Water Pollution

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POLLUTION is one of the major environmental problems these days. The term pollution has been defined in a variety of ways.

According to E.P. Odum, pollution is an undesirable change in the physical, chemical or biological characteristics of our air, land and water that will harmfully affect the human life and the desirable species, or that may waste or deteriorate our raw material resources.

In Environmental (protection) Act, 1986 of India "environmental pollutant" means any solid, liquid or gaseous substance present in such concentration as may be or tend to be injurious to environment; and 'environmental pollution" means the presence in the environment of any environmental pollutant. There are two basic types of pollutants.

Non-degradable Pollutants— The materials and poisonous substances such as aluminium cans, mercurial salts, long chain phenolic chemical, and DDT that either do not degrade or degrade only extremely slowly in the natural environment are called non-degradable pollutants.

The non-degradable pollutants also combine with other compounds in the environment to produce additional toxins. The obvious and sensible solution, which is of course not so easy to practice, is to ban the dumping of such materials into the environment, or to stop production of such substances entirely by replacing them with degradable substances.

(b) **Biodegradable Pollutants**— Pollutants such as the domestic sewage can be rapidly decomposed by the natural processes or some artificial systems that enhance nature's great capacity to the decompose and recycle are called biodegradable pollutants.

Heat or thermal pollution can be considered in this category since it is dispersible by the natural means. However, serious problems arise with the degradable type of pollutants when their quantity into the environment exceeds the decomposition or dispersal capacity of the environment.

Water Pollution— Water is one of the most important natural resources and a regular supply of clean water is very essential for the survival of all living organisms. Any physical, biological, or chemical change in water quality that adversely affects living organisms or make water unsuitable for desired uses can be considered pollution. There are many natural sources that contaminate water such as poison springs, oil seeds and sedimentation from erosion.

Pollution control standards and regulations usually distinguish between point and non-point pollution sources. Factories, power plants, sewage treatment plant, underground coal mines, and oil wells are classified as *point sources* because they discharge pollutants from specific locations, such as drain pipes, ditches, sewer outfalls. These sources are discrete and identifiable, so they are relatively easy to monitor and regulate. It is generally possible to divert effluent from the waste streams of these sources and treat it before it enters the environment.

In contrast, *nonpoint sources* of water pollution are scattered or diffuse, having no specific location where they discharge pollutants into a particular body of water. Nonpoint sources include runoff from farm fields and feedlots, golf courses, lawns and gardens, construction sites, logging areas, roads, streets and parking lots. Whereas point sources may be fairly uniform and predictable throughout the year, nonpoint sources are often highly episodic.

Sources of Water Pollution

Although the types, sources and effects of water pollutants are often interrelated, it is convenient to divide them into major categories. Let's look more closely at some of the important sources of pollution and the effects of each type of pollutant.

Infectious Agents

The most serous water pollutants in terms of human health worldwide are pathogenic organisms. Among the most important water borne diseases are typhoid, cholera, bacterial and amoebic dysentery, enteritis, polio, hepatitis and schistosomiasis. Malaria, yellow fever, and filariasis are transmitted by insects that have aquatic larvae. Altogether at least 25 million deaths each year are directly or indirectly due to these water related diseases. Nearly two-thirds of the mortalities of children under 5 years age are associated with water borne diseases.

The main source of these pathogens is from untreated or improperly treated human wastes. Animal wastes from feedlots or fields near waterways and food processing factories with inadequate waste treatment facilities also are sources of disease-causing organisms. The United Nations estimates that 90 percent of the people in developed countries have adequate sewage disposal, and 95 per cent have clean drinking water.

The situation is quite different in less-developed countries 2.5 billion people in these countries lack adequate sanitation, and that about half these people also lack access to safe drinking water. Conditions are especially bad in remote, rural areas where sewage treatment is usually primitive or nonexistent, and purified water is either unavailable or too expensive to obtain. *The world Health Organisation estimates that 80 per cent of all sickness and disease in less-developed countries can be attributed to waterborne infectious agents and inadequate sanitation.*

Oxygen-Demanding Wastes

The amount of oxygen dissolved in water is a good indicator of water quality and of the kinds of life it will support.

- Water with an oxygen content above 6ppm will support game fish and other desirable forms of aquatic life.
- Water with less than 2ppm oxygen will support mainly worms, bacteria, fungi and other detritus feeders and decomposers.

Oxygen is added to watery diffusion from the air, especially when turblence and mixing rates are high, and by photosynthesis in green plants, algae, and cyanobacteria. Oxygen is removed from water by respiration and chemical processes that consume oxygen.

The addition of certain organic materials, such as sewage, paper pulp, or food-processing wastes, to water stimulates oxygen consumption by decomposers. The impact of these materials on water quality can be expressed in term of *biochemical oxygen demand* (BOD): a standard test of the amount of dissolved oxygen consumed by aquatic micro organisms over a five-day period. An alternative method, called the chemical oxygen demand (COD) uses a strong oxidising agent to completely break down all organic matter in a water sample. This method is much faster than BOD test, but normally gives much higher results because it oxidises compounds not ordinarily metabolized by bacteria. A third method of assaying pollution levels is to measure *dissolves oxygen* (DO) content directly using an oxygen electrode. The DO content of water depends on factors other than pollution. But it is usually more directly related to whether aquatic organisms survive than is BOD. The effect of oxygen –demanding wastes on rivers depend to a great extent on the volume flow and temperature of their water. In cold water dissolved oxygen can reach concentrations up to 10 ppm, even less can be held in warm water. Aeration occurs readily in a turbulent, rapidly flowing river, which is therefore, often able to recover quickly from oxygen depleting processes. Downstream from a point source, such as a municipal sewage plant discharge, a characteristic decline and restoration of water quality can be detected either by measuring dissolved oxygen content or by observing the flora and fauna that live in successive sections of the river.

Plants Nutrients and Cultural Eutrophication

Rivers and lakes that have clear water and low biological productivity are said to be oligotrophic (oligo = little + trophic = nutrition). By contrast, eutrophic (Eu + trophic = truly nourished) water are rich in organism and organic materials. Eutrophication is an increase in nutrient levels and biological productivity. The rate of eutrophication and succession depends on water chemistry and depth volume of inflow, mineral content of the surrounding watershed and the biota of the lake itself.

Human activities can greatly accelerate eutrophication. An increase in biological productivity and ecosystem succession caused by human activities is called cultural eutrophication. Cultural eutrophication can result from increased nutrient flows, higher temperature, more sunlight reaching the water surface or a number of other changes. Increased productivity in an aquatic system sometimes can be beneficial. Fish and other desirable species may grow faster, providing a welcome food source.

Eutrophication, thus denotes the enrichment of a water body by input of organic material or surface run-off containing nitrates and phosphates. Elevated phosphorus and nitrogen levels stimulate "blooms" of algae or thick growths of aquatic plants, Bacterial population also increase fed by larger amounts of organic matter. The water after these changes becomes cloudy or turbid and has unpleasant tastes and odors. In extreme cases, plants and algae die and decomposers deplete oxygen in the water. Collapse of the aquatic ecosystem can result.

Inorganic Pollutants

Some toxic inorganic chemicals are sometimes released from weathering of rocks and are carried by run off into lakes or rivers or percolate into ground water aquifers. This pattern is part of natural mineral cycles. Humans often accelerate the transfer rates in these cycles thousands of times above natural background levels through mining; processing, using and adopting improper methods of disposing minerals and mineral wastes.

In many areas, toxic, inorganic chemicals introduced into water as a result of human activities have become the most serious form of water pollution. Among the chemicals of greatest concern are heavy metals, such as mercury, lead, tin and cadmium. Super toxic elements such as selenium and arsenic, also have reached hazardous levels in waters in some regions. Other elements are normally not toxic at low concentrations. However, their higher concentration may lower water quality or adversely affect biological communities.

Metals

Many metals such as mercury, lead, cadmium, and nickel are highly toxic. Levels in the parts per million range – so little that you can not see or taste them – can be fatal. Because metal are highly persistent, they accumulate in food chains and have a cumulative effect in humans.

Mercury Pollution

Among the naturally occurring and the industrial pollutants, mercury is one of the worst offenders and a dangerous pollutants. The element is poisonous, both in the form of inorganic and organic compounds. Methyl mercury gives off vapours. There are many records of fatal poisoning from mercury vapours. It has been found responsible for the spread of fatal mercury poisoning called Minamata epidemic that caused several deaths in Sweden, and Japan. The cause of death was due to the presence of excess of mercury in fish (27 to 102 ppm) with an average of 50 ppm (on dry weight basis) that comprised a large part of the villagers diet in these countries. The safe level of mercury in surface water for domestic use as prescribed by Central Pollution Control Board, New Delhi (1985) is < 0.002 ppm, the limit prescribed by the WHO (1971) is < 0.001 ppm.

Mercury readily penetrates the central nervous system causing teratogenic effect among children born in the Minimata area of Japan i.e. the infants whose mothers were exposed to large amounts of methyl mercury were liable to be affected with mental retardation, cerebral palsy and convulsions. Methyl mercury penetrates to the fetus through the placenta. The concentration of mercury in the blood and the brain of the fetus was about 20% higher than in mother.

Fluoride Pollution

Sources of fluorine compounds in nature and from man's activities, and the air-borne fluoride toxicity are one of the major source of air pollution. Water and soil borne problems of fluoride compounds are also equally hazardous. Fluorine is universally present in varying amounts in soil, water, atmosphere, vegetation and animal tissues. Because of its chemical reactivity, it is found in nature only in combined form.

In Rajasthan, fluorosis problem has reached threatening proportions, according to a study by the Defense Science Laboratory in Jodhpur. The study notes that fluoride has permanently crippled over 3.5 lakh inhabitants and is likely to cripple many more. In some cases, due to the compression of nerves by awkwardly growing bones, paralysis sets in. Fluorosis is prevalent in the district of Jodhpur, Bhilwara, Jaipur, Bikaner, Udaipur, Nagaur, Barmer and Ajmer. Nagaur is among the districts where in several villages in fluoride pollution poses serious health hazards. Rajasthan is believed to have the maximum numbers of the humped back because of high fluoride concentration in water sources in arid and semi-arid zones. Apart from water, the arid and semi-arid soils are also said to contain fluorides. Due to this reason food grain cultivated in these regions contains relatively higher level of fluorides.

Lead Pollution

Lead poisoning is common in adults. Lead and processing industries constitute the major sources of serious lead pollution. Though the lead paints are greater hazards to children, who are prone to ingest and chew on painted articles as lead toys, painters also may run a risk from continual use and exposure. The lead used as stabilises in some plastic pipes is extracted by water thereby polluting the drinking water. Lead in glazing putty may be another source of pollution, especially for children. Lead used in insecticides, food beverages, ointments and various medicinal concoctions for flavouring and sweetening is also an important source of lead poisoning.

Lead pollution causes liver and kidney damage, reduction in hemoglobin formation, mental retardation and abnormalities of fertility and pregnancy. The chronic lead poisoning causes Gastrointestinal troubles, Neuro-muscular Effect, Central Nervous System effect or CNS syndrome.

Arsenic in Drinking water

Arsenic, a natural toxin and a common contaminant in drinking water, may be poisoning millions of people around the world. Arsenic has been known since the fourth century B.C. to be a potent poison. It has been used for centuries as a rodenticide, insecticide and weed killer, as well as a way of assassinating enemies. Because it isn't metabolized or excreted from the body, arsenic accumulates in hair and fingernails, where it can be detected long after death. The largest population to be threatened by naturally occurring groundwater contamination by arsenic is in West Bengal, India and adjacent areas of Bangladesh. Arsenic occurs naturally in the sediments that make up the Ganges river delta. Rapid population growth, industrialization, and intensification of agricultural irrigation however have put increasing stresses on the limited surface water supplies. Most surface water is too contaminated to drink, so groundwater has all but replaced other water sources for most people in this region.

Non-metallic salts

Desert soils often contain high concentrations of soluble salts, including toxic selenium and arsenic. You have probably heard of poison springs and seeps in the desert where these compounds are brought to the surface by percolating groundwater. Irrigation and drainage of desert soils mobilize these materials on a large scale and can result in serious pollution problems. Such salts as sodium chloride that are nontoxic at low concentration also can be mobilized by irrigation and concentrated by evaporation, reaching levels that are toxic for plants and animals.

In many countries close to polar regions, millions of tons of sodium chloride and calcium chloride are used to melt ice from roads in winters. The corrosive damage to highways and automobiles and the toxic effects on vegetation are enormous. Leaching of road salt into surface waters may have a devastating effect on the aquatic ecosystems.

Sediments

A certain amount of sediment enters streams and rivers. However, erosion from farmlands, deforested slopes, overgrazed lands, construction sites, mining sites, stream banks, and roads can greatly increase the load of sediment entering water ways. Sediments (sand, silt and clay) have direct and extreme physical impacts on streams and rivers. When erosion is slight, streams and rivers of the watershed run clear and support algae and other aquatic plants that attach to rocks or take root in the bottom. These producers, alongwith miscellaneous detritus from fallen leaves and so on, support complex food web of bacteria, protozoa, worms, insect larvae, snails, fish, crayfish and other organisms which keep themselves from being carried downstream by attaching to rocks or seeking shelter behind or under rocks; even fish that maintain their position by active swimming occasionally need such shelter to rest.

Sediments entering waterways in large amounts have an array of impacts, and, silt, clay and organic particles are quickly separated by the agitation of flowing water and are carried at different rates. Clay and humus are carried in suspension, making the water muddy and reducing the amount of light penetrating the water hence photosynthesis.

Thermal pollution and Thermal shocks

Raising or lowering water temperatures from normal levels can adversely affect water quality and aquatic life. Water temperatures are usually much more stable than air temperatures, so aquatic organisms tent to be poorly adapted to rapid temperature changes. Lowering the temperature of tropical oceans by even one degree can be lethal to some corals and other reef species. Raising water temperatures can have similar devastating effect on sensitive organisms. Oxygen solubility in water decreases with rise in temperature. At normal temperature water has an oxygen content of about 14.5 ppm, but at 80 °C it contains only 6.5 ppm, so species requiring high oxygen levels are adversely affected by warming water.

Human cause thermal pollution by altering vegetation cover and runoff patterns as well as by discharging heated water directly into rivers and lakes.

The most convenient way to remove excess heat from an industrial facility is to draw cool water from a source like an ocean, a river, a lake or an aquifer, run it through heat exchanger to extract excess heat, and then dump the heated water often back into the original source. A thermal plume of heated water is often discharged into rivers and lakes, where rise in temperature of water can disrupt many processes in natural ecosystems and drive out sensitive organisms. Nearly half the water we draw from various sources is used for industrial cooling. Electric power plants, metal smelters, petroleum refineries, paper mills, food-processing factories, and chemical manufacturing plants all use or large amount of water for cooling and release water that gets heated in the process.

To minimize thermal pollution, power plants are often required to construct artificial cooling ponds or cooling towers in which heat is released into the atmosphere and water is cooled before being released into natural water bodies.

Ground Water Pollution

An exhaustive study of urban water supply system in 75% developing countries by Dietrich and Henderson (1963) suggested that at least 60% of the population, especially in outer city areas and distant villages, is still dependent on underground sources for drinking water. This very important source of water is now threatened with pollution from seepage pits, refuse dumps, septic tanks, barnyard manures, transport accidents, and with diverse agricultural, chemical or biological pollutants. Other major sources of groundwater pollution include sewage and soluble salts. The widespread practice of dumping raw sewage in shallow soak pits has resulted in pollution of ground water in many cities. It attributes in the rise of cholera, hepatitis, dysentery and other water borne diseases, especially in the regions where the water table is high.

Most ground water in the country contains trace levels of naturally occurring radioactive substances or their by-products. In addition, radioactive substances in ground water can result from the nuclear energy programme. At present there are eight functional nuclear power stations in the country and six more projects are in the pipeline. Operations like mining and milling of radioactive ore, chemical reprocessing and radioactive waste disposal can also be source of radioactive pollution in underground water.

Ocean Pollution

Coastal zones, especially bays, estuaries, shoals, and reefs near large cities or the mouth of major rivers, often are overwhelmed by human caused contamination. Suffocating and sometimes poisonous blooms of algae regularly deplete ocean water of oxygen and kill enormous numbers of fish and other marine life. High levels of toxic chemicals, heavy metals, disease-causing organisms, oil, sediment, and plastic refuse are adversely affecting some of the most attractive and productive ocean regions. The potential losses caused by this pollution amount to billion of dollars each year.

Oceanographers estimate that between 3 million and 6 million metric tons of oil are discharged into the world's oceans each year from both land- and sea-based operations. About half of this amount is due to maritime transport. Most oil spills result not from catastrophic, headlines accidents, but from routine open-sea bilge pumping and tank cleaning. These procedures are illegal but are easily carried out once ships are beyond sight of land. Much of the rest comes from land-based municipal and industrial runoff or from atmospheric deposition of residues from refining and combustion of fuels.

Water Pollution Control

Appropriate land-use practices and careful disposal of industrial, domestic, and agricultural wastes are essential for control of water pollution.

(i) *Source Reduction* – The cheapest and most effective way to reduce pollution is usually to avoid producing it or releasing it to the environment in the first place. Elimination of lead from gasoline has resulted in a widespread and significant decrease in the amount of lead in surface waters in the United States. Careful handling of oil and petroleum products can greatly reduce the amount of water pollution caused by these materials. Although we still have problems with persistent chlorinated hydrocarbons spread widely in the environment, the banning of DDT and PCB in the 1970's has resulted in significance reduction in their levels in wildlife.

Modifying agricultural practices, can substantially reduce pollution due to excessive use of fertilizers and pesticides. Similarly, industry can reduce pollution by recycling or reclaiming materials that otherwise might be discarded in the waste stream. Both of these approaches usually have economic as well as environmental benefits.

It turns out that a variety of valuable metals can be recovered from industrial wastes and reused or sold for other purposes.

(ii) *Non-point Source and Land Management*

Among the greatest remaining challenges in water pollution control are diffuse, nonpoint pollution sources. Unlike point sources, such as sewer outfalls or industrial discharge pipe, which represent both specific locations and relatively continuous emission, nonpoint sources have many origins and numerous routes by which contaminants enter ground and surface water. It is difficult to identify let alone monitor and control – all these sources and routes. Some main causes of non point pollution are being presented here to give an idea.

The EPA estimates that 60 percent of all impaired or threatened surface waters are affected by sediment from eroded fields and overgrazed pastures. Pollutants are also carried by runoff from streets, parking lots, and industrial sites that may contain salts, oil residues, pieces of rubber, metals, besides many industrial toxins. New buildings and land development projects such as highway construction affect relatively small areas but produce vast amount of sediment, their disposal when done carefully, can help in reclaiming land. Generally, soil conservation methods also help protect water quality. Applying precisely determined amounts of fertiliser and pesticides and proper irrigation not only saves money but also reduces contaminants entering soil and water sources. The water preserving wetlands that act as natural processing facilities for removing sediment and contaminants helps protect surface and groundwater. In urban areas, citizens can be encouraged to recycle waste oil and to minimize use of fertilizers and pesticides. Runoff can be diverted away from storms and lakes. Many cities are separating storm sewers and municipal sewage lines to avoid flow of contaminants to water sources.

Human Waste Disposal

As we have already seen human and animal wastes usually create the most serious health related water pollution problems. More than 500 types of disease-causing (pathogenic) bacteria, viruses and parasites can travel from human or animal excrement through water. The term sewage refers to the contents of sewers carrying the waterborne waste of a community.

The process of treatment has the following advantages:

(i) The water and nutrient components of the sewage are recycled through crop irrigation or other industrial usages.

(ii) Pollution sources can be eliminated.

(iii) Pollution load can be reduced, and

(iv) Economic benefits can be achieved through crop yield at low cost.

Municipal Sewage Treatment

Over the past 100 years, sanitary engineers have developed ingenious and effective municipal wastewater treatment systems to protect human health, ecosystem stability and water quality. This topic is an important part of pollution control and is a central focus of every municipal government: The sewage treatment includes the following four steps:

1. *Primary Treatment*– This involves the removal of floating and suspended solids, paper, rags etc. by physical and chemical means i.e. screaming, shredding, flocculating and sedimentation. Suspended matter as well as some oxygen demanding waste are removed in the process.

Primary treatment begins as the sewage flows or pumped through the sewer pipes, bacteria initiate its breakdown. Partially decomposed sewage is than filtered as it enters the sewage processing plant. The sewage is allowed to pass through a series of coarse and fine screens to remove the large floating objects. The screens are usually consists of a series of parallel bars. The waste so removed is often passed to a comminutor/shredder where paper and rags used to shred to an acceptable size.

Though nearly 50 per cent of the materials suspended in sewage are removed by this treatment if water to be used for drinking purpose, it has to be treated further.

2. *Secondary Treatment*

This involves decomposition of the organic material of the sewage through metabolic action of organisms accelerated with abundant of oxygen. The breakdown is accomplished with a wide variety of organisms, including bacteria, protozoans, worms and snails. The techniques most commonly used are: trickling filter process and the activated sludge process.

Trickling filters, also known as biological filters, consist of thick bed of gravel containing bacteria over which the sewage is sprinkled at a uniform rate. The filters are not less than two metres deep and circular on rectangular in plan. When the waste water spreads over the bed, it makes contact with abundant of oxygen. As a result, the organic molecules in the waste get decomposed. In the activated sludge process, organic waste and the decomposing organism are suspended as a flocculent mass in the liquid by mechanical agitation in aeration tanks or by diffuse air. The waste continuously flows through the sludge tanks of about 10 feet deep, 20 feet wide and hundreds of feet long. Algae in the sludge generate oxygen to be required for the growth and multiplication of the bacteria.

Despite the secondary treatment, some toxic chemicals, phosphate containing detergents and radioactive substances passed out unaltered. If such water is discharged, toxic substances may accumulate in rivers or lakes killing plants and animals.

3. *Tertiary Treatment*

This involves removal of some of the suspended matter which escapes from final settling tanks in the process of secondary treatment. Some of the techniques which assist in their removal include chemical coagulation, filtration, carbon absorption and chemical oxidation with strong oxidizing agents such as addition of hydrogen peroxides and chlorine.

Fine particles are combined into conglomerates by the process of coagulation the filtered out by passing the wastewater through a bed of gravel or finally graded coal. For instance treatment by addition of alumina-ferric followed by sand filtration and chlorination will yield a clear colourless water almost free from bacterial contamination.

4. *Sludge disposal*

This involves the processing and ultimate disposal of the sludge produced in sedimentation tanks. This increases about half of the cost of sewage treatment. In small works, the sludge is run on the drying beds in a thin layer of about 150 mm deep. Their drying of the sludge takes place partly due to drainage through the sludge into the drains below the bed and partly due to evaporation by sun and wind. Within a few weeks the sludge dries. However, if the volume of the sludge is large, it has to be dried by mechanical means. Nowadays, most sewage works, digest ad sludge an-aerobically to produce more stable products and to kill pathogenic organisms, if present there in. Digestion may be carried out in closed tanks.

The processed sludge is then disposed off at some suitable sites. Disposal of sludge to farmland is practised at many places since nutrients are returned to the land.

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