ENVIRONMENTAL ECONOMIC: FUNDAMENTALS

Economics is a well-developed discipline with an extensive body of theory, a paradigm associated with how the economic world works, and a number of branches, or fields of study, associated with pieces of the economy. The fundamental building blocks of economics are contained in micro economics. Related to micro economics permeates all of economics and econometrics permeates all of applied economics.

Environment is the whole complex of abiotic (physical – Lithosphere, Hydrosphere and Atmosphere) and biotic (Plants [flora] and animals [fauna] including man) factors that act upon an organism on an ecology, community and ultimately determination form and survival. In short environment consists of Biosphere, Lithosphere, Hydrosphere and Atmosphere. It is multi-dimensional, multi-factoral and multi-sectoral.

Significance of environmental balance

1. Still India lives in agriculture which is mostly depend on environment.
2. The life and death of men is connected with trees.
3. Country's economic and social development depend o environment.
4. Environment is a symbol of Indian culture (worship and pray to nature).
5. Human happiness depends upon environment (droughts, famines, earthquakes, floods).
6. Environmental balance is the prerequisite for sustainable development.

Environmental Economics is an applied field of economics which is concerned with the impact of the economy on the environment, the significance of the environment to the economy and the appropriate way of regulating economic activity so that balance is achieved among environmental, economic and other social goals. The primary contribution of environmental economics has been in the area of non-market valuation, i.e., methods for measuring demand curves for goods when there is no market. The essence of environmental problem is the economy – producer behaviour and consumer desires.

History of Environmental Economics

From classical economists to modern economics have developed their doctrines in the context of environment. David Ricardo (1772-1823) had expressed his 'environmental economic impact' in term of the impact of the supply of good quality of land and therefore diminishing returns in farm production. Thomas Malthus (1766-1834) told the per capita food supply reduced as population grew in relation to the scarcity of fertility of land. According to Karl Marks (1818-1883) capitalist system is not sustainable because of environmental destruction. Therefore, environmental economics is as old as mainstream economics.

The formal field of environmental economics probably dates to the late 1950s and early 1960s with the important contributions emerging from the "think tank" Resources for the Future, the field really took off in the 1970s and has been booming ever since. Coase Theorem (1960) given certain assumptions for the most efficient solution to pollution damage situation is a bargaining process between polluter and the sufferer. In the 1990s the payoff is beginning to be seen in terms of influence on environmental policy.

Environmental economics get big push by Stockholm Conference on the human environment (1972), the U.S Global Report, the publication of resourceful Earth Report (1984), reports of Our Common Future (1987) et cetera.

Nature of Environmental Economics

1. Environmental Economics is a science as it involves with observations, experiments, testing, analysis et cetera.
2. It is a social science as it deals with society, people and human being.
3. It is a normative real science. Its study approach is not only "what is?", but "what ought to be?".
4. It is multi-disciplinary science.

Issues in Environmental Economics

1. Measuring the demand for non-market goods and service has become central to many public debates over environmental quality.
2. Regulation of environmental goods and services.
3. Are differential environmental regulations compatible with free trade?

Ecology is the science of interrelationship between man and living and non-living surroundings. Eco-system is the term utilized to a certain identifiable set of ecological inter-relationships

Environmental Economics and Ecological Economics:

1. Environmental economics tends to involve economists who have extended their discipline and paradigm to consider environment, where as ecological economics tends to involve ecologists who have extended their discipline and paradigm to consider humans and economy.
2. One major distinction between the two fields is associated with value and thus the way in which social decisions are made that depend on measures of value of the environment. Conventional economists believe that value to society derives from the individual values held by human members of society. Ecological economists take a more bio-physical view of value.
3. However, the greatest distinction between the fields emerges when considering environmental problems with very long term horizons, such as global warming or disposal of nuclear wastes. As some environmental economists will readily admit, economics has a difficult time analyzing problems in which costs and benefits span long time horizon. For instance, storing nuclear wastes can involve potential risks that extend for a quarter of million years. The benefits of the storage are reaped by the present consumers of nuclear power; the costs, if any, are borne by future generation that must live with the nuclear repositories. The conventional economics approach to this is to add up all of the costs and benefits, whenever they may occur, but to apply a discount factor to reduce the importance of future costs in the sum. Inevitably, this means that what happens a century from now has very little effect on the decisions that are made today. To many people, this is disquieting (causing worry and unhappiness). Ecological economists have proposed other ways of dealing with the intertemporal decision problems, particularly the notion of sustainability.

Environmental Economics and Resources Economics are very closely related. Nearly all text books combine the treatment of both. Environmental economics involves questions of excessive production of pollution by the market or insufficient protection of the natural world, due to market failure. Resources economics, on the other hand, is concerned with the production and the use of natural resources, both renewable and exhaustible.

Environmental economics is concerned with static questions of resource allocation. Time is not really an issue in deciding on the right amount of air pollution in London. Resources economics, on the other hand, is concerned with dynamics. Time is what makes renewable and exhaustible resource questions interesting.

Environmental Economics and Environmental Policy: Environmental economics as it is applied to real environmental problems can be invaluable in helping make those important environmental policies.

INTERLINKAGES BETWEEN THE ECONOMY AND THE ENVIRONMENT

(Hanley et. el., p.3)

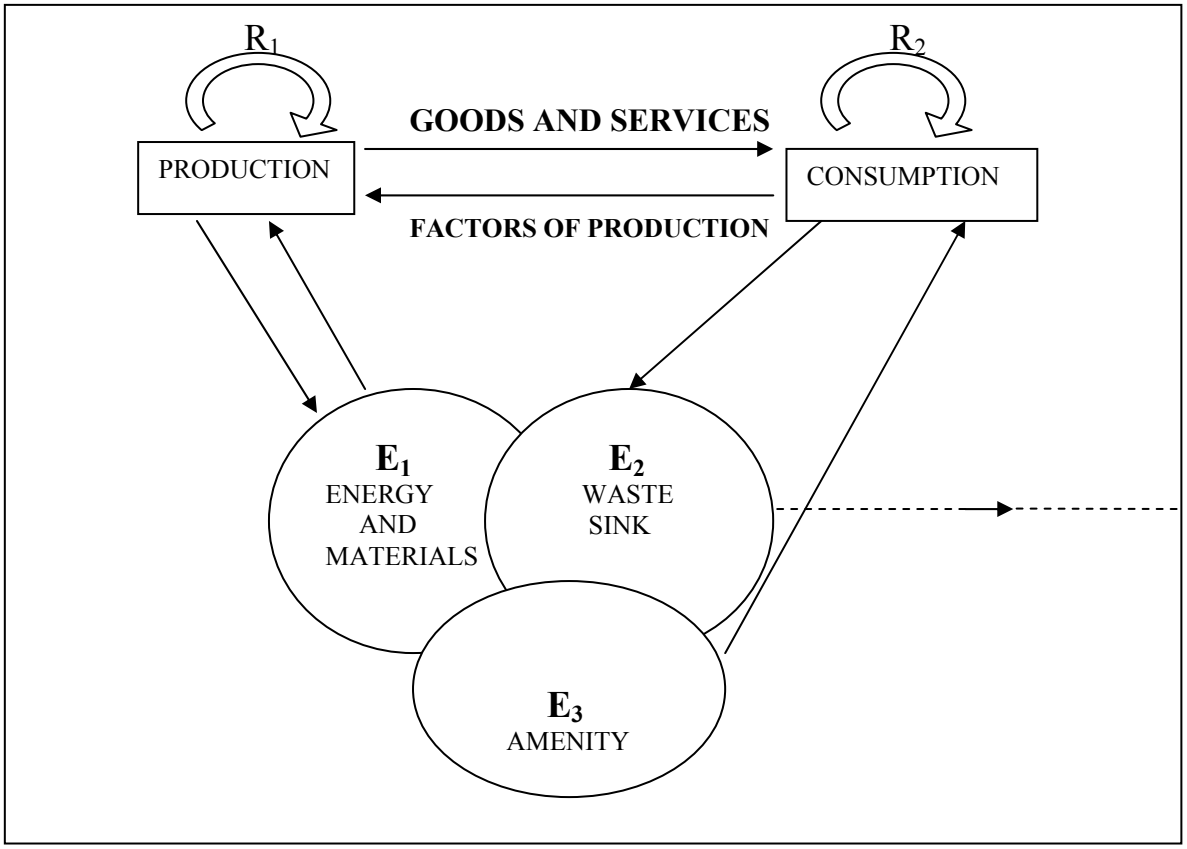


Figure 1: Economy- Environment Interaction

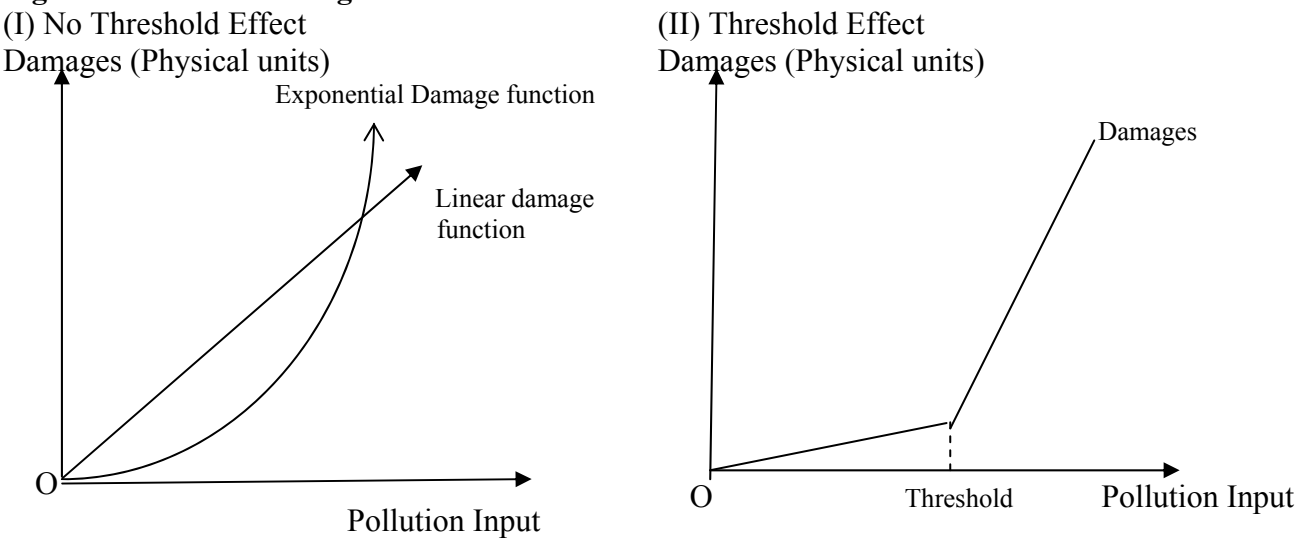
Let the economy has two sectors: production and consumption. Exchange of goods and services and factors of production taken place between the two sectors. The environment is shown in two ways: as the three interlinked circles E_1, E_2 and E_3, and the all-encompassing boundary labeled E_4. The production sector extracts energy resources (such as oil) and material resource (such as iron ore) from the environment. These are transformed into outputs; some useful (goods and services supplied to consumers) and some which are waste products, such as SO_2. There is some recycling of resources within the production sector, shown by the loop R_1, and within the consumption sector, as shown by the loop R_2.

The environment's first role, then, is as a ***supplier of resources***. Its second is as a ***sink***, or receptor, for waste products. These wastes may result directly from production or from

consumption. Such inputs, which are variously termed as 'cumulative' and 'conservative' pollutants, include metals such as lead and cadmium, and man-made substances such as PCBs (polychlorinated biphenyls) and DDT (dichloro-diphenyl-trichloro-ethane). In some case, wastes are biologically and/or chemically processed by environment (*assimilative* capacity for the waste or *bioaccumulation*). For conservative pollutants a positive flow in a year $\mathbf{F_t}$ adds to the stock $\mathbf{S_t^c}$. This is not true for degradable, assimilative wastes, where the stock in any time period $\mathbf{S_t^a}$ depends on current flow *less* that amount removed by biodegradation, or by chemical reactions in the case of gases such as methane, i.e., $\mathbf{S_t^a = F_t - A_t}$, where '$\mathbf{A_t}$' is the amount assimilated in 't' period. We should note that the amount assimilated in any period ($\mathbf{A_t}$) may depend on the level of emission s in previous periods.

For cumulative pollutants, the stack in any period t* is $\mathbf{S_t^c = \Sigma_{ti}^{t=t^*} F_t}$ where '$\mathbf{t_i}$' is the historical date when emission began. For a given location, $\mathbf{S_t^c}$ may not accurately predict the stock of cumulative pollutants, since some transport of the pollutants is possible to another location.

Figure 2: Possible Damage Functions



So far we have seen that the environment acts as a waste sin k, as a partial recycling factory for human wastes from production or consumption and as a source of energy and material resources. The next to be considered that marked E_3 in the figure 1. The environment acts as a supplier of amenity, educational and spiritual values to society (individuals). Neoclassical economics judges economic values as being dependent on social well-being, measured as the sum of 'individuals' levels of well-being. Individual well-being is measured by utility, thus, social welfare is the sum of individual utilities. There are, thus, no separate 'collective' goods. Individuals derive utility from consuming goods and services (meals, holidays) and the state of natural environment.

$$\mathbf{U_A = U\ (X_1, X_2, \ldots X_n; Q_1, Q_2, \ldots Q_m)}$$

Where $\mathbf{U_A}$ is utility, $\mathbf{(X_1, X_2, \ldots X_n)}$ are goods and services produced in the production sector, and $\mathbf{(Q_1, Q_2, \ldots Q_m)}$ are environmental assets. $\mathbf{Q_1}$ could be local air quality, $\mathbf{Q_2}$ local water quality, and $\mathbf{Q_m}$ the stock of blue whales. The environment thus supplies utility directly to individual *A* via the vector of assets, and indirectly via its roles in the production of the vector of goods and services $\mathbf{(X_1, X_2, \ldots X_n)}$. Clearly one result of an increase in the output of any element of the *X* vector will be a decrease in the quantity or quality of an element in the *Q*

vector. For example $\mathbf{X_1}$ is consumption of services provided by owning a car, but car production and operation cause decreases in air quality, $\mathbf{Q_1}$. An increase in the consumption of 'car services' increases utility ($\boldsymbol{\delta U_A/\delta X_1}$ is positive), but this increase in car use decreases air quality ($\boldsymbol{\delta Q_1/\delta X_1} < 0$). This fall in air quality reduces utility in an amount ($\boldsymbol{\delta U_A/\delta X_1} * \boldsymbol{\delta Q_1/\delta X_1}$). The net effect is thus ambiguous, depending on the relative strengths of the positive and negative changes.

What this simple example shows is that using the environment for one purpose (as a supplier of material resources) can reduce its ability to supply us with other services, such as the ability to breath clean air. This is why in figure 1 the three circles E_1, E_2 and E_3 are shown as overlapping: there are conflicts in resource use. These conflicts would include the following:

- using a mountain region as a source of minerals means its amenity value is reduced;
- using a river as a waste disposal unit means its amenity value is reduced and that we can no longer extract so many material resources (fish to eat) from it;
- felling a forest for its timber reduces the electricity-generating capacity of a dam, owing to soil erosion and reduces amenity values since the forest's inhabitants (animals and human) are displaced or destroyed;
- preserving a wetland for its aesthetic qualities forgoes use of the drained land for agriculture.

The environment is thus a scarce resource, with many conflicting demands placed on it. We term the scarcity resulting from these conflicting demands *relative scarcity*, which in principle a correct set of (shadow) prices could solve. This we distinguish from *absolute scarcity*, whereby all demands on environmental services are simultaneously increasing. The major cause of absolute scarcity is economic growth: this implies an increase demand for materials and energy, an increase in waste outputs and increased demand for environmental quality as an input to recreational, educational and scientific activities.

It is apparent, therefore, that economics has a role to play, since much of economics is concerned with allocating source of resources to conflicting demands. But it will also become clear that the economy system, primarily the market system, works very poorly in allocating environmental resources. The reasons for this failure are largely addressed in latter chapters.

Returning to figure 1, the boundary marked $\mathbf{E_4}$ represents the global life-support services provided by environment. These include:

- maintenance of an atmospheric composition suitable for life. The earth's atmosphere is made up largely nitrogen (78%); oxygen (21%); argon (0.93%); water vapour (variable); and CO_2 (0.035%) with numerous trace gases. The limit of variability in this mixture, from the point of view of continued existence, are small;
- maintenance of temperature and climate. The naturally-occurring green house effect warms the earth from its 'effective' mean temperature of -18^0C to the current global average of 15^0C. Changes in the composition of upper atmosphere can change this warming;
- recycling of wastes and nutrients. Examples are the hydrological, carbon and oxygen cycles. Clearly, economic activity operates within this environment, and thus, is shown as being encapsulated by it. The dashed line between E_2 and E_4 indicates that emissions can affect these global support services.
-

THE FIRST TWO LAWS OF THERMODYNAMICS

The interlinkages between environment and economy are governed by the first two laws of thermodynamics. The fist law of thermodynamics states that matter, like energy, can neither be created nor be destroyed. We can convert matter into energy, convert to one form of energy into another form of energy and, in principle, convert energy into matters. The second law of thermodynamics is also know as the entropy law which states that in a closed system, the use of matter-energy causes a one-way flow from low entropy resources to high entropy resources; from order to disorder.

BASIC THEORY

(Unit I: Market System and environment, Welfare and environment, the economics of externalities)

MARKET SYSTEM AND ENVIRONMENT

MARKET SYSTEM: A market is an exchange institution that serves society by organizing economic activities. Markets use prices to communicate the wants and limits of a diffuse and diverse society so as to bring about coordinated economic decisions in the most efficient manner. Market failures occur when private decisions based on market prices do not generate an efficient allocation of resources.

Inefficiency implies that resources could reallocate to make at least one person better off without making any one worse off. Efficiency is defined as Pareto optimality – the impossibility of reallocating resources to make at least one person in the economy better off without making someone else worse off.

ENVIRONMENT: Environment performs three important functions to provide necessary comfortable living to human kind – supplying natural commodities like water, air (E_3 – amenity), helping to produce many materials and non-material things (E_1 – Energy and Materials), and assimilate the by-products of our production and consumption (E_2 – Assimilator).

In this connection, environment supplies all the 'goods' needed 'free of cost'. It means that the environment commodities have no market and as such 'no price' or we can call it 'zero prices'. Again environmental commodities are non-rival (one person's use does not reduce other's use) and non-excludable (provision to any one person automatically makes it available to others). Therefore, in case of environmental market fails. Market failure arises in six cases:

- incomplete market;
- externalities;
- non-exclusion;
- non-rival consumption;
- non-convexities; and
- asymmetric information.

Environmental quality is an economic good in the sense that, it is scare and this quality can be degraded by over use or abuse. Because of externality of this factor due to market failure, there is a cost imposed on the society but not accounted by the firm causing the degradation of quality of environment. This is to say that externalities, like pollution disrupt smooth and efficient functioning of the market system. If the services of environment are priced and brought into the market system, imposing cost to producer (or firm), then the pattern of use of free environmental goods would be entirely different and the welfare of the people would be enhanced.

WELFARE AND ENVIRONMENT

There are two schools of thought regarding welfare economics. Both schools agree that individual's welfare is a subjective concept consisting of his utilities or satisfaction. But the difference is that one school regards welfare as satisfaction derived from economic goods, while the other contends that it is satisfaction derived not only from economic goods but also from non-economic goods. Practically, we take only the former, keeping latter constant.

No difficulty is involved in the comparison of individual welfare as we use the technique of individuals' choice into account. But on the contrary, the welfare of the society or 'social welfare' is highly elusive (difficult to find/define/achieve) and abstract form. The only way of defining social welfare is to set down the aggregate utilities or satisfaction of all the individuals in the society. According to Pareto, social welfare is the collective welfare of all individuals in the society.

Competitive economy and social welfare

Generally, the consumers are guided by the utilities and satisfaction they derived in demanding and consuming the goods, while producers (firm) will be guided by profits and losses in their venture. Every operator in perfect competitive market, whether consumer or supplier, is only a price taker and not a price maker. The general equilibrium price in such a market is determined by impersonal forces of market demand and supply with the assumption that the level of technology, tastes, preference and other fact ors remain constant.

The theorem of welfare economics summarize the major benefits of market on social welfare, of which the first fundamental theorem is of most concern for market failure. The first theorem says that if: (i) a complete set of markets with well defined property rights exist such that buyers and sellers can exchange assets freely for all potential transactions and contingencies (***complete property rights***); (ii) consumers and producers behave competitively by maximizing benefits and minimizing costs (***atomistic participants*** – no influence over prices); (iii) market prices are known by all consumers and firms (***complete information***); and (iv) transaction costs are zero so that charging prices does not consume resources (***no transaction costs***); then the allocation of resources will be a Pareto optimum.

Briefly, the *first theorem of welfare economics* states that in a competitive economy, a market equilibrium is Pareto optimal. The *second theorem* states that in a competitive economy, any Pareto optimum can be achieved by market forces provided the resources of the economy are appropriately distributed before the market is allowed to operate.

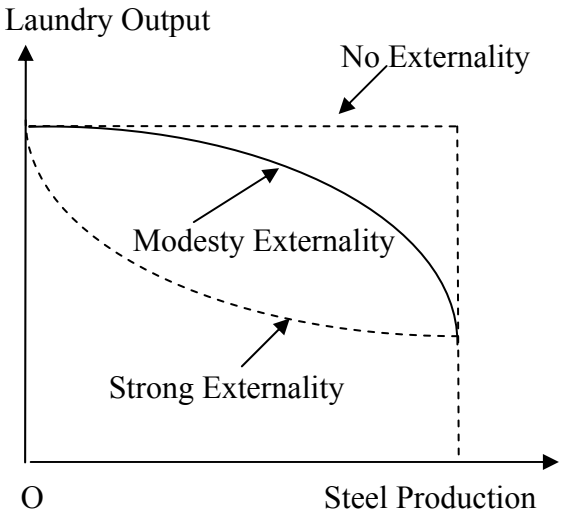
THE ECONOMICS OF EXTERNALITIES

The externality is the classical special case of incomplete markets for an environmental asset. An externality exists, if the consumption or production activity of one individual or firm affect another person's utility or firm's production function so that the conditions of a Pareto optimal resources allocation are violated (Hanley et el, 1997, p.29). An externality exists when the consumption or production choices of one person or firm enters the utility or production function of another entity without that entity's permission or compensation (Kolstad, 2000, p. 91). Note that this external effect does not work through a market price, but rather through its impact on the production of utility or profit. The set of markets is incomplete in that there is no exchange institution where the person pays for the external benefits or pays a price for imposing the external costs.

Externality: Examples (Kolstad, 2000, p. 90-92)
If I like to play my stereo loudly, my neighbours must listen as well. If a laundry is located next to a steel mill, the act of making steel increases costs for the laundry because of all the dirty and smoke generated in making steel. One more additional driver on a congested highway generates externalities for all the other drivers. Of course there can be also positive externalities. In a classic example of externalities, the owner of an apple orchard provides a positive externality for neighbouring apiary (in term of the quantity and sweetness of the honey). And the apiary provides a positive externality to the orchard in terms of the bee pollinating the apple blossoms. The generation of knowledge also provides positive externalities in the sense that its benefit is rarely confined to those who generate the knowledge.

Figure 1 illustrates a **production externality**. Shown are production possibilities of steel and laundry – the maximum amounts of the two that can be produced. Note that with no externality, both can produce some maximum amount and the two firms are essentially independent of one another. With a modest externality involved (e.g., smoke) increased steel production diminishes laundry output. If the externality is strong enough, the possible output combinations can even be nonconvex, leading to potential pricing problems. If we move two firms from each other, the strength of the externality is bound to decline.

Figure 1:
Production Possibilities with an externalities



A production externality exists when one firm's profits are involuntarily affected by another's. More specifically, suppose the technology of producing laundry is given by

$$L = f_L(x_1, \ldots, x_n, e)$$

where L is output of laundry and $x_1, \ldots, x_n$ are n different inputs into laundry production. The variable e is smoke emissions from steel manufacturing, which is of course chosen by steel mill. The steel mill produces steel (S) and smoke emissions (e) using inputs $z_1, \ldots, z_m$ according to

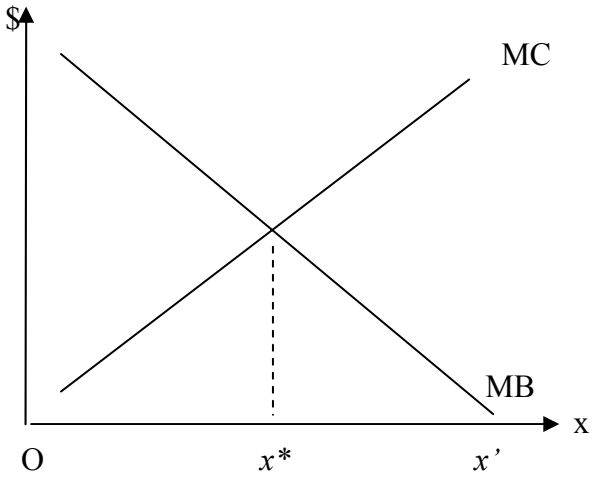
$$S = f_s(z_1, \ldots, z_m)$$
$$e = f_e(z_1, \ldots, z_m)$$

Note that e is chosen by steel mill but e enters into the production function of the laundry. The laundry has no say over what the level of e is nor how e enters its production function. Thus the smoke is an externality.

Externality: Private and Social Optimum ((Hanley et el, 1997, p.29-30)
Suppose there are two parties: Riley and Ole. Riley produces pulp and paper, and discharges the waste water back into the Cloquet River. Ole lives downstream and uses the river for his rafting and kayaking business. Riley's disposal action has a direct negative impact on Ole's production of safe enjoyable rafting and kayaking. If transaction costs are too great, so that the market for clean water or pollution controll is non-existent, a wedge is driven between the private and socially optimal allocation of recourses.

Figure 2 shows the private optimum, x', and the social optimum, x^*, level of pollution for the Riley and Ole example, given the markets are incomplete.

Figure 2:
Socially and privately optimal level of pollution



Consider a simple representation of the externality in the Riley and Ole example. Given that Riley selects a privately optimal level of pollution, x', let his net profits, π^R, be written as

$$\pi^R = \pi^r - c(x)$$

where is the profits before emission abetment, and $c(x) \geq 0$ is the cost of abetment such that costs decreases with increased pollution, $c'(x) \equiv dc/dx < 0$, where marginal abetment costs equal to zero, $c'(x') = 0$ at a threshold level of pollution, x'. Therefore, Riley's marginal benefit from increased pollution equals $-c'(x)$.

Let Ole's net profit, π^O, given his damaged by Riley's pollution, be written as

$$\pi^O = \pi^o - D(x)$$

where π^o is Ole's profits given no pollution, and $D(x)$ is the monetary equivalent of damage suffered where damages increase with increased pollution, $D'(x) \equiv dD/dx > 0$. Ole's marginal cost of increased pollution is therefore equal to $D'(x)$.

The socially optimal level of pollution is determined by taking account of Riley's impact on Ole. The social optimum requires that Riley's marginal benefit be balanced against Ole's marginal costs, $-c'(x) = D'(x)$, represented by x^* in figure 2. If Riley ignores his negative impact on Ole, he will continue to pollute until his marginal benefits from pollution are zero, $-c(x) = 0$; that is Riley will pollute until he no longer receives any benefit. Riley's optimal level of pollution is represented by x' in figure 2. Since $x' > x^*$, the market has failed to allocate resources efficiently: too much pollution is released into the Cloquet river.

Measure to solve the problems of externalities (Joshi, 2001, p.109-112)

1. Taxes and Subsidies imposed by government.
2. Implementation of property right.
3. Auction or sell of pollution permit.
4. Direct governments control by pollution control board.

Pecuniary Externality

A Pecuniary Externality occurs when one person's actions affect the prices paid by another person. Since prices do not enter into utility or production functions, this is not a conventional externality and in fact does not involve inefficiency. For example, you have been a swordfish eater for many years. Recently you have been seen the prices of swordfish rise dramatically due to the increasing popularity of fish in a healthy diet and depletion of swordfish stocks. The actions of others have driven up the price of swordfish so that now you have to pay more so you consume less of it.

MODULE II AND III
ENVIRONMENTAL PROBLEMS

(Air Pollution, Global Warming and Green House Effect, Water Pollution, Pollution and Urbanization, Energy use and Environmental Problem, Transport and Technology, Health and Environment,)

AIR POLLUTION

Definition and composition of air

The elastic, in visible and tasteless mixture of gases that surrounds the earth is called 'air'. The cover of air that envelopes the earth is known as 'atmosphere'. It serves many functions like to absorb most of the cosmic (harmful) rays from outer space and protect living beings from their harmful effects. It also maintains heat balance of the earth.

The air is normally composed of 78.09 % of nitrogen, 20.94% oxygen and 1% mixture of carbon dioxide, water vapour, and small quantities of inert gases like argon, neon helium et cetera. Air constitutes about 80 % of man's daily intake by weight. Human beings breath nearly 22,000 times a day inhaling about 60 KGs of oxygen.

Structure of Atmosphere

SPHERES	DISTANCE FROM EARTH	TEMPERATURE VARIATION
Troposphere	08-18 KMs	Normal to -60^0C
Stratosphere	Up to 50 KMs	-55^0C to 5^0C
Mesosphere	Up to 80 KMs	5^0C to -95^0C
Ionosphere	Up to 500 KMs	Up to 1200^0C
Exosphere	Up to 1600 KMs	Very very high

AIR POLLUTION

Air pollution is, generally, the disequilibrium condition of air caused due to introduction of foreign elements from natural and man made sources to the air, so that it becomes injurious to biological communities. In other words, it may be described as the imbalances in the quality of air, so as to cause adverse effects on the living organisms existing on the earth.

SOURCES OF AIR POLLUTION

I. Natural Sources: The natural sources of air pollution are volcanic eruptions releasing poisonous gases like SO_2, CO et cetera, forest fire, natural organic and inorganic decays, sand and dusts. All these are produced naturally and released in air, making it foul and injurious to health.

II. Man Made Sources:

(a) Increase in population: The rapid explosion of population is one of the most important factors of air pollution. Increases in population lead to global warming and emission of green house gases. Increase in population also causes deforestation which has great adverse effect on air.

(b) Deforestation: Plants maintain the balance of CO_2 and O_2 in the nature. Because plants purify the air by taking CO_2 for their use in photosynthesis and liberating O_2 to be used up by animals during respiratory activities, again liberating CO_2 used by the

plants. Indiscriminate cutting of plants, trees and cleaning of forests by man for his own needs has disturb the balance between CO_2 and O_2 in air quality.

(c) Burning of fossil fuels and fires: The byproducts of burning wood, coal and fossil fuels are poisonous gases such as CO, CH_4, SO_2, NO_x et cetera. The kind, quality and concentration of these pollutants depend on the type of fuel being used. Thus, we see that various poisonous gases released by burning of fossil fuels and fire, pollute the air making it unfit for breathing.

(d) Emission from vehicles: The automobile exhausts are responsible for more than 75 % total air pollution. The automobiles like cars, scooters, motors, taxies trucks et cetera release huge amount of poisonous gases like CO (about 77%), NO (about 8 %) and hydrocarbons (about 14%) in addition to leaded gases and particulate leads et cetera as a result of incomplete combustion of petrol and diesel with oxides of nitrogen in the presence of sunlight to form "***autochemical smog***" in the atmosphere. This smog is very toxic in nature.

(e) Rapid Industrialization: A large number of industries such as chemical industries, paper and pulp mills, cotton mills, metallurgical plants and smelters, petroleum refineries, mining and synthetic rubber industries are responsible to about 20 % of our air pollution. The common pollutants of these industries are various types of inorganic and organic gases and materials in the smoke they produced. The most pollutants are CO_2, CO, SO_2, NO_2 et cetera.

The smoke coming out from chimneys of large number of factories contains SO_2 gases. This gas sometimes mixes in air with small particulates of metals near the factories and gets oxidized in SO_3. The SO_3 and SO_2 are harmful and also react with water vapours to form sulphuric acids (H_2SO_4) and sulphurous acid (H_2SO_3). This acid comes down on the earth in the form of "ACID RAIN".

(f) Agricultural Activities: Different types of biocides such as pesticides, insecticides, herbicides et cetera which are used in agricultural practices cause air pollution because some amounts of these poisonous substances is carried away by wind to different places during their spray over crops and thus make the air foul for human health and their animals.

(g) War: The air pollution is caused by various types of sophisticated explosives used in wars. Radioactive rays coming out from atomic reactors or nuclear explosions pollute the air extensively and bring sufferings to mankind to a very large extent. For example, Hiroshima and Nagasaki in Japan affected after World War II.

EFFECTS OF AIR POLLUTION (Sankaran, 2001, p.203-212)

(A) Effects of Air Pollution on Human Being: Polluted air enters the human body mainly through respiratory system and pollutants in the air make their access into the throat, lungs and other parts of the respiratory organs. The first system that would get impaired by polluted air in the respiratory system and the person would have respiratory diseases like bronchitis, Tuberculosis, asthma, influenza et cetera. CO, SO_2, NO_x, Ozone as pollutants would cause respiratory diseases and at times may prove fatal if the concentration is large. Hydrogen sulfide, besides irritating the respiratory system, may

cause headache, sleeplessness, pain in the eyes and also damaging nerve tissues. Ammonia as a pollutant would damage the respiratory tracts and eyes.

(B) Effects on Animals: The pollutants may enter through crops consumed by the livestock, as the air-borne contaminates accumulate in vegetation and fodder. Fluorides, laid and arsenic pollutants are very injurious to livestock. Dairy firms situated near industrial centers where arsenic pollution is prevalent , should exercise extraordinary caution as the livestock would be effected very easily by this poison laid contamination, which would create symptoms of loss of appetites, depression, breathing troubles and paralysis.

(C) Effects on Plants and Vegetations: Sulfur dioxides, hydrogen fluoride, particulates, smog, oxidants like ozone, chlorine, herbicides et cetera have toxic effect on vegetation. The damage can manifest in the form of visual injure such as yellowing, marking, bending of leaves resulting in retardation of plant growth and final extinction. Pollutant particles settled down on the surface of the leaves and block the process of chlorophyll.

(D) Effects on Materials and Goods: All types of materials and goods are affected by air pollution. Textile products, leather products, paper, rubber, glass et cetera would be effected by pollutants. Though air pollution these products change its colour, brightness, smoothness and also texture. Sulfur dioxide with high concentration would react on building materials, metals, textile goods, paper and paints et cetera.

(E) Effects on Historical Monuments: Atmospheric pollutants may cause great damage to historical monuments like statues, memorial buildings, temples, churches and tombs et cetera. The oil refinery in Mathura, 65 KMs from Agra, poses a threat to the beauty and brilliance of the wonder of the world, 'The Tajmahal'. The SO_2 emissions from the refinery could certainly affect not only 'The Tajmahal' but also Red Fort, build out of sand stones.

(F) Effects on Climate and Weather Conditions: Air pollutants are capable of affecting changes in cloud formation, temperature of the atmosphere and expectation of rain depending on the local and regional conditions. These could change the climatic conditions.

AIR POLLUTION IN INDIA (Sankaran, 2001, p.213)
The ten most polluted cities in the world are Bangkok, Beijing, Mumbai, Kolkata, Delhi, Karachi, Los Angel, Manila, Moscow and New York. In India the most affected cities by air pollution are Mumbai, Kolkata, Delhi, Kanpur, Chennai, Hyderabad, Jaipur, Ahmedabad, Nagpur et cetera. The National Environmental Engineering Research Institute (NEERI), Nagpur initiated the air quality monitoring g programme in 1978 in ten cities in India. The analysis of data of NEERI revealed that annual mean value of the suspended particulate matters (SPM) indicated positive trends in Mumbai, Cochin and Jaipur. SO2 level were also positive in Mumbai, Kolkata, Cochin and Nagpur. NO2 were also positive in Mumbai, Kolkata, Cochin, Delhi, Hyderabad, Kanpur and Nagpur.

Bhopal Gas Tragedy (1984)
On December 2, 1984, Bhopal experienced the worst tragedy caused by massive leakage of Methyl- Iso-Cyanides (MIC) from the Union Carbide Pesticide Plant. This industrial accident

which is related to air pollution resulted 5000 to 10000 deaths and nearly 200000 people were affected and around 50000 are seriously affected.

Apart from this massive casualties, children born to women who were pregnant, had either died or had deformities. The vegetation in an area of 35 KMs around the factory was also affected.

AIR QUALITY CONTROL (Sankaran, 2001, p.216)
It is imperative in the part of the government to ensure air quality by properly undertaking air pollution control programmes by means of effective legislation and implementation. It should follow three steps

- Air Monitoring
- Identification of Sources of Air Pollution
- Quality Control

Air Monitoring
There are different methods and techniques for air monitoring. Filtration techniques, Gravity techniques, Precipitation techniques are used in particulate air pollutants. In case of gaseous pollutants absorption, adsorption, cold trapping methods can be adopted. In addition to base level data, continuous monitoring should be done for gases such as CO, SO_2, NO_x et cetera.

Identification of Sources of Air Pollution
It is very difficult to identify a particular source(s) of air pollution as the topography and meteorological conditions would make the dispersion of polluted air to the length and breadth of the region or beyond. The pollutants are emitted either by 'mobile' sources or by 'stationary' sources. Motor cars, trucks, power two wheelers, railway engines and plethora of transport traffic, come under the category of mobile sources of air pollution. Under stationary sources, we shall have all the industrial units, factories, processing centers and power plants, besides commercial and residential complex in urban areas.

Control of Pollution
The third step in air quality control is reduction of pollutants in the air by means of adopting efficient and modern technology. These control measures should incorporated through appropriate legal methods, prescribing pollution control measures at the unit level in the case of stationary sources and at the individual vehicle level in case of mobile sources. Minimum standards of air quality should be prescribed. Effective monitoring of air should be undertaken periodically to ensure air quality.

There are various procedures available to control air pollution, depending on the technology used. The first step in this is to contain the pollution to maximum extent possible by adopting appropriate engineering technology, so that the release of toxic substances from the exhausts and chimneys is considerable reduced. The second process is to replace or substitute old technology with new technologies by which there will be reduction of pollution. The third process is to have the released pollutants ineffective by means of dilution or self cleansing so that the concentration effects of pollution would be reduced.

GREEN HOUSE EFFECT AND GLOBAL WARMING

What is a "Green House"?

A "green House" is a construction of wood or steel frame with panes of glass to let the heat and light of the sun through, for hastening the growth of plants or for rearing tropical or delicate plants kept inside the glass house. The green house hold the energy it receives through the glass panes, conserves the heat without allowing it to go again. Imagine that the surface of the earth is a gigantic green house with various types of plants and living beings. The gases in question are transparent to the sun's ray like glass panes and they hold the heat inside the green house.

What is a "Green House Effect"?

The green house effect refers to the phenomenon whereby Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Chlorofluorocarbon (CFC) and Ozone (O_3) gases trap long wave infra-red-gases radiation (heat) in the atmosphere, there by warming the earth. This term green house effect was first coined by J. Fourier in 1827. The effect also known as 'atmospheric effect', 'global warming' or 'carbon dioxide problem'.

Though **CO_2** contributes the maximum share of green house effect to make the earth warmer, its proportion in the atmosphere is only 0.03 per cent and hence, even a small rise in it is very dangerous. At present CO_2 is increasing by three per cent a year. **CH_4** is emitted naturally by some forms of animal life and in agriculture. Most atmospheric CH_4 comes from biological sources. It is present at roughly 1.7 parts of million and is increasing at a rate of about 1.1 per cent each year. It is stated that in trapping heat, CH_4 is 25 times as effective as CO_2. **CFCs** are a group of synthetic compounds which can break ozone in the stratosphere. Of the many CFC com pounds CFC-11 and CFC-12 are very important. A molecule of CFC-12 has 20000 times the capacity of CO_2 to trap heat and CFC-11, 17500 times capacity. Both of the compounds are long lived and are increasing g in the atmosphere at a rate of 5 per cent per year.

N_2O is produced naturally through microbial action in the soil, burning of timber, decay of crop reduces and combustion of fossil fuels. Atmospheric concentration of N_2O is increasing by about 0.25 per cent per year. A molecule of N_2O has 250 times of the capacity of CO_2 to trap heat. **O_3** in the stratosphere shields the earth from Ultra Violet Rays (UVRs), but nearer the ground level in the troposphere, O_3 is an effective green house gas. Concentration of tropospheric ozone is increasing in the northern hemisphere.

Major Sources of Green House Gases

A number of industrial as well as agricultural operations generate and emit waste gases into the atmosphere. For instance, burning of fossil fuels emit CO_2, growing paddy or livestock release CH_4, the use of aerosols as coolants in refrigerators and air conditioning dev ices or sprays release CFCs into the atmosphere. In addition to the sources just given, there are many other sources of green house gases as given below.

1. A number of factories spread all over the world burn immense quantity of coal, oil and natural gases and spew huge amount of CO_2, together with another undesirable gases through their chimneys into the atmosphere.
2. Power stations based of fossil fuels are significant and wide spread major sources of man made CO_2.
3. A large fleet of automobiles, railway, air craft et cetera use an immense quantity of diesel and petrol releasing huge amount of CO_2 every year.

4. Burning of fire woods and deforestation are the major sources for the production of CO_2.
5. An estimate indicates that plants, soil and earth which are large storage of pools of unoxidized carbon, contain about 2 trillion tones of carbon. These trees release carbon as CO_2 after oxidizing it.
6. A large scale of forest fire either kindled by deliberate or inadvertent actions of man contributes much to release of CO_2, favouring green house effect.
7. Halogenated gases (CFCs) and halons are released to the atmosphere during operations and maintenances of appliance and equipments using these molecules as coolants and propellants.

CONSEQUENCES OF GREEN HOUSE EFFECT / GLOBAL WARMING

1. With increase level of CO_2, the temperature in the earth's surface rises causing more evaporation of surface water, leading to further temperature increase.
2. It has been estimated that if earth's temperature increases from 2 to 4.5^0C, it will result in receding many glaciers, melting of ice caps in the Polar Regions found over Greenland and Antarctica.
3. Because of increased concentration of CO2 and due to much warmer tropical oceans, there may occur more cyclones and hurricanes and early snow melt in mountains will cause more floods during monsoon.
4. A slight increase in global temperature can adversely affect the world food production. Biological productivity also decreases due to warming of surface layer.

CONTROL / REDUCE OF GREEN HOUSE GASES

1. Reduce the consumption of fossil fuels such as coal and petroleum. This can be achieved by depending on non-conventional renewable sources of energy such as wind, solar, nuclear and bio energy.
2. Dispose of the green house gases elsewhere instead of in atmosphere.
3. Learn to adopt and accept the changing climate.
4. International cooperation for attempting the reduction of green house gases.
5. No driving day once a week should be imposed on all countries.
6. Advanced researches are necessary to assess and evaluate the potential of methanol obtained from methane, which can be efficiently used in transport sector.
7. Greenery and re-forestation of the landscape is the only immediate solution of every increasing concentration CO_2 of in the atmosphere, so that the green house effect may be decreased.

PROGRAMMES IN INDIA TO CONTROL GREEN HOUSE EFFECT

1. Ozone monitoring and development of CFCs substitute.
2. Green houses molecules monitoring.
3. Sea level monitoring and modeling.
4. Air sea interaction.
5. Effect of increased UV-B and climatic change in ecosystem, aquatic systems and industrial materials.
6. Paleo-environmental studies.
7. The mesosphere-stratoshpere-Troposhpere Radar (MST Radar) near Tirupati, AP, continuously monitor the state of atmosphere from near the ground to 90 KMs.

WATER POLLUTION

(Definition, Types, Sources, Effects, Control Methods)

DEFINITION OF WATER POLLUTION

Water is regarded as polluted when it is changed its quality, composition directly or indirectly as a result of human activities, so that it becomes useless or less suitable for drinking, domestic, agricultural, fisheries or other purposes for which it would otherwise be quite suitable in its natural or unpolluted state. In other words, any foreign substances, either from natural or anthropogenic sources that impair the use of water as sources may be called water pollution.

TYPES OF WATER POLLUTION (Sharma and Kaur, 1994, p.205-7)

Generally, water pollution can be classified mainly into four categories. These are

- Physical Pollution of Water
- Chemical Pollution of Water
- Biological Pollution of Water and
- Physiological Pollution of Water

Physical Pollution of Water: The physical pollution of water brings about changes in water with regard to its colour, odour, density, taste, turbidity (muddy) and thermal properties et cetera.

Chemical Pollution of Water: The chemical pollution of water causes changes in acidity, alkalinity of pH, dissolved oxygen (DO) and other gases in water.

Biological Pollution of Water: Biological pollution is brought about by bacteria, viruses, algae, diatoms like protozoa, rotifers, crustaceans and plant toxins. Contaminated water supplies frequently create infections of the intestinal tract (like dysentery, cholera, typhoid and gastroenteritis), polio and infectious hepatitis.

Physiological Pollution of Water: Physiological Pollution of Water is caused by several chemical agents such as chlorine, sulphur dioxide, hydrogen sulphide, ketones, phenols, amines, mercaptans and hydroxyl benzene. Chlorination of water usually converts phenol to ortho or para chloro phenol which tastes like medicine and produces offensive odour.

On the basis of sources and storage of water, water pollution may be divided into five categories:

- Ground Water Pollution
- Surface Water Pollution
- Lake Water Pollution
- River Water Pollution
- Sea Water Pollution

SOURCES OF WATER POLLUTION (Sankaran, 2001, p.168-170)

The Water Pollution is mainly cause by ***natural process*** in which the decomposed vegetable, animal and weathered products are brought into mail water sources. All these processes are interdependent on each other and lead to deterioration of natural environment. ***Anthropological process*** such as industrial, agricultural, urban, domestic, radioactive, mining

sources, use of pesticides and fertilizers by man et cetera are poured in water deteriorating it to such an extent that it be comes unfit for living communities. Let us take it in detail manner.

1. **Organic Pollutants**:
   (a) ***Oxygen Demanding Wastes***: These include domestic wastes, sewage, I industrial wastes from food processing, meat packing and slaughter houses, paper and pulp, mills and tanneries, agricultural run-off et cetera. Most of them are biodegradable organic components which are putresible, creating rotten and foul smell. They de compose by bacterial activities with the help of dissolved oxygen in water. This results a depletion of oxygen in water which is harmful to aquatic life.
   (b) ***Diseases Creating Wastes***: Sewage and other wastes would create pathogenic micro organisms and these would cause tremendous damage to public health. These microbes contain viruses and bacteria and they cause water borne diseases such as typhoid, dysentery, cholera and polio as well as other infectious diseases.
   (c) ***Sewage and Agricultural Run-offs***: Generally, sewage and run-off from agricultural land contain plant nutrients. This may stimulate growth of plenty of algae and similar aquatic weeds in the receiving water body. This results in degradation of the value of the water and it loses its dissolved oxygen in the long run, and the finally the water body becomes dead through eutriphication process.
   (d) ***Synthetic Organic Components***: These are the waste materials arising out of man-made synthetic materials, such as pesticides, insecticides, detergents, pharmaceuticals, food additives, synthetic fibers, plastics, paints and industrial chemicals et cetera which may enter the water course either by discharge or by spillage during transport. Most of these chemicals are toxic to plants, animals and also humans.
   (e) ***Oil Pollution***: Oil pollution n in ocean and rivers cause serious damage to aquatic plants, birds and animals. Oil pollution results in reduction of light transmission through surface water thereby reducing photosynthesis by marine plants. It reduces the dissolved oxygen in water endangering water birds and coastal plants. In recent years, oil pollution in seas has been increasing due to spills from cargo oil tankers, leakage from oil pipes, accidental fires in ships and oil tankers, besides oil based technologies and massive shipment.
2. **Inorganic Pollutants**: Finely divided metals, metal compounds, cyanides, sulphates, nitrates, mineral acids, inorganic salts et cetera form the inorganic pollutants in water. Some of the trace metals play essential roles in biological processes, but at higher concentration, they prove toxic to biota.
3. **Suspended Solids and Sediments**: Suspended solids and sediments in water are mainly due to soil erosion. Sediments are mostly contributed by natural process of erosion, agricultural development, mining and construction activities. Suspended solids in water mainly comprise of silt, sand and minerals eroded from the land.
4. **Radioactive Minerals**: The radioactive water pollutants may arise from mining processing of ores, e.g., uranium tailings, usages of radioactive isotopes in agricultural, industrial, medical research and applications, radioactive materials due to testing and also use of nuclear weaponry. The radioactive materials are toxic to any form of life if they exceed tolerance limit.
5. **Heated Effluents**: Many industries are using water as coolants, dispose off the waste hot water by returning it into the original water bodies which would lead to depletion of oxygen in water leading to damage to aquatic life.

EFFECTS OF WATER POLLUTION

1. **Effects on Human Being**: Water is a significant vehicle in transmission of diseases when it contains water borne pathogens or diseases producing organisms. These pathogens which can be viruses, bacterial, protozoms, parasitic worms cause such diseases such as dysentery, typhoid, cholera and infections.

   There are other diseases particularly prevalent in developing areas, transmitted through polluted water, urban filariasis, for example, is transmitted through mosquito breeding in polluted water. Polluted water is unfit for swimming and for many water sports popular in most of the developed countries.
2. **Effects on Industrial Water Supplies**: Water pollution may reduce the utility of water for industrial use. The range of quality required or desirable in industrial application is very wide. So polluted water can involve substantially high costs for industries – the cost of purifying the water.
3. **Effects on Agriculture**: Water pollution can greatly affect the productivity of irrigated land. All natural water contain inorganic salts, particularly, chloride. When this water used in the processes of irrigation, the salt concentrates in the wet soil. If they are allowed to accumulate, soil fertility would diminish and eventually land would become barren.
4. **Effects on Aquatic Food Resources**: The effects of water pollution on fisheries are well known. Fish may kill directly by specific toxics or through oxygen depletion. The changes in temperature affect their breeding and their fitness as food may be spoiled or their market value lowered through changes in flavour or through contamination by pathogenic organisms.

CONTROL OF WATER POLLUTION

We can not stop the use of water. Using water means there will be water pollution. We can not stop water pollution totally. So we have to control it. Control of water pollution essentially involves treating of effluents discharge by industries and treating of sewage by producing for more treatment plants.

Sewage treatment proceeds three stages: primary, secondary and tertiary stages. In the primary treatment stage solid wastes are removed through mechanical; process. The organic matter is removed by biological process in the second stage. Virtually, all the remaining pollutants are removed in the tertiary stage. Phosphates are the most the most difficult to be removed after the tertiary treatment is over. Hence in some cases the phosphates and nitrates are channeled to land as fertilizers.

For complete removal of pollutants more advanced west treatment methods are used. Some of them are:

- Chemical Oxidation Method
- Carbon Absorption Method
- Electro Dialysis Method
- Reverse Osmosis