There are various studies on the social and economic aspects of pollution. They had discussed at length as to how pollution damaged and jeopardised the health of human beings, animals, and crops in particular and the environment in general. Projecting the far-reaching socio-economic implications of pollution, practically all these studies have contributed richly to the definition and discussion of various conceptual issues. A review of these studies could not only throw newer light on the various concepts and theories involved, but also provide a proper perspective to the present study.

2.1 Concepts

"Pollution", according to the National Academy of Sciences, "is an undesirable change in the physical, chemical or biological characteristics of air, land and water that may or will harmfully affect the living conditions and cultural assets or that may or
will deteriorate raw material resources."¹

The World Health Organisation (WHO) has defined pollution as "the substance which got into environment by the activity of man in concentration, sufficient to cause harmful effects to his health, vegetation, property or to interfere with employment of his property."²

The State of New Jersey defined 'Air pollution' as the presence in the outdoor atmosphere of one or more air contaminants in such quantities and duration as are, or tend to be injurious to human health, or welfare of animal or plant life, or would unreasonably interfere with the enjoyment of life and property.³

Pollution meant the introduction by man, directly or indirectly, of any hazardous waste into the environment as a result of which there arise many hazards to human health, plant or animal life, harm to living resources or to ecosystems, damage to amenities or interference with other legitimate uses of environment.⁴

Literally "pollution" meant to make or render the environment unclean. Pollution was an undesirable change, in environment, private or public, in physical, chemical or biological characteristics of our land, air, water that may or will harmfully affect human life or that of desirable species. Further pollution might also be defined as a return to the environment of materials in harmful state.\(^5\)

Pollution Studies

Industrialisation was considered the barometer of civilisation. However, environmental pollution and human efforts for betterment of living standards were two sides of the same coin. The side effects were commonly grouped into a few broad categories:

i) Resource deterioration, e.g., soil or forest resources.

ii) Biological pollution, represented by agents of human disease and by animal and plant pests; chemical pollution arising out of air pollution, industrial effluents, pesticides, metal and detergent components and similar agents.

iii) Physical disruption, e.g., thermal pollution, silting and noise.

iv) Social disruption such as congestion and loss of a sense of community.\(^6\)

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Classification of Pollutants

On the one hand, the traditional picture of the pollution of air, water and soil had become much more complicated, synthetic substances which were not found in nature had appeared and the chemical composition of the effluents and discharges into the atmosphere was extremely diverse. The situation was also aggravated by the fact that many of them entertained chemical reactions among themselves and formed new compounds which were extremely dangerous to every living thing.

On the other hand, new pollutant-noise, thermal, radioactive, electromagnetic, gravitational and even psychological, had been added to the traditional ones. It was yet unclear, how these factors influenced nature and man, but the results of the study of some of them testified to their dangerous character.\(^7\)

Air Pollution

Total suspended particulates might be of the size of 100 microns or less. Fine particulates of the size of less than 15 microns can bypass the human body's respiratory filters and penetrate into the lungs. In addition, it interfered into the general efficiency of photosynthesis, so that plants could not produce nutrients for very survival. It was estimated that as many as 3000 chemicals had been added to the atmosphere. Not all of these were hazardous.

\(^7\)The Hindu, 6 April 1986.
A special committee set up in USA identified only 21 chemicals as toxic.

Air pollution usually consisted of suspended or settable solid or liquid, particles and gaseous chemical compounds and occasionally, biologically viable particulates such as bacteria. The term 'stationary source' would mean any building, structure, facility or installation which emitted or might emit any air-polluting contaminant.

Nature of Air Pollutants

The polluted air masses were classified as follows:

(a) **Dust:** It is a mixture of air of irregular shaped mineral particles in the size range from one to hundred microns (1 micron = $10^{-6}$ m) formed by crusting, chipping, grinding or line operations or by natural disintegration of rocks and soil particles of organic matter were also classified as dusts.

(b) **Smoke:** It is a mixture of air of very fine particles formed by combustion or other chemical processes in the size range from 0.01 to 1 micron. The particles might be spherical if formed by condensation.

(c) **Fume:** It is a mixture in air of small particles in the size range from 0.1 to 1 micron. The particles were formed in industrial processes of various sizes. Fume was similar
to smoke.8

The Impact of Air Pollutants

The impact might be broadly classified in terms of nuisance, economic or health effects. Nuisance effects included the reduction of visibility by fugitive dust arising from resuspension or redispersion of particulates from storage pills of ash, coal or other granular powdery materials and demolition wastes. Economic effects ranged from soiling of buildings, materials and furnishing to deterioration of property such as textiles, rubber, building stones, books, etc. Air pollution also represented a direct economic loss through crop damage. Health effects involved the toxicity of air pollutants for animal and human populations. Basically, there were two approaches to health impacts namely, the pharmacealogical paradigm and toxicological paradigm based on proposed projects vs actual real life.

Types of Air Pollution Control Equipments

Depending on the particle size, the control mechanism involves three separately related forces namely impaction, interception and diffusion. The various air pollution control equipments are the following:

Electrostatic precipitator (ESP). The industrial ESP was

invented in 1907 by Frederic Cottrell and was later developed by Schemilt, Robinson, White and others. This was based on passing a dust stream through a highly closed electrostatic field, which charged the dust or smoke and caused agglomeration and precipitation of agglomerative policies.

The Chinese engineer Sheng Tiwens has developed a special 120 metre chimney with a diversional device at the inner rim of the top. This chimney served as an efficient dust remover with longer life span.  

Dry collectors. The following types of equipment could be found within the above category, namely, cyclones, filters, bag houses, and moving filters. Because of modest dimensions, better maintenance possibilities, greater reliability and lower capital cost, fabric filters were widely used in cement production.

Wet Collectors. Wet collectors were designed to develop an interface between the scrubbing impact and gas being cleaned.

Water Pollution

Water was never pure in the chemical sense. But a serious aspect of it was when impurity was caused by sewage, industrial and trade

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waste, and physical pollutants. Industries contaminated the atmosphere and affected the living thing by emitting hazardous items such as arsenic, lead, acids, nitrogen and so on.

**Chemical Pollution**

Chemical pollution was the presence in plants and animal tissues including feed and food stuffs of adulterant chemicals which had no beneficial effects.

**Noise Pollution**

Noise pollution would be the presence in the open atmosphere or in the confined space of a noise generally considered undesirable except possibly by the source responsible for it. In the latter case, noise pollution did not exist in the space immediately surrounding the source.

**Thermal Pollution**

Thermal pollution referred to the discharge into the environment of a stream of air or water which was at different temperature from that of the environment at the point of discharge or downstream of this point.

**Waste Pollution**

Waste pollution meant the presence on land, or maker of solid material, organic and inorganic which had no beneficial qualities.
Radiation Pollution
Radiation pollution referred to the pollutants which were the necessary by-products of operation of nuclear reactor for production of electric energy, propulsion of shifts and so on. As soon as mankind needed the benefits of energy produced by nuclear fission, it had to face radio-active pollutants.

Criteria of Selecting a Pollution Control Device
The key parameters determining the selection of pollution control equipments were particle size, flow of gas, chemical and physical properties of particles, required efficiency of collection and cost of total system.

Bubble policy. Bubble policy allowed plants to find the most cost-effective way to reduce pollution, considering the plant's overall impact on the environment, rather than dictating pollution levels for each discharge point.

Product charge. Product charge was a fee imposed on a special product, judged to have undesirable environmental effect. It was a method of ensuring that the expected environmental harm associated with the use of certain products became part of those products' costs to their manufacturers or consumers.
**Marketable permits.** Marketable permits provided a method to allocate allowable discharges among polluted sources located in specified areas.

**Pollution Compensation Plans**

Pollution compensation plans defined the liability and provided compensation for environmental damage. They were financed by manufacturers and users of designated products. But the immeasurability problem was there. Tax incentives and creation of environmental auditors, who should issue periodic certificates were also some recent developments.

**Effluent fees and payment.** For every unit of pollution emitted, the emitter would be required to pay a fee or tax. This might encourage investment in abatement and reduce the level of pollution. Through effluent payments, government might pay emitters, for every unit of pollution that the industry might not emit. This in practice might be done through subsidies.

**The Concept of Environment**

The term 'environment' might be defined as the total mix of biological and physical systems existing in a given area. A precise definition for environment would then call for the enumeration of the elements contained in the two systems in any given area.
The term "environment" is an inter-disciplinary concept and included wide variety of issues concerning human settlements, natural resources, plants, animal life and pollution of all sorts. Linkages between resources, environmental pollution and development were present in various processes in the intricate social, economic, technological and ecological systems that constituted our modern societies.  

Economics and Ecology
Economics might be considered as a branch of human ecology, since it studied the interactions of energy and materials among individuals in the socio-economic system. Ecology might be considered as the economics of environment, since it was concerned with the interaction and exchange of energy and materials among individuals in ecological systems.

Uncontrolled consumption patterns depleted precious non-renewable natural resources, upon which future development depended. Rapid population and economic growth also stimulated the demand for scarce resources. Economic activities produced waste which was discarded to the environment, as if it were the receptacle. This was the economic aspect of it.

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Environmental problems became a public policy issue in England in 1860s. In the previous generation, the British had attempted to adopt the institution of a free market. But after some time, the British Government began to reimpose restraints. However, Polanyi has argued that the first inferences were generally to solve the environmental problems created by the market.\textsuperscript{11} To him, English society was reacting against market institutions which were threatening to disrupt its very environment and social fabric.

Emergency of new pattern of economic growth which was less destructive environmentally, was pointed out by Willy Brandt Commission's report, "World Growth Performance for Survival."\textsuperscript{12}

\textbf{Growth vs Environment}

Many environmentalists, regarding noise and smoke pollution and the destruction of wild life and natural beauty that followed in the wake of expanding industry and communications, considered that the continued pursuit of growth by Western society was more likely on balance to reduce rather than increase the social welfare.\textsuperscript{13}

Economic growth in terms of Gross National Product was crossing

\begin{itemize}
  \item \textsuperscript{11}Karl Polanyi, \textit{The Great Transformation} (Boston: Beacon Press, 1957).
  \item \textsuperscript{12}North-South: A Programme for Survival (London: Pan Books, 1980).
  \item \textsuperscript{13}E. J. Mishan, \textit{The Cost of Economic Growth} (London: Staples, 1967).
\end{itemize}
Indeed a rise in GNP would enable a nation more easily to bear the costs of eliminating pollution. 

Economic Growth and Pollution

The relation between economic growth and pollution has been discussed by many economists.

2.2 Theories of Pollution

Many theories have been propounded regarding externality and other problems created by different types of pollution. They discussed how externalities could be internalised optimally. Of course, the main objectives and hypotheses of the present study were also framed only in the background of such theories.

Smith and his followers were deeply concerned with the living standards of people and their environment. Marx was aware of only the resource-use rather than environmental pollution. The Neo-Classical Economists led by Marshall along with Pigou, Wicksell and Walras evolved the theory of external economies and diseconomies

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which was highly relevant to studying modern environmental problems.

The short supply of fuels and resources during 1960s and 70s led to the projection of environmental economics as a separate discipline. Technological advance demanded "materials balance" as an optimizing factor between resource-use and environmental effects.

Theory of Pervasive External Cost

Mishan and Kapp proposed that, with so many materials circulating in the atmosphere, in rivers, lakes and oceans, in underground water-tables, in the soil and in the bodies of wildlife, all of them could be turned over as private property to people for use in market transactions. It could be argued that if all resources could be made into private property at least some tractable names could be made. However, there is no basis for assuming that by making more resources into property would yield better results than leaving only fewer resources as property. This was an application of a complicated argument proposed in advanced economic theory called "the theory of the second best." According to this theory, if markets for several factors in an economy were imperfect, then making one more market perfect would not necessarily move the economy toward a better position, even if making all markets perfect would yield the best outcome. Mishan and Kapp argued that this invalidated the entire idea of achieving efficiency through the market.

Polanyi agreed with this view, but he went further by including the benefits of stable social communities, along with the use of air and water and basic bio-geochemical cycles, among the things that could be made into property. Polanyi argued that there were disastrous consequences to making part of society into a commodity (labour), that could be moved about by the result of price changes, and by making part of nature into a commodity (land), whose uses could be altered by similar price changes. Polanyi's belief was that the attempt to run the economy by a self-regulating market was a Utopian experiment that failed. Society, he argued, would have to take charge of the economy to prevent disaster. The replacement of market forces by planning was necessary, with the only question being, whether the planning should be democratic or dictatorial.

Theory of Unmarketed Goods
The main feature of many environmental goods and bads was that they had no market at least in the normal sense. It was often suggested that commodities outside the sphere of markets could not be measured by money units. But environmental goods too had a "price", though the price was not observed in the market. Though prices of such goods appeared to be zero, their "true" prices were positive. Sometimes environmental goods might fetch higher prices than what cost-benefit studies, suggested as prices.
**Input-Output Environment Models**

Victor in his study "Pollution, Economy and Environment" attempted to estimate the demand for water (an economic commodity in his terminology) and discharge of wastes by industries in Canada. If some procedures, for extending the relative insistance of each waste discharged, could be worked out, it might help devising "a pollution league table" from such results. There could be various approaches. First, pollutants widely regarded as very important from the ecological point of view and the list of industries according to the input-output coefficient, that showed how much pollutant was produced per unit value of output, might be selected. Unless the input-output table was sufficiently disaggregated, one might not be able to use this information for any policy purpose. Second, developing the first idea, one would not allow for the size of total output in each industry, so as to assess the total waste from each industry. Finally, an attempt to place a monetary valuation on the environmental commodities, and discharges could be made. To do this, the standard prices reflecting society's evaluation of these items on a conceptual basis were required. But going from cost benefit theory to practice was at the very base very difficult and was often virtually impossible, although some figures could be obtained, it had no meaning. Victor's study used only relative weights, that is, he did not attempt to use absolute money values for items, and the weights were derived by asking an expert to assign them.

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Leontief's Extended Input-Output Model

Leontief extended the input-output tables which he originated to include a pollution abatement sector. This was an important departure, since pollution was itself an industry requiring inputs from other industries. Also, pollution coefficients were estimated, relating tons of pollutants to some unit in the model. No flow from the environment to industry was incorporated, so that like most of the other models, the principle of materials balance was not included in the model.

The general structure of Leontief's extended model is tabulated as follows.

<table>
<thead>
<tr>
<th>Industry inputs</th>
<th>Industry outputs</th>
<th>Anti-pollution activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry outputs</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Industry outputs</td>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>

Matrix A was the traditional input-output matrix relating inputs to outputs. Matrix B related industrial inputs to pollution elimination activities, which were noted as a cardinal feature of Leontief's system. Matrix C related pollution emissions to industrial outputs. Matrix D showed the pollution reduction as a result of anti-pollution activity. By manipulating the table, Leontief was able to assess the effect of the level of emission in individual works of particular level of final demand. At the aggregate level, the model permitted the estimation of the total level of pollution that would result,
if a given projected level of final demand occurred. This model could also estimate the price effect of particular anti-pollution measures, a feature of input-output model that appeared to be a desirable one from the point of view of governments.19

The Roskill's and Walter's Models20

Roskill and Walter made improvements over the property price approach which was based on the concept that individuals could buy peace-like properties for a price, choosing to locate their homes in peaceful areas and by choosing to work for employers who located their activities in such areas. Both based their concepts on the valuation of noise. The significant feature of these models was valuation per unit of noise (pollution). The essentials of these approaches were that (i) they might be useful for the estimation of property price depreciation, and (ii) the estimation of consumer's surplus.

Efficiency and Equity Theory

The above theory was illustrated with the following example. The case of a chemical factory producing product x and discharging its wastes into nearby waterway was considered. These discharges reduced the utility of the water and its suitability for other uses such as swimming. Since water was a common property, its services were not sold. The cost in terms of reducing water quality was overlooked by the pricing system. The price of product x was too low and inefficient resource allocation resulted. A similar illustration was

19 Quoted in Victor, Pollution, pp. 50-56.
20 Quoted in D. W. Pearce, Environmental Economics (London: Longmans), p. 27.
given for air pollution resulting from factory fumes. These external effects posed two problems.

First, failure to count the external cost led to an under-supply of the benefits, which were reduced by pollution. Second, the existence of pollution posed distributional or equity problems. Through the loss of environmental quality, consumers of air and water were forced to subsidise consumers of product x, much as they would, if a tax were imposed on them and transferred to the latter.

The problem of equity related to the distribution of gains and losses among polluters and pollution victims and to the incidence of pollution and prevention on households, grouped in relation to income size.21

The Coase Theorem

Coase, who studied the problem of social costs, was a pioneer and might have been the first to emphasize the potential for the kind of averting behaviour or adjustment to externality.22 The Coase theorem might be illustrated with an example.

The case of a factory dumping wastes in a stream, also used as a source of irrigation water by a farm was considered. It was supposed that the farmer had no protected right to the water, and

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there was no law against dumping. The farmer presumably would be willing to pay the factory for each gallon of water not discharged, as long as the payment was not greater than the marginal damage. The factory for its part would require a payment not less than the marginal benefit of dumping. Thus the equilibrium payment would result in an amount of dumping that equated the marginal benefits to the marginal damage.

Then it was supposed that the farmer enjoyed a right to clean water from the stream. The factory would be willing to pay to discharge each gallon of waste water as long as the payment did not exceed the saving; but the farmer would require a payment at least equal to the damage done by the discharge. Again, equilibrium would arise where the marginal benefits from dumping equalled the marginal damage.

The allocation of resources would be the same regardless of the property rights. The allocation would maximise the value of production. No intervention by government was required to achieve this result. Thus, the Coase Theorem, however, was established. There was a question, whether or not, it was correct on its own terms.

In this example, the only affected party was the farmer, but the stream pollution individually might affect many other parties
too like the consumers. Recreational opportunities would be diminished. There might be public health impacts and so on. Thousands or even millions of people would be affected. Coase explicitly assumed no transaction costs, which was realistic in the two party setting of his examples: a rancher whose wandering cattle trample on a farmer's crops; a significant confectioner whose machinery disturbed a doctor in an adjacent office and so on. All the affected parties would have to be studied and asked what they would be willing to do to overcome pollution damages; and accordingly preventive and ameliorative measures should be taken.

Leftwitch and Sharp, writing on economics of social issues, explained the relation between pollution users and polluters with cost implications diagramatically.23

The Concept of Externality

Externalities are non-exchangeable inter-dependencies between individuals and firms. Perhaps the most widely relevant feature of environmental goods and environmental degradation was the 'spill-over' effects notably in public goods. Another way of talking about these effects was to say that public goods exhibited external benefits and public bads exhibited external costs. It was expected of externality to be a wider phenomenon than publicness, because interference of this kind tended to be a basic feature of any economy.

Externality aspect might arise because of the inputs used, or because the act of consumption itself was a nuisance. In the former case, pollution might be an offensive behaviour. Essence of an externality was that it involved:

(i) interdependence between two or more economic agents, and
(ii) a failure to price by economic agents that are independent.

The production of commodities by firms generated an externality that affected adversely each consumer. Externality was a pure public good or bad. What one person consumed did not affect the amount available for consumption by others. Although air pollution was clearly a public good, externality in this sense, varied geographically: some areas were more polluted than others. It might be said that the same aggregate emissions entered all utility functions; but the disutility suffered by any consumer also depended in part on his consumption of land or in other words, on where he lives. In order to determine the value of a much less ambitious, and more realistic control, a tax on pollution, that makes decentralised competitive equilibrium of Pareto optimal was suggested.  

Types of Environmental Damage Cost
The environmental damage is a cost to the society. This cost might be of three types, namely (a) the cost to compensate the past damage, and to prevent the future damage; (b) the cost to meet production

or property losses, and (c) the cost paid for real environmental
damage which cannot be defined (quantified) in money terms.

Social Cost and Externality
Social cost might be measured either in terms of opportunity costs,
or in terms of disutility. Economists usually defined the social
costs of production in terms of similar direct and indirect costs. 25
Planners ignore social costs with a view to minimising cost; but
it backfires in course of time at compound rates.

The negative externality arising out of the absence of pro-
perty rights over air and water (environment) might be internalised
according to Pigou by investing some property rights in the environ-
ment and charge for its uses through a tax.

The Concept of "Spaceship Earth"
This phrase discussed by Boulding suggests that pollution was at
least material residuals from production and consumption activity,
and might always and increasingly be with the people. Because the
earth is like a spaceship. It is a closed system with respect to
materials. A related concept developed by Ayres and Kneese in 1969
was that of "materials balance." According to physical law of

25 Mathew Edel, Economics and Environment (New Jersey:  
conservation of mass, residuals would be roughly equal in mass, to the total amount of fuels, foods and raw materials entering the economy. If the economy was growing, so was pollution. It follows that pollution would be pervasive, associated with most economic activities, not just the few that the theorists of the 1950s and before suggested.

One example, of the phenomenon of, "environmental reservoirs" was the increasing concentration of $\text{CO}_2$ from fossil fuel combustion in the global atmosphere. The fear was that this might lead to a warming and melting of the polar ice caps, with attendant adverse effects, including the flooding of coastal areas.\(^{26}\)

The Controversy Over Limits to Growth Theories

The study on limits to growth was sponsored in 1972 by the Club of Rome and conducted by M.I.T. team of system analysts headed by Meadows. It was argued that the limit of earth's capacity to absorb the waste products from agriculture, industry and large cities would be reached long before resources were exhausted. If every country in the world was to become as industrialised and as urbanised as the United States and Japan, there was little doubt that the earth would be subject to ecological disruption.

\(^{26}\)Fisher, Resources and Environmental Economics, p. 165.
According to Meadows if the present growth trends in world population, industrialisation, pollution, food production and resource depletion continue unchanged, the limits to growth on this planet would be reached somewhere within next 100 years.\textsuperscript{27}

The Social-Psychology Model

The social-psychology model was derived from the Attitude Behaviour Theory. This included three distinct inter-related response components, a cognitive component, an affective component and a conative component. Cognitive component referred to knowledge and belief about pollution; the affective component referred to feelings and emotions regarding pollution; the conative component referred to both overt behavioural responses to pollution and verbal report of intuitive act in some manner regarding air pollution.

Cement

In modern parlance, the term 'cement' referred to any material that is used as a bonding agent for causing diverse materials to adhere. The application of hydraulic cement in the construction and road building industries has become extensive; however, the unmodified term 'cement' referred to almost exclusively to those products.\textsuperscript{28}

\textsuperscript{27}Dennis L. Meadows, \textit{Limits to Growth} (Cambridge: MIT).

\textsuperscript{28}The \textit{Encyclopaedia of Americana} (1963).
According to the New Hutchinson 20th Century Encyclopaedia, cement was a bonding agent used to unite particles in one mass or to cause one surface to adhere to another. The term was applied to a variety of materials such as flyces and pastes, and also bituminous products obtained from tar. In general, it was a powder obtained from burning together a source of lime or chalk and clay which was the universe of concrete.29

Cement was a generic term for a material which on hydration and when mixed with aggregates formed a very strong building material known as concrete. It might be of three types: portland cement, composite cement and high alumina and super sulphated cement.

The principal materials required in the manufacture of portland cement were calcereous deposits (source of lime) and agillaceous (source of silica) and aluminium.30

Manufacturing process
Cement was made from lime, silica, iron oxide and other materials. The three major processes of cement manufacture were preparation of raw materials, calcination and finishing.

Cement consisted of various aluminates and silicates of calcium and calcium aluminate. In good quality cement the ratio

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29 New Hutchinson 20th Century Encyclopaedia, "Cement".  
of silica to aluminia should be between 2.5 and 4. The usual four methods of cement manufacture were dry, wet, semi-dry and semi-wet.

Principal Emissions and Wastes of Cement Manufacture

Depending upon the nature of cement manufacture, the following emissions and wastes had been reported.

**Particulates.** Usually mildly alkaline and originate chiefly from the kiln pre-heater system.

**Gaseous.** It is a very small proportion of metals not retained in the clinker, but emitted together with other volatiles such as SOX and phosphorous.

**Solid wastes.** These are the quantities of dust deposited in the kiln and varied according to the type of process employed.

**Liquid effluent.** This is generally small and relatively contained toxics.\(^{31}\)

Soot and Smoke

In the cement industry, pollution by soot and smoke has remained a problem to be solved since its establishment. Soot and smoke were inevitably generated in the operation of industrial furnaces

\(^{31}\)Ibid., pp. 25-26.
at factories and were emitted from smoke stacks into the air. In the air pollution control law, the term "soot and smoke" was defined as sulphur oxides, smoke dust, hazardous substances (cadmium, chlorine, fluorine, lead, nitrogen oxide and others) and dust.

Early in 1970s itself in U.S.A., the cement pollutants were estimated to be 1.7 billion pounds of particulates. The pollution levels due to emissions from cement plants and affecting the surroundings thereof were determined by means of emission measurements and for propagation calculations, which measured dust deposits and heavy metal concentrations.

Monitoring. Dust emissions were monitored by optical measuring devices, installed at the relevant sources of dust in cement plants. They were easier to maintain, cheap and reliable.

Types of Environmental Impacts of Cement Pollution

Damage estimation. One way of estimating the damage caused by pollution was to determine the physical magnitudes and then imputing the value to each. The values should be inferred directly from the pollution concentration. This might avoid the risk involved

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33 ZKG International, p. 62.
in the first method failing to capture all effects separately. Aesthetics might be quoted as an example. There were two methods for the evaluation of damages. The first was a two-step method of determining the physical effects of pollution and then imputing value to each. The second was to estimate a relationship directly between ambient concentrations and a measure of value, ordinarily residential property value.  

The damage values might also be calculated as a function of differences in ambient concentrations. This was normally done by relating differences in land or property values to differences in air pollution levels. Over a dozen studies of this type had been carried out during the last decade; the pioneering work was by Ridker in 1967, and also Ridker and Henning in 1969.  

Estimation of Control Costs

Control costs were those entailed by changing in some respect, the pattern of economic activity which gave rise to pollution. In order to determine these costs, it might help to have a theory or model of the way a polluter will respond to pay a tax. In the more recent literature of a formal optimising procedure, linear programming often had been used to select the options and their levels.  

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34 Fisher, Resources and Environmental Economics, p. 204.
Criteria for Fixing Standards

Generally, the standards prescribed ranged from 80 to 90 per cent of pollution to be abated. Standards were fixed not in terms of percentages to be abated, but in terms of actual pollutants discharged. Though pollution standards were set in India at a level comparable with the standards in the advanced countries, particularly U.K., the policy appeared to be to set them at a level, the cost of attaining which could easily be borne by the Industry, or even passed on to consumers in the form of an increase in price. Such a price rise was only marginal and would not curtail demand and hence production. These standards were supposed to take care of safety aspects.

The Central Board for Prevention and Control of Water Pollution in India had been preparing industry-wise comprehensive documents in evolving industry’s specific minimal national standards.

ISI Standard

Air and water quality standards in India approved by ISI were based on the techno-economic feasibilities of treatment techniques, protection of the environment, likely damages to receiving media and their usages. In the case of cement units, emissions of nitrogen oxides to the ambient air from plants might be a maximum of 200 ppm.
Comprehensive Laws of Pollution Control

During the Medieval period, King Edward of England signed the first Air Pollution Law, the Sea Coal's Act. In 1938, Richard II prohibited the throwing of dung filth carbages into ditches, rivers, and other waters. In the case of air pollution, the legislation on 'Classified Establishment' was passed in France in 1810. The River Pollution Prevention Act of 1876 in England, The Rivers and Harbour Act of 1899 in U.S.A., The Law of 30th November 1857 in Denmark, Law of 20th March 1865 in Italy, The Law of 13th June 1879 in Spain and The Decree of 5th December 1892 in Portugal were some of the early legislations.

Sweden was the first country in the world to introduce a comprehensive Act during May 1969 to protect the environment. Denmark (1973), U.K. (1974), Canada (1972), Sudan (1975), Australia (1970), Romania (1975), Republic of Germany (1970), Malaysia (1974), Thailand (1975), Iran (1974), U.S.A., Switzerland, Netherlands, Italy and Japan have introduced comprehensive laws dealing with water, air and land pollution. Many other provisions like the London Dumping Conventions, the European Charter, Minimal National Standards and National Ambient Air Quality Monitoring network were some other advances made in the direction of tackling the pollution problem.

Government of India established the National Council on Environmental Planning and Coordination (NCEPC) in 1972. The Central
Board of Prevention and Control of Water Pollution Act was enacted in 1974. Central and State Pollution Control Boards have also been constituted. In 1969, as a pioneering measure, "The Maharashtra Prevention of Water Pollution Act" was passed. Recourse had to be taken under sections 772 and 778 of the Indian Penal Code 1960 and under the sections 133 and 144 of code of criminal procedure to abate pollution. The Central Pollution Control Board initiated a project to control particulate pollutants from stone crushers, during 1986-87 utilising water sprayers. The Board recommended that any cement factory producing 200 tons a day or less, should not emit dust 250 mg per normal cubic metre in protected areas and 400 mg per normal cubic metre in other areas.

During 1976, the Government of Tamil Nadu constituted the Tamil Nadu Pollution Control Board. The Air(Prevention and Control of Pollution) Act was passed in 1981. The Environmental Court has also been established. Maharashtra and Orissa had their own legislations earlier against water pollution. These enactments prescribed pollution standards for treatment of effluents and emissions and also constituted Central and State Boards for prevention and control of pollution. A more comprehensive environment (protection) Bill was passed in 1986, which not only consolidated some of the earlier Acts enacted piecemeal, but also was supposed to have given more powers to the Central and State Boards for prevention and control of Pollution and increased the penalties and terms of imprisonment for non-compliance.
Under the 1968 Law, the Central Government could even order the closure of industrial units violating pollution standards, or order the stoppage of the supply of electricity or water or any other service. Since litigation took a long time, the power to order closure of offending units was needed for preventing pollution in the meanwhile. It appeared that such powers were vested only with the Central Government, and not yet delegated to State Boards. Legal provisions have been incorporated in the Environment (Protection) Act of 1986 for hazardous substances management.

**Economic Implications of Pollution (Cement) Control Devices**

The pollution control devices employed in cement plants not only controlled pollution, but also economised the resources utilised at the production process. The use of each device might be a burden on the unit. The most economical choice of proper anti-pollution device for a specific problem would be made only after considering a number of factors like capital costs, interest charges, power and maintenance costs, tax credits and the value of the material collected by the device.

In cases where benefits and costs could not be evaluated by monetary value, anti-pollution decisions should not await the results of a full economic calculation. They would have to be based largely on subjective judgements. The most economic way of achieving pollution abatement should be thought of and employed.
How to Compute Monetarily the Cost of Pollution

Economic loss could be generalised to all plants and vegetations in the vicinity of the polluting plant. From health point of view too, the loss created by shortening the lives of individuals, the productivity loss, and the health and other similar expenses were caused by pollutants of a factory. These could be calculated.

The loss of agricultural and industrial productivity was also to be added to this which became a saving now. The same case applied to animal resources too. If such benefits were greater than the costs of the device, definitely it should be established.

Criteria for Evaluating Environmental Policies

The most pertinent considerations for the appraisal of environmental policies might be dependability, permanence, adaptability to economic growth, equity, incentives for maximum efforts, economy, political attractiveness, minimal interference with private decisions, disposal plans for hazardous wastes, public access to information, collection of hazardous wastes in a safe manner, objective assessment of the range of development alternatives in environmental and social terms. 37

Environmental Conservation and Management

Conservation might be defined as 'the management of human use of

biosphere so that it might yield the greatest sustainable benefit to the present generation, while maintaining its potential benefits to meet the aspirations of future generations.

Management meant "the collection, transport, storage, treatment and disposal of hazardous wastes." The two important issues in environmental management might be (i) the need to ensure the long term ecological balance of the planet earth; and (ii) the potentially high economic costs of redressing short-term and usually short-sighted inappropriate solutions. These difficulties have to be surmounted.

\[38\] Ibid.
2.3 Review of Literature

Many studies have been conducted on the various socio-economic implications of pollution. Their empirical findings have been classified as follows.

i. Studies dealing with the impact of pollution on health, and thereby on employment, productivity, income, expenditure and aesthetics of individuals.

ii. Studies pertaining to the loss of yields and lives of animals due to pollution.

iii. Studies dealing with the impact of pollution on agriculture and its allied activities.

iv. Studies relating to the environmental damages (changes) due to pollution menace.

v. Studies carried out to measure cost aspects of pollution, its control devices and the awareness of society regarding the problems.

vi. Studies connected with the measures taken in both the private and public sectors to combat the evil effects of pollution.

One of the early studies was specifically addressed to the issue of human health damage from air pollution. It was done by Ridker in 1967, using data of 1958. Ridker estimated that 18 to 20 per cent of the cost of diseases was due to air pollution.
His estimates were taken from a study which correlated lung cancer to various groups of people in urban and rural areas and from another study which used a similar approach to air quality.\(^\text{39}\)

A study by Desai dealt with the health problem of people living in and around the Sandhur Mine area of Karnataka during 1978-82. The mines in the area were mainly iron and manganese. The survey revealed that people of this area were affected by different diseases known as "slow killers", which were mainly air and water-borne.\(^\text{40}\)

Another study by Larsen revealed that the particulate and sulphur oxide levels were high and this resulted in high death rates. He graphically illustrated the positive correlation between pollutant concentration and deaths in London and New York.\(^\text{41}\)

Yet another study has shown that a majority of 500 odd labourers engaged in crushing stones and making stone dust at 64 crushers were victims of cirrhosis, a deadly disease and tuberculosis.\(^\text{42}\)

\(^{39}\)Irwing Sax, ed., *Industrial Pollution*, p. 537.


\(^{41}\)A. Ralph Larsen, in *Air Pollution and Industry*, ed. R. D. Ross, p. 3.

\(^{42}\)The *Patriot*, 30 October 1986, p. 2.
Pechkam listed many of the ecological and economic effects of visibility reduction by air pollution.\(^{43}\)

For the 18,000 residents in the villages of Manali and Ennore, thermal power plant and chemical units have become health hazards. At least one member in practically all the families was affected with one or other ailments. The cost of medicare more than offset the prosperity gained by the residents on account of these units.\(^{44}\)

In a study on "Occupational Health Hazard at the Indian Rare Earth Plant" by Padmanabhan, focus was made on health status of workers, quantity of pollution load, work enforcement and health, and safety apparatus available, including the internal safety organisation and compensation structure.

The study classified health effects of radiations into two, namely, stochastic and non-stochastic. The main findings were that radiation at higher levels induced sterility. The biological process was a massive cell death beyond the replacement potential of the organism. It was found that the radiation also caused heart diseases. This agreed with the findings of Arthur Elkis' view that calcium was the main villain. These pollutants would also give rise to many cancerous and genetic disorders among


\(^{44}\)The Hindustan Times, 12 August 1986, p. 7.
the workers. Lave and Seskin in their studies reported increased daily mortality, aggravation of heart and lung diseases, accentuation of asthma, increased incidence of acute respiratory diseases in children and increased incidence of chronic bronchitis, all associated with air pollution. With the help of a regression analysis, they proved that urban air pollution caused half of the statistically average cases of bronchitis or that of the lost income and the medical expenses due to it. This was 4.5 per cent of all the economic damages created mortality. They concluded that the measures of air pollution were significant factors in explaining variation in total death rate across the areas of United States. For total cancer and for cancer of the digestive system in particular, there was a close association with air pollution.

Membrino, in his report after studying the impact of American industrialised wastage, found that the sewages and chemicals were the most polluted in the country and that would cause cancer and birth defects.

A study made in 1980 by the National Institute of Occupation Health (NIOH), in an Asbestos unit in Ahmedabad revealed that 15 per cent of the total subjects had the presence of asbestos

45V. T. Padmanabhan, "Occupational Health Hazards at Indian Rare Earths Plants," Economic and Political Weekly, 21 (1986).
46Lave and Seskin, Air Pollution and Human Health, pp. 238-39.
bodies in their sputum. About 50 per cent had respiratory diseases; 25 per cent had crepitation (a cracking sound detected in the lungs) and 9 per cent had opec areas in the lungs. To minimize the fatal diseases of asbestosis, a conference of ILO in Geneva in 1984 suggested that employers should be required to prevent the release of asbestos fibres, and provide medical facilities to workers. 48

Severe poisoning might arise from the ingestion of as little as 100 mg of arsenic; chronic effects could appear from its accumulation in the body even at low intake levels. Carcinogenic properties had also been imputed to arsenic. Arsenic might occur in water as a result of mineral dissolution, industrial discharges or due to the contamination of insecticides, according to Unni. 49

Hodgson analysed data of 2.5 years of New York city for acute effects of air pollution at non-episodal levels and concluded that slight or moderate increases in concentration of air pollution during a month could be expected to result in increased mortality from heart and respiratory diseases amounting to several hundred deaths. 50

While the acute effects of air pollution were alarming, the chronic effects were of more concern. Epidemiological and clinical studies have related various air pollutants with everything from common cold to various forms of cancer. Epidemiological and clinical studies, too numerous to review in one section, have repeatedly correlated air pollution and respiratory diseases.

The second series of Criteria Documents released by National Air Pollution Control Association (NAPCA) dealt mainly with motor vehicle emissions (hydrocarbons, carbon monoxide and photochemical oxidants).

Jaffe compiled a summary of biological effects of photochemical pollutants on man and animals. He concluded that photochemical oxidants such as frequently found in urban community atmospheres caused repeated and continuing biological impact on man and animals.

Mueller and Hitchcock summarised the toxicological effects of low concentrations of nitrogen dioxide in 1969.

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55 P. K. Mueller and M. Hitchcock, "Air Quality Criteria-Toxicological Appraisal for Oxidants, Nitrogen Oxides and Hydro-
Fly ash samples were collected from the Electrostatic precipitator of a coal-fired power plant in Hong Kong. The cytotoxicity of fly ash particles was assessed using an in vitro culture assay as the rate alveolar macrophages. It was found that the viability of the cultured alveolar macrophages depended not only on the particle, but also on their metal content. This relationship was also reflected by the degrees of damages of surface morphology of the cells and the release of cytoplasmic and lysosomic matter enzymes into the culture medium.  

Lave and Seskin, focussing on the respiratory related epideomological studies have derived a lower bound estimate of 200 million dollars yearly saving in U.S. health costs, if air quality were improved 50 per cent. Research on health effects of air pollution in humans had been conducted both in the laboratory settings, and in situations where aggregate correlation between pollutant levels and disease rates were obtained.

In the case of mental health outcomes, many other important factors, such as unemployment, were also correlated with higher levels of air pollutants. By examining simultaneous correlation between a pollutant and health outcome, one might be assured that health effects were immediate.

Similar facts were also reported in the findings of Waldbott

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and Khan.\textsuperscript{58,59} In the dissertation entitled, "Some Economics of Air Pollution Control," Crocker of the University of Missouri, reported that a cross-sectional multiple regression analysis of the data regarding the economic aspects of pollution on beef cattle and pasture lands in Florida, brought out the following results:

(i) the pollution damage created by the phosphate factories decreased the standard of health of the beef cattle and also the value of the pasture lands; and

(ii) either the pollution caused by the phosphate companies must be brought down to the minimum technologically feasible level of the industry or the companies should buy up these sites, subject to severe pollutant fumigations.\textsuperscript{60}

According to a study by the scientists of Veterinary College, Mhow, livestock and poultry were affected by Methyl Isocyanate (MIC) that leaked from Union Carbide Pesticide Plant at Bhopal in 1984, and found to give lesser yield of milk and eggs. This

\textsuperscript{58} L. George Wadbott, "Health Effects of Environmental Pollutants (St Louis: Mosby Company, 1973).


\textsuperscript{60} Thomas Dunston Crocker, Some Economics of Air Pollution Control (Columbia: University of Missouri, 1967).
was the case with the six buffaloes and 81 poultry birds which were brought from Bhopal after the gas tragedy. The scientists in ICAR, National Dairy Research Institute, Karnal and at the Indian Veterinary Research Institute also found out similar impacts.61

Studies undertaken by the National Institute of Oceanology, in and around Bombay, have shown the disappearance of sensitive marine species, and decrease in their quantity and diversity due to pollution.62

Mackintosh reported that chronic lead poisoning had been observed frequently in horses that had been grazing near smelters, lead mines and in orchards that had been sprayed with insecticides containing lead.63 Stockinger also reported that cattle and horse were poisoned by inhaling the air contaminated by zinc and lead within half a mile of zinc and lead smelters. In the vicinity of a coke oven, the herbage was found to contain 25 to 46 ppm of lead. This was sufficient to cause poisoning of cattle and sheep.64 According to Stockinger and Coffin, flouride and other pollutants probably caused more widespread damage to livestock in the United States than any other pollutants.65

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62 The Hindustan Times, 12 August 1986, p. 5.
65 H. E. Stokinger and D. L. Coffin, "Biologic Effects..."
Phillips reported that cattle and sheep were the most susceptible to fluoride toxicosis, of all farm animals.66

Sullivan stated that a study of the effects of air-borne arsenic from nearby smelter on animals in Saxony forest was reported by Prell. Red deer, foxes and horses were all affected. Bees in the area had a high mortality rate.67

According to Furtado, there was a direct link between the sulphur dioxide from industrial smoke stacks and the deaths of aquatic life in lakes and streams of the United States and Canada.68

Air pollution impact on vegetation has been recognised for at least a century. Hindawi pointed out that the leaf was the primary indicator of injurious effects of air pollution.69 Krishnamurthy reported that about 600 trees of tamarind in Tiruchirapalli district adjoining the Chettinad Cement Factory, fetched an annual revenue of Rs30,000 per year to the Government, before the factory was started ten years ago. When the study was conducted of Air Pollutants in Air Pollution, ed. A. C. Stern (New York: Academic Press, 1968).

the same number of trees could not fetch even Rs10 per year due to decline in yields, as the impact of cement dust pollutants (see also Appendix IIB-D).

Kesava Reddy found that the presence of chromium in the tannery effluent, influenced the metabolic process of plants and the incidence of deleterious effect was more in the case of sensitive plants.

A study by Sabarathnam et al. reported that ozone, \( \text{SO}_2 \) and nitrogen dioxide in decreasing order had major effects on soyabean growth. These have been found to cause anatomical, biochemical, morphological and physiological changes and to reduce yield by 11.44 per cent.

Naik found that thermal power plant's aerial discharge at Talchar had great environmental impacts. All the annual evaluations by the Swiss National Forestry Office indicated that in the whole 36 per cent of forests covering over a quarter of Swiss territory was afflicted by pollution problem.

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74 The Hindu, 26 December 1985, p. 5.
It was reported in Japan that 223 people died of cadmium poisoning disease called 'Iti: Iti' (It hurts! It hurts!) because of its slow painful and sometimes fatal effects. The fields at Tayama were polluted through river Jinzu which had a cadmium refining unit on its bank. After soil pollution prevention law was passed, the Government was to replace the top 40 cm of soil of 1500 hectare in 1980 itself (an investment of 3.5 billion yen). Still 1400 families, which relied on these lands cultivated and produced about 4000 tons of semi-polluted rice only.75

The productivity level of about 1000 hectares of land around a cement factory in Coimbatore has been reduced to about 20 per cent of what was recorded a decade ago. Even improved varieties did not perform well in these lands, due to heavy cement deposition on soil and plants. Coconut trees bearing 200 nuts on an average per year, per tree, previously could yield only about 60 under-sized nuts now. The quality of vegetables along with quantity also deteriorated. It was likely that these lands would become completely unproductive and unfit for human habitation in the immediate future, if the cement dust emission was unabated.76

Krishnamurthy observed that cement dust produced a greyish

75 The Hindu, 23 February 1986.
76 The Hindu, 15 February 1986.
white coating on the entire leaf surface. After the deposited
dust was removed, the foliage was chloratic. Precarious leaves
experienced slow death. Pockets of dead cells were noticed on the
lamina of all the parts. Yield of plants was affected to a very large extent.\textsuperscript{77}

Leaf samples of six plant species collected from locations
near the aluminium fabrication plants in Sai Kung, Hong Kong were
found to be heavily contaminated by Al, Cd, Pb, Cu and Zn as deter­
mined by inductively coupled plasma (ICP). Scanning Electron
microscopic studies showed that the significant amount of dust
particles with elevated concentration of heavy metals were deposited
on the leaf surface. The degree of dust deposition and metal
contamination varied significantly among different species.\textsuperscript{78}

Peckham of the Division of Economic Effects Research of
the NAPCA and his co-workers had compiled rather complete literature
survey on the effects of various forms of pollution and the socio­
economic implications thereof.\textsuperscript{79} These and the Criteria Documents
contained comprehensive summary on the subject. In similar lines,
WHO also has prepared a document entitled "Rapid Assessment of
Air, Water and Land Pollution Sources" giving a list of nearly 140

\textsuperscript{77}Krishnamurthy, "Impact of Cement Kiln Exhaust...", p.45.
\textsuperscript{78}N. E. Y. Tam et al., "Heavy Metal Contamination by Al­
Fabrication Plants in Hong Kong," International Symposium on Environ­
mental Pollution and Toxicology: Programmes and Abstracts(1986),p.34.
\textsuperscript{79}Peckham, "Odors, Visibility and Art," p. 157.
industrial processes of concern.

In its latest report on the state of the world 1989, the Washington based World Watch Institute listed depletion of ozone layer along with greenhouse effect, soil erosion, deforestation and population growth as the main problems of the environment. According to it, initially there was a belief that ozone depletion was seasonal and unique to Antarctica. After the conclusions emerged from more than 100 scientists of 10 countries, the NASA data on Ozone Trends Panel Report indicated that ozone losses were taking place not just over the poles, but all over the globe. Such ozone layer depletion could be stopped by reducing emissions of ozone depleting chemicals which harmed ozone layer.

Manbe and Wetherald analysed the temperature effect of CO$_2$ at a constant relative humidity and the average amount of cloudiness. Their results indicated that for a change in CO$_2$ from 300 to 600 ppm, an increasing temperature of 4.25°C was the outcome.  

At a National Seminar on Conservation in New Delhi, it was acknowledged that environmental pollution disfigured historical

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monuments and objects; it was stated that apart from air and water pollutants even paint, lacquer and other finishing materials contained harmful components to art objects.\(^81\)

The International Organisation for Economic Cooperation and Development estimated the total damage in the member states caused by air pollution alone, including health cost at about 3–5 per cent of GNP. For the FRG, this represented losses to the economy of DM 40–70 bn. annually. Forest damage value could be estimated up to DM 100 bn. For these calculations, it should be remembered that much of ecological damage, particularly in the long term, such as acidification of soil, threats to drinking water or extinction of natural species could not be quantified in monetary terms at all.\(^82\)

In the Ambur and Vaniyambadi tanning towns on the Palar belt of Tamil Nadu, about 600 wells have become completely polluted due to tannery effluents and the Ambur municipal water supply scheme commissioned at a cost of Rs45 lakhs in 1976 had to be abandoned after the King Institute, Madras found the water unfit for human consumption. About 40,000 hectares of fertile agricultural lands, i.e., 12 per cent of the total lands had also been polluted. About 25,000 tannery workers suffered from "dermatitis"

\(^81\) Indian Express, 6 August 1986, p. 10.
\(^82\) Environmental Policy and Law 16 (1986) 40.
and "skin diseases." There was an increase of 300 per cent in disorders like bronchitis and 500 per cent increase of tuberculosis between 1980 and 1985.  

The picturesque farming Polish village of Bagomice resembled a "Ghost Town" today. It was poisoned to death by an acrid wild smoke that leaked out 24 hours a day from the chimneys of Glogow Copper Foundry that loomed 3 km away. The pollutants were the high levels of SO₂, copper, lead and dust. This created diseases, plus a high level of premature abortions. Government ordered evacuations, and 40 of 57 affected parties demanded compensation from the plant and for others the process was going on.

Vanadium contents of the soils, and the plants in the polluted and non-polluted areas were investigated and analysed in China. It was found that Vanadium contents of the soil especially surface soils in the polluted areas were much higher than that of the non-polluted area, and that the natural background value of vanadium was obviously higher than the mean value of the world soil. The plants in the polluted area had accumulated a number of vanadiums and their contents were more than that of the non-polluted area.

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Pillet focussed on the analysis of the subsystem to evaluate the environmental role by means of energy externality procedure. 86

The fact that air and water pollutants impaired the environment and its ecology was substantiated also through the findings reported in news media. 87

One of the earliest and most commonly cited studies of the economic significance of pollution was conducted by the Mellon Institute during 1913. 88 Primarily the costs of soiling and wasted fuels (from incomplete combustion) were considered. It was concluded that the average annual per capita costs due to such effects in the Pittsburgh area were about $20. 89 Subsequent updating


of this figure on the basis of the commodity price index apparently led to the now common range of estimates between $60 and $70 per capita yearly. Kneese examined the problems associated with these extrapolations and presented a more comprehensive basis for analysing the economic effects.

The economic effects of pollution have been discussed by a number of authors like Ridker, Kohn, O'Connor et al., Walker and Michelson.

Numerous articles, theses and books have struggled with the purely economic concepts of air pollution and its control. Peckham surveyed the literature on the economics of air pollution and cited more than 385 references; but with all conceptual and fact-finding studies, the quantifying problem continued with regard to the cost of unabated air pollution and its control. On the 'Costs of Control' side, there were some comprehensive works.

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Investigations undertaken in many countries have documented a relatively high level of awareness (from 65 per cent to 95 per cent) in polluted areas. Studies conducted in Chotanagpur of India by Bladen and Curren in 1976 and studies in Yugoslavia and U.K. by Kroome, Probald and Wall in 1973 have supported the above fact.

Over 90 per cent of the subjects thought that government agencies should do something about pollution. A number of studies by McEnvoy (1972), Rankin (1969) and Schusky, Stanford Workshop (1970), found that between 50 and 70 per cent of respondents were willing to pay increased taxes to reduce air pollution. 94

According to the Commission of European Communities, 95 the scope for advancing the use of clean technologies in the cement industry arose in the following ways:

i) in the manufacture of Portland cement clinker by substitution of the wet process by dry, semi-dry or semi-wet processes;

ii) use of lower grade solid fuels instead of oil or gas;

iii) by manufacturing composite cement containing a proportion of industrial waste materials instead of Portland cement based upon 95 per cent clinker; and

iv) by combustion of combustible industrial and municipal waste waters.

95 "Clean Technology in the EEC Cement Industry "(1983).
Another important finding of the Commission was that throughout the world, especially in the European countries, there had been a shift in the production processes from wet to dry, semi-dry and semi-wet processes. The Commission felt that there was much scope for reduction in raw materials and energy consumption of cement industry.

Fazio and Cascio using input-output tables in the environmental fields assessed the effects of anti-pollution measures on various economic magnitudes such as industrial output, GNP, and price level. 96

Christiansen and Haveman did not approve the view that pollution abatement expenditure was a negative factor to the fall off in productivity growth. 97 They also held the view that the merits of anti-pollution measures in contributing to economic welfare could not be reflected in marketed or measured output. These effects included improved health, longer life, expanded outdoor opportunities and reduced demands for cleaning and related activities.

Quoting a study of American pulp and paper industry, Royston pointed out the positive correlation between profits of firms and environmental protection. 98

96 Quoted in Environmental Economics, ed. Pearce, p.27.
98 Royston, p. 79.
Another project relating to the USA was carried out by the CONSAD Research Laboratory in the USA in 1971.\textsuperscript{99} It related only to specific air pollutants, and three possible policy measures were considered:

\begin{enumerate}
\item[a)] that all control costs would be borne by the industry;
\item[b)] that the free play of markets would be allowed; and
\item[c)] the cost sharing policy in which government and industry shared the control costs equally.
\end{enumerate}

It was found that heavy polluting industries were able to bear the control costs without passing on significant price increases to the consumers. If industries were allowed to pass on the cost increase to the consumers, the study predicted price increases of only 0.4 per cent with consumers and producers bearing 0.2 per cent each. It was implied that government might take care of producers to subsidise them.

The studies conducted by a group of Botanists in the Tea and paddy belts of Assam confirmed the damage costs by heat and light radiations from two public sector units namely OIL and ONGC, with implications that sufficient anti-pollution measures were not taken by even these public sector units.\textsuperscript{100}

\textsuperscript{99}Ibid., p. 29.  
\textsuperscript{100}The Hindustan Times, 25 November 1987, p. 7.
In a study conducted by scientists as Rohta district, it was reported that despite laws, no effluent treatment was reported to have been made by public and private sector units of Bihar which dumped their effluents in Bakra drain, which affected thousands of people and cattle.\textsuperscript{101}

The Tamil Nadu State Pollution Control Board took action against tanneries in the North Arcot district, which had 302 registered tanneries and 65 unregistered units.\textsuperscript{102} The offending units were accused of discharging 12 million litres of untreated effluent daily, without employing proper and sufficient anti-pollution measures. Till two decades ago, Vaniyambadi taluk of the district was one of Tamil Nadu's richest agricultural areas. But pollution has converted it into a vast barren tract. This was reflected in a two-thirds fall in the number of families dependent on agriculture from 24,000 two decades ago to 8000 today; cultivable land in the taluk has declined from 68,000 hectares to 22,000 hectares. Besides, an estimated 2,000 drinking water wells in the taluk have turned repugnanty brackish. The tannery workers were the worst hit. Deserting their barren fields, they were ironically driven to the very units that shook their placid lives. The number of workers has really multiplied from mere 5,000 two decades ago, to about 50,000 today. Not surprisingly, a tannery

\textsuperscript{101}The Sunday Observer, 10 April 1988, p. 2.
\textsuperscript{102}India Today, 30 November 1987, pp. 144-149.
worker without rash on his body is a rarity. This reflected the indifference of the polluting units towards anti-pollution measures.

Pollution created by the cement factories of India was damaging the environment which suffered a degradation at least for the past 40 years, having far-reaching socio-economic implications. Measures have been thought and implemented to abate pollution at the factory level and to overcome the evil impacts outside the factory. The above studies have subscribed to the cause of these efforts. Still cement pollution continues to be a menace threatening the health, employment, productivity and prosperity of man, animal and vegetation.

In sum, the various concepts and theories dealing with the externality and social cost aspects of pollution were discussed in the first half of this chapter. The methods of damage estimation and computing costs of pollution were also studied. The legislations based on standards were enumerated.

In the second section, empirical findings of previous studies dealing with the impact of pollution on the health of human, animal and plant species in particular and environment in general were presented.