thead>
<tr>
<th>Water Characteristics</th>
<th>Unit</th>
<th>Into inland Surface Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>-----</td>
<td>7-8</td>
</tr>
<tr>
<td>SS</td>
<td>Mg/l</td>
<td>100</td>
</tr>
<tr>
<td>BOD5</td>
<td>Mg/l</td>
<td>30</td>
</tr>
<tr>
<td>COD</td>
<td>Mg/l</td>
<td>250</td>
</tr>
</tbody>
</table>

Source: Jivendra (1995)

Comparing table II.3 and II.4 we find that in respect to COD limit, there is large difference between standards put forwarded by pollution board and IS 2490.

2.7.2 Air Pollution Guideline:

Similar to water pollution there is also minimum national air pollution standard level put forwarded by Central Pollution Control Board. The Central Pollution Control Board in exercise of its powers conferred under section 16 (2) (h) of the Air (Prevention and Control of Pollution) Act, 1981 (14 of 1981) hereby notify the National Ambient Air Quality Standards with immediate effect.
<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Time Weighted average</th>
<th>Concentration in ambient air</th>
<th>Method of measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Industrial Area</td>
<td>Residential, Rural &amp; other areas,</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sulphur Dioxide (SO2)</td>
<td>Annual Average*</td>
<td>80 µg/m³</td>
<td>60 µg/m³</td>
</tr>
<tr>
<td></td>
<td>24 hours **</td>
<td>120 µg/m³</td>
<td>80 µg/m³</td>
</tr>
<tr>
<td>Oxides of Nitrogen as NO2</td>
<td>Annual Average*</td>
<td>80 µg/m³</td>
<td>60 µg/m³</td>
</tr>
<tr>
<td></td>
<td>24 hours **</td>
<td>120 µg/m³</td>
<td>80 µg/m³</td>
</tr>
<tr>
<td>Suspended Particulate Matter (SPM)</td>
<td>Annual Average*</td>
<td>360 µg/m³</td>
<td>140 µg/m³</td>
</tr>
<tr>
<td></td>
<td>24 hours **</td>
<td>500 µg/m³</td>
<td>200 µg/m³</td>
</tr>
<tr>
<td>Respirable Particulate matter (size less than 10 um)(RPM)</td>
<td>Annual Average*</td>
<td>120 µg/m³</td>
<td>60 µg/m³</td>
</tr>
<tr>
<td></td>
<td>24 hours **</td>
<td>150 µg/m³</td>
<td>100 µg/m³</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>Annual Average*</td>
<td>1.0 µg/m³</td>
<td>0.75 µg/m³</td>
</tr>
<tr>
<td></td>
<td>24 hours **</td>
<td>1.5 µg/m³</td>
<td>1.00 µg/m³</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>8 hours</td>
<td>5.0 µg/m³</td>
<td>2.0 µg/m³</td>
</tr>
<tr>
<td></td>
<td>1 hour</td>
<td>10.0 µg/m³</td>
<td>4.0 µg/m³</td>
</tr>
</tbody>
</table>

Source: Central Pollution Control Board (1994)

- Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval
- 24 boudy/8 hourly values should be met 98% of the time in a year.
  However, 2% of the time, it may exceed but not on two consecutive days.
2.8: Epidemiological Studies of Communities Near Pulp and Paper mill:

Communities near pulp and paper mills are exposed to many hazardous chemicals. Over 250 chlorinated compounds have been identified in pulp mill effluent. These may become more toxic, more lipophilic and therefore bioaccumulative, less bio-degradable, mutagenic and carcinogenic (Soskolne and Sieswerda, 2010).

Polychlorinated dibenzodioxins (dioxins, PCDDs) and polychlorinated dibenzo-furans (furans, PCDFs) have received lots of attention for their persistency and potential for accumulating in biological tissues. One of the PCDDs, tetrachlorobenzopara-dioxin (TCDD) has been designated as a definite human carcinogen by the IARC. According IARC (International Agency for Research on Cancer) review very high levels of exposure to PCDFs may cause liver cancer. Both the respiratory tract and skin can be routes of exposure for dioxins and furans (Soskolne and Sieswerda, 2010).

There are many studies (Ferris et al, 1976; Jaakkola et al, 1990, Serdula and Semenciw, 1993; Blot and Fraament, 1977) conducted in different parts of the world which examined the health status of populations living near pulp and paper mills. They found incidence of cancer, and variety of annoyance symptoms such as headaches, nausea and eye and throat irritation.

EPA (1997) described toxic air and water pollutants and their impact on human health. These are mentioned below:
1. Volatile Organic Compounds (VOCs) play a significant role in the chemical reactions that form ozone. Ozone in the lower atmosphere can cause many health problems as it damages lung tissue, reduce lung function and adversely sensitises the lung to other irritants.

2. Total Reduced Sulphur is the pollutant that is associated with foul odours from pulp and paper mill.

3. Exposure to particulate matter has been linked with adverse effects including aggravation of existing respiratory and cardiovascular disease and increased risk of premature death.

4. Chloroform is another human carcinogenic. Short term exposure to chloroform can adversely affect the central nervous system and result in dizziness and headaches. Long term exposure by inhalation can adversely affect liver and cause hepatitis and jaundice.

5. Exposure to dioxin and furan can cause skin disorders, cancer and reproductive effects. These pollutants can also affect the immune system.

6. Adsorbable Organic Halides’ (AOX’s) exhibit toxicity which may bio-accumulate in fish tissue. This may present a risk to human health if large amounts of fish exposed to these substances are consumed.

2.9: Quality of Life and Industrial set up:

The impact of an industrial set up on QOL of locality is ambiguous and may vary industry wise. From externalities point of view also, there exists wide range of heterogeneity. But we cannot rule out impact of industry on locality. An industry has both positive and negative impact. These positive and negative
impacts may be direct as well as indirect. People who are employed in the industry enjoy direct benefit. Due to industrial set up, there is an influx of population from outside region thereby raising aggregate demand for goods and services in the local market. Moreover depending on any industry some ancillary industry grew up. These can be considered as indirect benefit of industry. All these help the beneficiaries to boost up their income earning opportunities. Apart from scope of employment, industry also develops some sorts of socio-economic overhead like roads, hospital, school, water supply etc. and these stimulates QOL of localities. On the other hand, industry is one of the sources of pollution. It emerges several toxicants in the air and water. People lives proximity to industry, who breathes in polluted air, drinks polluted water raises probability of falling ill. Apart from these there is odorous smell, noise etc. which affect QOL negatively.

Therefore, impact of industrial set up on quality of life depends on relative strength of positive and negative impact. So far as we can say industry may have positive impact on income and employment generation which improves quality of life. But if industrial production is associated with emission of toxic pollutants then we may say it impairs quality of life. Finally if there is stronger influence of positive impacts relative to negative impacts quality of life will improve and vice versa.

2.10 Concept of Profitability:

Neo-classical microeconomic studies postulate that one of the goals of firm is profit maximisation. This seems reasonable as profit is yardstick for future business expectation and expansion. However, profit and profitability is not the
same thing though they are very close in concept. Profit is absolute criteria while profitability is relative. The term profitability in abstract sense may be defined as the quality of being profitable i.e., yielding profit or advantage. Profit is usually expressed as the difference of total expenses involved in making or buying of a commodity and the total revenue accruing from its sales. This difference, when expressed, as a proportion of invested capital or current outlay or sales, shows the profitability of a business (Barthwal 2007). Hence we can write profitability in following form:

\[
\text{Profitability} = \frac{\text{Total Revenue} - \text{Total Cost}}{\text{Total Revenue}}
\]

Profitability may also be expressed as the proportion by which the price per unit sold would greater than the average or marginal cost. This is the rate in turnover which is called ‘price-cost margin’ (Barthwal 2007). This is expressed as below:

\[
\text{Profitability} = \frac{AR - AC}{AR}
\]

One may use the term profitability and profit efficiency synonymously. But these two terms are not same. While profitability is the ratio of profit to sales or revenue, profit efficiency means how much away a firm’s profit is from the maximum profit firm can accrue given input and output price. Profitability is an

---

4 Delis, Fillipaki and Staikouras (2008) explained two kinds of profit efficiency: standard and alternative. Standard profit efficiency measures how close a profit making institution or firm is to producing the maximum possible profit given a particular level of input and output prices. On the otherhand alternative profit efficiency may be helpful when some of the assumptions underlying cost and standard profit efficiency are not met. Within the framework of alternative profit efficiency, efficiency is measured basing on input price and level of output.
index of efficiency and is regarded as a measure of efficiency and management guide to greater efficiency. Though profitability is an important yardstick of efficiency, the extent of profitability cannot be taken as the final proof of efficiency (Trivedi 2010).

From the point of view of management, Trivedi (2010) conceptualised profitability in three ways:

1. Gross profit to Net Revenue Ratio.
2. Net Operating Profit to Net Revenue Ratio.
3. Return on Capital Employed Ratio.

Gross Profit Ratio: Gross profit ratio is important for management because it highlights the efficiency of operation and also indicates the average spread between the operating cost and revenue. Any difference position in this ratio is the result of a change in the operating cost or revenue or both. It is expressed as follows:

\[
\text{Gross Profit Ratio} = \frac{\text{Gross Profit}}{\text{Net Revenue}} \times 100 \quad \text{(2.15)}
\]

Gross Profit = Total Revenue – operating expenses.

Net Operating Profit Ratio: The Net Operating Profit Ratio expresses the relationship between net operating profit and net sales. This is given as below:

\[
\text{Net Operating Profit Ratio} = \frac{\text{Net Operating Profit}}{\text{Net Sale/Revenue}} \times 100
\]

\[
\text{.................................. (2.16)}
\]
Return on Net Capital Employed Ratio: It measures satisfactorily the overall performance of a business in terms of profitability. This Ratio expresses the relationship between profit earned and capital employed to earn it. The ratio is given as below:

\[
\text{Return on Net Capital Employed Ratio} = \frac{EBIT}{Net\ Capitai\ Employed} \times 100,
\]

\[\text{......... (2.17)}\]

Where, EBIT = Profit before interest and tax.

2.10.1 Profitability and Production:

In this subsection we are interested to study the possible relationship between profitability and production. We have already defined profitability in our previous section where operating profit ratio has been considered to indicate profitability.

From micro-economic theory we know that total revenue and total cost is the function of output such as:

\[R = f(\text{output}) \quad \text{........................ (2.18)}\]

\[C = g(\text{output}) \quad \text{........................ (2.19)}\]

Where, \( R \) and \( C \) denotes total revenue and total cost.

Now, profit is the excess of revenue over cost. Thus we can write profit as:

\[\text{Profit} (\Pi) = R - C\]

\[= f(\text{Output}) - g(\text{Output})\]

\[= P(\text{output}) \quad \text{................. (2.20)}\]
Therefore, we have found profit as function of output. Again if we divide profit by “revenue (R)” we will get profitability as a function of output.

Now, what is the probable direction of relationship between profitability and output? Whether profitability is increasing function of output?. Profitability of a firm will increase when rate of increase in the sale revenue of a firm is more than rate of increase in cost of production. This can be better explained with the help of a diagram which assumes monopolistic competition in the market:

![Figure 2.5: profit maximization output of a firm](image)

In the diagram OQ is the optimum output of the firm since at this level of output all the condition of equilibrium is fulfilled by the firm. At equilibrium level of output profitability of the firm is also maximum. Thus,

$$\text{Profitability} = \frac{PP \times C \times C}{OP \times P \times Q^*}$$
We can split the relationship between profitability and production into two heads:

(a) Output less than optimum Point:

When a firm’s output is increasing towards $Q^*$, profitability is supposed to increase with the increase in output. Because output less than optimum though gives higher price of the output but it is offset by prevailing higher average cost. The shape of average cost curve (AC) depicts that as the level of output increases AC falls and it again rises after reaching the minimum point. Suppose the firm is producing at $OQ^{**}$ level of output. At this level of output price is $OP^{**}$ which gives profit equivalent to $P^{**}P^{***}C^{**}C^{***}$. Apparently, this is less than profit at equilibrium level of output.

(b) Output more than optimum level:

When the firm’s output crosses $Q^*$ which is the optimum level of output, profitability declines with the level of output. This is because output more than optimum level is accompanied by – (i) fall in the price of the product, and (ii) rise in the average cost.$^5$

2.11 Socio economic Benefit:

From the earlier analysis it is reflected that industry is associated with both benefit and cost. When industry generates income and employment in the economy it creates some socio-economic benefit. Unemployment is one of the crucial socio-economic problems of an economy. Industry helps in generating

---

$^5$ Average cost falls right of the equilibrium point, reaches minimum point and then rises upward again. A firm can not enjoy the benefit of producing at lowest cost because profit beyond equilibrium level of output falls due to a sharp decline in the average revenue.
income and employment in two ways: firstly, many people get direct employment in the industry. Secondly, many ancillary business or small industries build up basing on that industry. Apart from this, business activities are stimulated due to growing demand in the market. On account of all these positive aspect of industry, a backward or previously underdeveloped region converts into urban or relatively developed region. However, these sorts of positive benefits depend on performance and type of industry. If the industry is more employment elastic its benefit is more. Industry which is more labour intensive is also more employment elastic. According to Hirschman strategy of economic development, an industry is more beneficial whose forward and backward linkages are more.

From the discussion in previous sections we have already been acquainted with negative impact of industry. Industry (e.g. pulp and paper) emits a number of pollutants in the air and water. Inhalation or intake of those toxic pollutants may cause many significant health symptoms. The disease associated with paper industry has already been discussed. These sorts of health impact of industrial pollution causes two types of costs: (a) Treatment cost, and (b) Productivity loss.

(a) Treatment Cost: due to environmental pollution people often suffers from diseases. To get cure from these diseases or to take preventive measures they have to spend money for treatment. These costs can be divided into two types: (a) Cost of Doctor Visit; and (b) Medicine and other costs (such as blood test, X-ray etc.).

(b) Productivity Loss: due to disease burden sometimes people loss their productivity partially or fully. According to micro· economic theory

---

6 See Hirschman, A: Strategy of Economic Development
workers are paid according to their marginal productivity. Therefore, disease burden causes loss of earnings. Total loss in income will be the total work days lost multiplied by income per day.

Apart from health cost industry also affects property value. Here we consider two types of property value. First, industrial impact on house rent; i.e., house rent is used as a representative of property value. Secondly, impact of industrial emission on metal comes within its contact. Here, we have chosen one common metal that is tin which is widely used as a material of house.

We have already been concerned about two fold impact of industry: positive impact and negative impact. Thus, the direction of impact of industrial set up on price of property depends on development or spread effect of industry and environmental impact of industry. If the concerned industry is pollution sensitive, then it is supposed to affect house and land prices negatively, which forms an additional cost to the localities. However, as discussed in section 2.5.1 if the industry does not emit hazardous pollutants then its health impact is close to zero and on the other hand its spread effect or income generating impact is more, then property price may go up instead of falling down.

Now, pulp and paper industry emits numerous numbers of corrosive gases like hydrogen sulphide, chlorine compounds etc. Houses made of tin when comes with the contact of these gases gets corroded. Thus expected life time of tin comes down. This can be considered as an additional cost to house owners.
Now we will summarize total cost and benefit accrued from industrial setup in a region. This is presented as following:

\[
\begin{align*}
\text{Industry} & \quad \downarrow \\
\text{Benefit} & \quad \downarrow \\
\text{Income} & \quad \& \\
\text{Employment} & \\
\text{Cost} & \\
\text{Doctor Cost} & \quad \downarrow \\
\text{Medicine & other Cost} & \\
\text{Wage or Income Loss} & \\
\text{Loss of Property Value} & \\
\end{align*}
\]

\textbf{Figure 2.6: Classification of Cost-benefit of an Industrial setup}

In the above classification of benefit and cost accrued from industrial setup we have put some limitations. There are many other possible benefits and costs of an industry. From the point of view of benefit, due to industrial setup local infrastructure such as road and communication, power supply, health infrastructure, education etc. supposed to be developed. On the other side industry may be the cause of many other socio-economic costs. These may be in the form of burden of over-population, increasing mortality, dissatisfaction arises from industrial noise or odour etc. For the present study we confine socio-economic benefits to income and employment only and socio-economic cost to health cost, productivity loss (wage or income loss) and loss of property value.

In the blend of socio-economic benefit and cost, it is imperative to define ‘Net Socio-economic Benefit’. We define NSEB (Net Socio-economic Benefit)
as the discrepancy between socio-economic benefit and socio-economic cost.

Thus, NSEB can be written as follows:

\[ \text{NSEB} = \text{Total Socio-economic Benefit} - \text{Total Socio-economic Cost}. \]

The complete methodology and assumptions in computing NSEB has been presented in chapter five on Methodological Framework.

2.12 Summary:

Thus the present chapter gives a theoretical and conceptual framework of the present study. The chapter deals with different conceptual issues. In section 2.2 we have discussed the concept of externalities. In section 2.3 we have related EKC with industrial production. We find in the initial stage of production, environmental pollution due to firm’s emission increases with the increase in production and at a subsequent higher level of production as the firm reaches in a position to apply environmental friendly technology environmental pollution starts declining. In section 2.4 we have dealt with overall industrial air and water pollution. Section 2.5 develops the relationship between an industrial set up and property value. We have found that an industrial set up has probable dual impact on property value. In section 2.6 we have briefly explained production of paper and sources of pollution. We find several types of pollutants emerge in different steps of paper production. In section 2.7 we have gone through the standard guidelines of water and air pollution. We have dealt with epidemiological studies of communities living near pulp and paper mill in section 2.8. We have found that pollutants that come out of pulp and paper industry can impair human health depending on concentration of pollutants exposed to the recipients. In section 2.9
we have discussed the concept of relationship between QOL and an industrial set up. Here we find industry can affect QOL in two opposite ways. Firstly, there is a probability that QOL of localities may boost up due to positive impact that an industry spreads. Secondly, industry can affect QOL negatively if it generates pollutants which can impair human health. In section 2.10 we have dealt with the concept of profitability and its measurement issues. Finally, in section 2.11 we have built up a conceptual framework of measuring socio-economic benefit of an industrial set up.

References:


EPA (1997) : The pulp and paper industry, the pulping process and pollutant releases to the environment, EPA-821-F-97-011.


