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Department of Information Technology

A Book Report on

“Water Pollution”

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Why?

WATER POLLUTION

WATER POLLUTION IS NOT JUST A CAUSE THAT'S SUPPORTED BY WIDE-EYED COLLEGE STUDENTS OR EXTREME ACTIVISTS.

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PREFACE

In recent months, extensive research effort has been invested in examining the relationship between exposure to Water pollution and resulting health effects. Data from epidemiological studies demonstrate associations between ambient particulate concentrations and increased morbidity and mortality, while data from toxicological studies have begun to provide potential biological explanations for these observed associations. Indeed, an important question which arises in most analyses is the quantification of the actual human exposure in urban environments (both indoor and outdoor environments). People spend about 85% of their time indoors and, therefore, are exposed to air pollutants (both gaseous and aerosol) from both outdoor (ambient) and indoor sources, which may be of different composition and possibly have different toxicities. Therefore, the physical, biological and chemical characteristics of aerosols determine their potential effects on human health and are important factors in indoor/outdoor studies. At the same time the characterization of ambient Water quality is an important step in the understanding of the sequence of events starting from emissions and ending at the human dose and health effects. The articles which appear in the present special issue of "Water, Air and Soil Pollution FOCUS" have their origin in the international conference "Protection and Restoration of the Environment III", which was held on July 3–7, 2021, in Crete. The papers presented in the Conference covered a wide range of scientific disciplines, from water quality and local environmental problems, indoor air quality issues to climate change issues and global air quality.

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The guest editors decided to present a special issue that focuses mainly on indoor/outdoor studies but also including papers on the chemical composition of ambient air. The paper presented here are based on those given at the Conference.

THE PURPOSE OF THIS BOOK:

The purpose of this book is to demonstrate by means of an example taken from an actual audit-"Water Pollution in India", how an environment audit using the Performance Audit approach was conceptualised, planned and carried out. In particular, it aims to:

- Illustrate the steps to be taken to conduct an environment audit.
- Place the methodology adopted for this audit within the International Standards of Supreme Audit Institutions (ISSAIs) relevant to environment audit

WATER POLLUTION SLOGANS THAT INSPIRE US ALL TO DO BETTER

- Be a part of the solution, not the pollution.
- Be aware and handle water with care.
- Change your water, change your life
- Clean water is blessing from God, don’t pollute it.
- Clean water starts with you
- Cleaner water, cleaner tomorrow.
- Destroy water- destroy life
- Don’t be mean, keep it clean
- Don’t blow it – good planets are hard to find
- Don’t let the future die; keep the water clean.

- Go green and drink clean.

- Keep calm & stop water pollution

SUMMARY

Water pollution (or aquatic pollution) is the contamination of water bodies, usually as a result of human activities, in such a manner that negatively affects its legitimate uses.: Water pollution reduces the ability of the body of water to provide the ecosystem services that it would otherwise provide.

Water bodies include for example lakes, rivers, oceans, aquifers, reservoirs and groundwater. Water pollution results when contaminants are introduced into these water bodies. For example, releasing inadequately treated wastewater into natural waters can lead to degradation of these aquatic ecosystems. All plants and organisms living in or being exposed to polluted water bodies can be impacted.

The effects can damage individual species and impact the natural biological communities they are part of. Water pollution can also lead to water-borne diseases for people using polluted water for drinking, bathing, washing or irrigation.

TABLES OF CONTENT

1. Introduction to Water Pollution:

Hydrosphere covers more than 75 per-cent of the earth's surface either as oceans (salt water) or as fresh water. Hydrosphere includes sea, rivers, oceans, lakes, ponds, streams etc.

Most of the earth's surfaces water is in the oceans, which contains about 35 parts per thousand of dissolved salt of the remainder, most of fresh water with salt content of 0.2% of found either in lakes and ponds (still water) or in rivers and streams (running water).

Fresh water is also available in the form of rains, snow, dew etc. Hydrosphere covers ground water also. Evaporation of water from oceans, cloud formation and precipitation are responsible for worldwide water supply through hydrological cycles. Water is essential to all life. Life was first originate in water.

Pollution of water is the presence of some foreign organic, inorganic, biological, radiological or physical substances in the water. These substances contaminate water by degrading its quality which may cause health hazard or decrease the utility of water.

There are two principle sources of water, surface water and ground water. Surface water comes from streams, lakes, rivers, shallow wells and reservoirs created by damming. Most surface water contains suspended solids, organic and inorganic substances, microbes and other biota. If these substances are present in water in optimum level, they do not cause pollution.

On the contrary some of them are useful in improving the quality of water. When the concentration of these materials or organisms are high, they degrade the quality of water and make it unfit for recreational, domestic, industrial or other use.

Some substances like industrial poisons, toxic chemicals and pathologic organisms pollute the water even at very low concentrations. Some pollution occurs naturally in the form of soil erosion, deposition of animal wastes and fallen leaves, solution of minerals in water etc. Much of it is the direct result of human activity.

These influence the fertility or productivity of soil in several ways:

i. They produce humus by decomposing dead plant and animal material

ii. Release minerals (e.g. calcium, magnesium and iron) from organic compounds for recycling

iii. Interconvert ions and molecules to other beneficial forms and

iv. Decompose toxic substances to harmless forms.

All these contribute to soil productivity. Any substance that adversely affects the productivity of the soil is a soil pollutant Soil pollution is also called as land pollution.

Air and water pollution can be spread to long distances. But soil is greatly localized. Any pollution of soil of one field need not always affect the soil of neighbouring field.

Properties of water are:

(i) Water is an excellent solvent,

(ii) It has a high specific heat and this property of high heat capacity of water is functionally important to aquatic organisms, and

(iii) Water possesses the highest heat of fusion and heat of evaporation, collectively known as latent heat, of all known substances that are liquid at ordinary temperature. The latent heat of water moderates the temperature of the biosphere. It also plays an important role in the evaporation of water and its condensation as well and as dew in the hydrological or water cycle

2. Meaning of Water Pollution:

In nature, water is in its pure from. Impurities get added to it as it percolates beneath the surface of the earth and also when it is used for human activities. Water pollution can be defined as the presence in water, of some foreign Substances or impurities (organic, inorganic, radiological or biological in such quantity so as to constitute a health hazard by lowering the water quality and making it unfit for use.

Water pollution is a state of deviation from the pure condition, where by its normal function and properties are affected. It has been mentioned before that a knowledge of aquatic environmental chemistry is the key to the understanding of water pollution and its control.

Water pollution can be best considered in the perspective of possible pollutant cycles throughout the environment. Any shift in the naturally dynamic equilibrium existing among the environmental segments: Hydrosphere/Atmosphere/Lithosphere (sediment) gives rise to the state of pollution.

3. Signs of Water Pollution:

(i) Bad taste of drinking water;

(ii) Offensive odours from lakes, rivers and ocean beaches;

(iii) Unchecked growth of aquatic weeds in water bodies;

(iv) Decrease in number of fish in fresh water, river water, sea water;

(v) Oil and grease floating on water surfaces.

(vi) These disturb the normal uses of water for public water supply:

Recreation and aesthetics;

Fish, other aquatic life and wild life;

Agriculture;

Industry;

4.Sources

a) Major Sources of Water Pollution:

There are two major sources of water pollution, namely:

(i) Point sources and

(ii) Diffused sources.

I. POINT SOURCES:
Those sources which can be identified at a single location are known as point sources. For instance, the flow of water pollutants through regular channels like sewage systems, industrial effluents etc. infiltration of industrial effluents, municipal sewage etc. contaminate the ground water and cause water pollution.

The water pollution caused by point sources can be minimised if all domestic sewage, industrial effluents, cattle field and livestock wastewater etc. are all centrally collected, treated upto requisite acceptable level and reused for different beneficial purposes.

II. DIFFUSED SOURCES:
Those sources whose location cannot be easily identified are called diffused sources. In this case, the pollutants scattered on the ground ultimately reach the water sources and cause water pollution, for i-instance, agriculture (pesticides, fertilisers), mining, construction etc.

The water pollution caused by diffused sources like agriculture can be controlled by changing the cropping patterns, tillage particles and advanced farm management practices which do not contaminate the water bodies

b) Common Sources of Water Pollution:

Common sources of water pollution are as follows:

i. Sewage:

A main source of pollution is raw or partially treated sewage discharged into rivers, lakes and streams. The discharge of huge quantities of municipal and domestic wastes and sewage pollute many water bodies. Sewage consists of the excreta (faeces and nitrogenous wastes) of animals. It is rich in organic matter and nitrogen compounds.

If used as a fertilizer in moderate concentrations, animal excreta (manure) can enrich the soil. But is sewage is allowed to accumulate in lakes and rivers, it can have serious effects on an ecosystem. Sewage increases the biological productivity and interferes with many uses of the water body. Waste containing toxic substances damage biological activity and kill useful organisms.

ii. Industrial Wastes:

Various types of industrial wastes are continuously poured in streams, rivers and lakes. The industries that cause pollution are printing, electroplating, soap manufacture, food products, rubber and plastics, chemicals, textiles, steel, sugar factories, glass manufacture etc. If industrial wastes are not released directly into water bodies, they can also percolate through the soil and pollute the ground water.

The paper mill wastes are concentrated with a number of inorganic substances. The coak works and plastic wastes have much phenolic compounds. Metal finishing plants release heavy metals and cynides. Caustic soda and chlorine factories release heavy metals such as cadmium, chromium, copper, lead, nickel, zinc and mercury.

All these metals are capable of binding with enzymes and interfering with normal cell metabolism. In some cases these metals concentrate through the food chain to levels that result in heavy metal poisoning. Cadmium poisoning is, called itai-itai ("ouch-ouch") in Japan because it is a painful disease that can be fatal.

Mercury poisoning produce a crippling and often fatal disease called Minamata disease (mercury poisoning occurred in Minamata City, Japan in 1953, when more than 100 persons died or suffered serious nervous system damage from, eating fish taken from Minamata Bay). The level of mercury in freshwater lakes and rivers have been rising in recent years. It can become highly concentrated in the bodies of fishes.

As already mentioned mercury enter human body through contaminated fishes. Many molluscs in streams are found to accumulate considerable amounts of copper and zinc. Cadmium and chromium present in sea are toxic for marine animals.

iii. Fertilizer Pollution:

Adding large amount of inorganic fertilizers to crop fields result in the nutrient enrichment of streams, rivers and lakes. A major part of fertilizer become available for excessive algal growth. This is more true for nitrogenous fertilizers (which are readily soluble) than phosphatic ones.

Nitrate in agricultural drainage contaminate drinking water. Nitrite poisoning or methemoglobinemia occurs in infants and farm animals by ingesting water or food containing high level of nitrite.

Bacteria normally found in the water are able to convert nitrate ions fertilizers and organic wastes to nitrite. The concentration of nitrates and nitrites are reduced naturally by the action of the denitrifying bacteria in water and soil.

iv. Insecticides:

The excessive use of pesticides cause water pollution, by penetrating through soil and getting dissolved in soil water. Some of them like DDT, DDE, DDD, Dielrin and polychorinated biphenyls are washed down with rain water and find their way to the sea through rivers and streams. These toxic substances accumulate in the bodies of aquatic organisms and cause a great harm to them.

v. Herbicides, Cleaning Agents & Food Additives:

Like insecticides, herbicides, cleaning agents, food additives, industrial materials, adhesives and many other synthetic materials containing new chemicals constantly introduced into water. Each year, approximately 70,000 kinds of organic chemicals are placed on the market that ultimately make their way through environment to the water.

Presence of these chemicals at increasing levels is of great concern because of their known toxicity, mutagenicity and carcinogenicity. Herbicides like monuron, simazin, 2-A-D and 2-4-5-T which are used to clear railroad and highways, weed control in agriculture and forest management are harmful for both plants and animals.

vi. Radioactive Wastes:

Many radioactive isotopes escape to water reservoirs, rivers and seas from nuclear power reactors. They enter the food chain in ecosystem. These wastes may accumulate in the bodies of aquatic animals like fishes causing harm to them as well as animals which eat them.

Cesium is known to accumulate in body muscles, Strontium in bones and Iodine in thyroid. Radioisotopes are said to cause cancer, malformation of body at birth, organ abnormalities etc.

vii. Oil Pollution:

Oil is a major pollutant in the sea. Oil spillages from tankers act as a toxic substance and affects the aquatic organisms. Surprisingly, the effect of oil on phytoplankton appears to be slight, but oil pose serious threat to marine animals especially fishes and birds.

viii. Inert Suspensions:
Fine particles of dust, clay, soil, ores are other pollutants of water.

Poisons such as acids, alkalies, phenols, cyanides, copper, lead, zinc, mercury, insecticides and fungicides pollute water.

Inorganic reducing agents such as sulphides and sulphites and ferrous salts are active under reducing conditions.

Oil from spills and washing of automobiles sometimes pollutes our water.

Considerable pollution is caused by such industries as leather tanneries, beet sugar refining and meat packing. About two thirds of all degradation of water can be attributed to various manufacturing activities, transportation and agriculture.

ix. Thermal Pollution:
Various industries require water for cooling. Thermal pollution is the discharge of hot water into river and estuaries from power stations. This raises the temperature of the water, thereby increasing the metabolic rate and oxygen consumption of microorganisms. This makes it all the more difficult for fish to survive.

x. Mining Wastes:
Mining causes water pollution in the form of acid drainage from coalmines, debris and saw weeds from hydromining methods.

xi. Silt Pollution:
Earth moving construction projects, deforestation and flood result in the production of silt in streams and lakes. This may interrupt or prevent the reproduction of fish by smothering eggs laid on the bottom.

5. Classification of Water Pollutants:

Water is used for various purposes like bathing, excretion, laundry, food preparation, cleaning of floors and equipment etc. After using the water, manufacturing plants, industries, residential, and commercial establishments discharge wastewater which is contaminated by many pollutants.

Water pollutants can be classified into the following categories:

(a) Suspended matter (Solids) comprises of silt, sand, mineral codes.

(b) Thermal discharges waste hot water returned to the original water bodies.

(c) Pathogens (Bacteria, Viruses, Protozoa, Helminths)

(d) Natural Organic Pollutants

(e) Synthetic Organic Compounds (Detergents, Pesticides, Fertilizers)

(f) Inorganic Chemicals (Acids, Alkalies, Metals)

(g) Radioactive substances

(h) Sediments.

I. SYNTHETIC ORGANIC POLLUTANTS:

The production of synthetic organic chemicals (more than 60 million tonnes each year as in 1980) has multiplied about ten times since 1950. These include fuels, plastics, plasticizers, fibres, elastomers, solvent, detergents, paints, insecticides, food additives and pharmaceuticals.

These presence in water (particularly bio-refractory organics, i.e. aromatic chlorinated hydrocarbons, etc.) imparts objectionable and offensive tastes, odours and colours to fish and aquatic plants even when they are present in low concentrations. This group includes oxygen-demanding wastes, disease-causing agents, plant nutrients, sewage, synthetic organic compounds and oil.

(i) Dissolved oxygen is an essential requirement of aquatic. D.O. in natural water is 4- 6 ppm. Decrease in this D.O. value is an index of pollution mainly due to organic matter, e.g. sewage industrial wastes from food-processing plants, sugar mills and tanneries; wastes from slaughter houses and meatpacking plants; run-off from agricultural lands, etc.

All these materials undergo degradation by bacterial activity in the presence of D.O., the net result being the de-oxygenation process and quick depletion of D.O.

$C + O_2 \rightarrow CO_2$

(ii) Water is the carrier of pathogenic microorganism and can cause immense harm to public health. The water borne diseases are typhoid and paratyphoid fevers, dysentery and cholera, polio, and infections hepatitis.

The responsible organisms occur in the faeces or urine of infected people and are finally discharged into a water body. Historically the first step in water pollution control was the disinfection technique for the prevention of water-borne diseases, which are still in use.

(iii) Sewage and run off from agricultural lands provide plant nutrients in natural settings, in the natural biological process called eutrophication (Greek word: well nourished). Algal blooms and large amounts of other aquatic weeds causes serious problems.

The excessive plant growth presents an unaesthetic scene and disturbs recreational use of water. The water body, in the process of eutrophication, loses all its D.O. in the long run and ends up in a dead pool of water.

II. OIL POLLUTION:

Oil pollution of the seas has increased over the years due to the increased use of oil- based technology. The sources of oil pollution are oil spill from cargo oil tankers on the seas, losses during off-shore exploration and production of oil, and leakage from oil pipelines crossing waterways and reservoirs.

Oil pollution reduces light transmission through surface water, and hence, photosynthesis by marine plants, decreases D.O. in water and cause damage to water birds, coastal plants and animals. In other words, it damages marines life on a massive scale and also affects the sea food which enters the human food chain.

III. PESTICIDES:

In the early period of human civilization it was realised that pests harm crops and transmit diseases both to men and animals. The use of chemicals to kill pests dates back to 70 A.D. when arsenic was recommended to kill insects.

In the sixteenth century the Chinese are used arsenic sulphide as an insecticide. Arsenic compounds were continued to be used as lead arsenate on a large scale during early twentieth century to control insect pests.

Paris green (Copper acetoarsenite) was extensively applied to pools in the tropics for controlling malaria transmitting mosquitoes. However, it was known that arsenical pesticides can persist in soil for up to 40 years and damage crops.

Pesticide is the general term for insecticides, acaricides, rodenticides, molluscides, herbicides, fungicides and similarly active compounds. The era of synthetic organic pesticides started around 1940. At present there are more than 10,000 different pesticides. They are broadly classified according to their general chemical nature into several principal types.

IV. INSECTICIDES:
Organophosphorus group e.g. malathion; Organochlorinc group e.g. DDT; carbamate group e.g. Carboaryl designed to kill insects in crops.

V. HERBICIDES:
Chlorophenoxy acid group e.g. 2, 4 dichlorophenoxy acid (2, 4%) meant for killing weeds or undesirable vegetation.

VI. FUNGICIDES:
Di-thio-carbamite group e.g. thiram, $(CH_3)_2$ NCSS. SCSN $(CH_3)_2$; Organometailic group e.g. phenyl mercury acetate, $C_6H_5HgOCOCH_3$ — toxic to moulds (fungi) and check plant disease.
The use of pesticides helped in the eradication of diseases such as malaria and typhoid and also in boosting crop production. About 0.1% of the total insects (500 species out of world total of 5.0 million) are harmful-these are mostly agricultural pests which are also carriers of human or animal diseases.

Inorganic pollutants:
This group consists of inorganic salts, minerals, acids, finely divided metals or metal compounds, trace elements, complexes of metals with organic in natural water, and organo- metallic compounds.

The metal-organic interactions involve organic species of both pollutants (such a EDTA) and natural (e.g. fulvic acids) origin. Such interactions depend on and play a role in redox equilibrate, colloid formation, acid base reactions and microorganisms mediated reactions in water. These have an impact on the toxicity of metals in aquatic ecosystems and on the growth of algae in water.

Polyphosphate in detergents, the major sources of phosphate in water, serve as algal nutrients and are of much concern as water pollutants. However, in an efficient sewage- treatment plant, it is possible to remove phosphates from sewage containing organic wastes as well as detergents.

6. Environment of Aquatic in Water:

Water quality characteristic of aquatic environment arises from a multitude of physical, chemical and biological interaction. The water bodies rivers, lakes and estuaries are continuously subject to a dynamic state of change with respect to their geological age and geochemical characteristics.

This is demonstrated by continuous circulation, transformation and accumulation of energy and matter through the medium of living things and their activities. This dynamic balance in the aquatic ecosystem is upset by human activities, resulting in pollution which is manifested dramatically as fish kill, offensive taste and odour, etc.

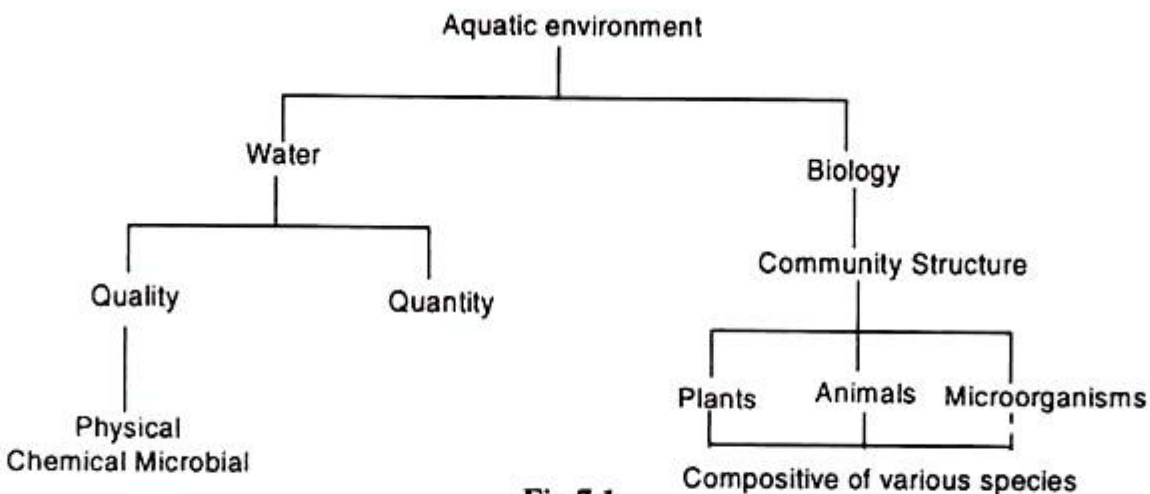


Fig 7.1.

The physiochemical characteristic of the aqueous phase have direct influence on the types and distribution of aquatic biota. Conversely, they are also influenced by the activity of the aquatic biota. These interactions can be readily explained with reference to a thermally stratified lake.

In general, deep lakes and marine environments are likely to undergo seasonal thermal stratification into a warm surface layer (epilimnion), an underlying layer of cool water of higher density (hypolimnion).

The hyppliminitic zone represents a condition where the biological decomposition of organic matter consumes all dissolved O_2, which cannot be made up since these layers are stagnant and cut off from the atmosphere. As a result of O_2 depletion, anaerobic biological populations dominate and reductions set in

$$NO_3^- \longrightarrow NO_2^- \longrightarrow NH_3 \longrightarrow N_2 \quad ...(1)$$

$$SO_4^{-2} \longrightarrow H_2S \quad ...(2)$$

Heavy metal ions, if present, will be precipitated as metal sulphides which settle at the sediment layer at the bottom.

Table 7.1:

Thermal stratification in a lake and Physical, Chemical-biological interactions

Temp. (C)	*Depth (metres)*	*Surface*
20	0	Epilimnion : Aerobic conditions, photosynthesis, phytoplankton, zooplankton higher forms of aquatic biota.
17	12	Thermocline : Temperature gradient physical barrier.
7	21	Hypolimnion : Anaerobic conditions. $NO_3^- \longrightarrow NO_2^- \longrightarrow NH_3 \longrightarrow N_2$ $SO_4^{2-} \longrightarrow H_2S$ Precipitation of metal sulphides, high organic content anaerobic microorganisms.
4	36	Sediment : High organic content, metal sulphides, anaerobic microoganisms

Thus water quality characterization must take in to account:

(a) The distribution dynamics of chemicals in the aqueous phase (soluble, colloidal or absorbed or particulate matter);

(b) Accumulation and release of chemicals by the aquatic biota;

(c) Accumulation and release by bottom deposits; and

(d) Input from land and atmosphere, e.g. air-borne contaminants and land runoffs.

ACID MINE DRAINAGE:

This is a very common and damaging problems in aquatic environment somewhat similar to acid rain problem. Coal mines, especially those which have been abandoned, discharge substantial quantities of H_2SO_4 and also Fe $(OH)_3$, into local streams through sewage.

These result from oxidation of FeS_2 in pyrite which occurs in large quantities in the underground seams which contain coal. FeS_2 is stable in absence of air but when the coal seams are exposed to air in mining operations, the oxidation reactions take place as shown below yielding large quantities of acid. These reactions continue long after the coal mining operations are over.

Microorganisms play important role in the overall process which consists of several reactions.

$$2FeS_2 + 2H_2O + 7O_2 \longrightarrow 2Fe^{2+} + 4HSO_4^-$$
$$4Fe^{2+} + O_2 + 4H^+ \longrightarrow 4Fe^{3+} + 2H_2O$$

Thiobacillus ferroxidans. At pH 3.5-4.5 the reaction may be catalyzed by a variety of bacterium, Metallogenium. Among other bacteria involved in the process mention may be made of thiobacillus thippxidans and Ferro bacillus ferrooxidans. Fe_3^+ dissolves pyrite further and together with the second reaction above, constitute a cycle for the dissolution of pyrite.

$$FeS_2 + 14Fe^{3+} + 8H_2O^- \rightarrow 15Fe^{3+} + 2SO_4^{2-} + 16H^+$$

$Fe(H_2O)_6{}^{3+}$ is acidic which at pH above 3 gives a precipitate of $Fe(OH)_3$:

$$Fe^{3+} + 3H_2O = Fe(OH)_3 + 3H^+$$

The stream beds, contaminated with acid mine water, are often coated with odd yellow deposit of amorphous semigelationous $Fe(OH)_3$; H_2SO_4 of acid mine water destroys aquatic life in water bodies. Streams at pH 3.0 implies the presence of 0.5 x 10^{-3} M H_2SO_4.

The prevention of water pollution from acid mine water is tough challenge for environmental chemists.

Carbonate rocks have been suggested for remedial measures:

$$CaCO_3 + 2H+ + SO_{4+}^{2-} \longrightarrow Ca^{2+} + SO_4^{2-} + H_2O + CO_2 \uparrow$$

But with rise in pH as this reaction proceeds, Fe $(OH)_3$ present in the system covers the particles of carbonate rock with a relatively impermeable layer. This inhibits further neutralization of H_2SO_4.

7. Effects of Water Pollutants on Different Parameters:

Effect of water pollutants on different parameters most commonly associated with water quality are:
(i) Colour

(ii) Taste and odour

(iii) Hardness

(iv) pH

(I) COLOUR:
As the colourless pure water travels through nature, it becomes coloured by various impurities. The tannins, humic acid etc. present in the organic debris water is aesthetically unacceptable and unsuitable for bathing, laundering, beverage manufacturing, food processing etc.

(II) TASTE AND ODOUR:
The causative agents that impart perceptible taste and odour to water include minerals, metals, soil salts, iron, manganese, phenols, free chlorine, unsaturated hydrocarbons, hydrogen sulphide and end products from biological reactions. Water tastes bitter when contaminated with alkaline impurities and salty when the impurities are metallic salts.

Biological decomposition of organic debris impart a characteristic taste and odour of rotten eggs which is mainly due to hydrogen sulphide. Growth of algae, micro-organisms, hydrogen sulphide and ammonia give an obnoxious odour to water making if unfit for use. The unpleasant taste and odour is aesthetically unacceptable even though it may not pose any serious threat to health.

(III) HARDNESS:
Hardness is the property of water on account of which it consumes soap without forming lather freely. Multivalent metallic cations, (Calcium, Magnesium, Iron, Manganese, Strontium, Aluminium) in solution contribute to hardness in water.

Hardness may be temporary or permanent. Temporary hardness is due to the presence of carbonates and bicarbonates of calcium and is known as carbonate hardness. Whereas permanent hardness is due to presence of chlorides, sulphates and nitrates of calcium and magnesium and is known as non-carbonate hardness.

Hard water consumes soap and there by results in economic loss. Lathering occurs only after all the hardness ions are precipitated by the soap (the water gets ‘softened’ by the soap) and the precipitated (soap and ions) adheres to the surfaces of articles [skin (the precipitate present in the skin pores makes the skin feel rough) tub, sink, clothes, dishes etc.] Hard water results in scaling and even bursting of boilers and hot waste pipes through which it passes.

(IV) PH (H-ION CONCENTRATION):

The H-ion concentration or pH value is a measure of the degree of acidity or alkalinity of water. pH value extends from 0 (maximum acidity) to 14 (maximum alkalinity) with the mid value 7 corresponding to exact neutrality.

If pH is less than 7 (i.e. water is acidic) tuberculation and corrosion will be caused.

8. Problems Caused by Water Pollution:

This severe water pollution problem caused in the following ways:

(I) BACTERIAL AND VIRAL CONTAMINATION:

Sewage waters may contain a number of pathogenic bacteria and viruses. This is a threat to human health as they cause a number of water-borne diseases such as typhoid, dysentery, hepatitis etc. Some of these may assume an epidemic state.

Biological oxygen demand (BOD):

Biological oxygen demand is the amount of oxygen required for biological oxidation by microbes in any unit volume of water. The release of raw sewage into lakes, rivers, ponds etc. creates BOD due to the oxidative breakdown of the detritus by microorganisms.

The number of microbes (Escherichia coli) also increases tremendously which consumes most of the oxygen. The number of bacteria (E. coli) in unit volume of water (called E. coli index) is also taken as a parameter of water pollution. Inorganic nutrients (such as phosphorus) stimulate the production of organic detritus, adding to the BOD.

Sewages are oxygen-demanding wastes. In its worst effect, this type of pollution can deplete the surface water of its oxygen, leading to the suffocation of fish and other obligatory aerobic organisms. The dissolved oxygen (DO) value in water along with BOD is indicated by the kind of organisms present in water.

For example, fishes become rare at DO value of 4 to 5 ppm (mg/1). BOD values of raw sewage varies between 200 and 400 mg/1. Water fit for drinking should have a BOD value of less than 1 ppm.

Chemical Oxygen Demand (COD):

It is the amount of oxygen required by organic matter in a sample of water for its oxidation by strong chemical oxidant. It is a very important parameter in management and design of the treatment plants because of its rapidity in determining values.

These values are taken as basis for calculation of efficiency of treatment plants and to figure the standards for discharging industrial/domestic sewage effluents in various types of water bodies.

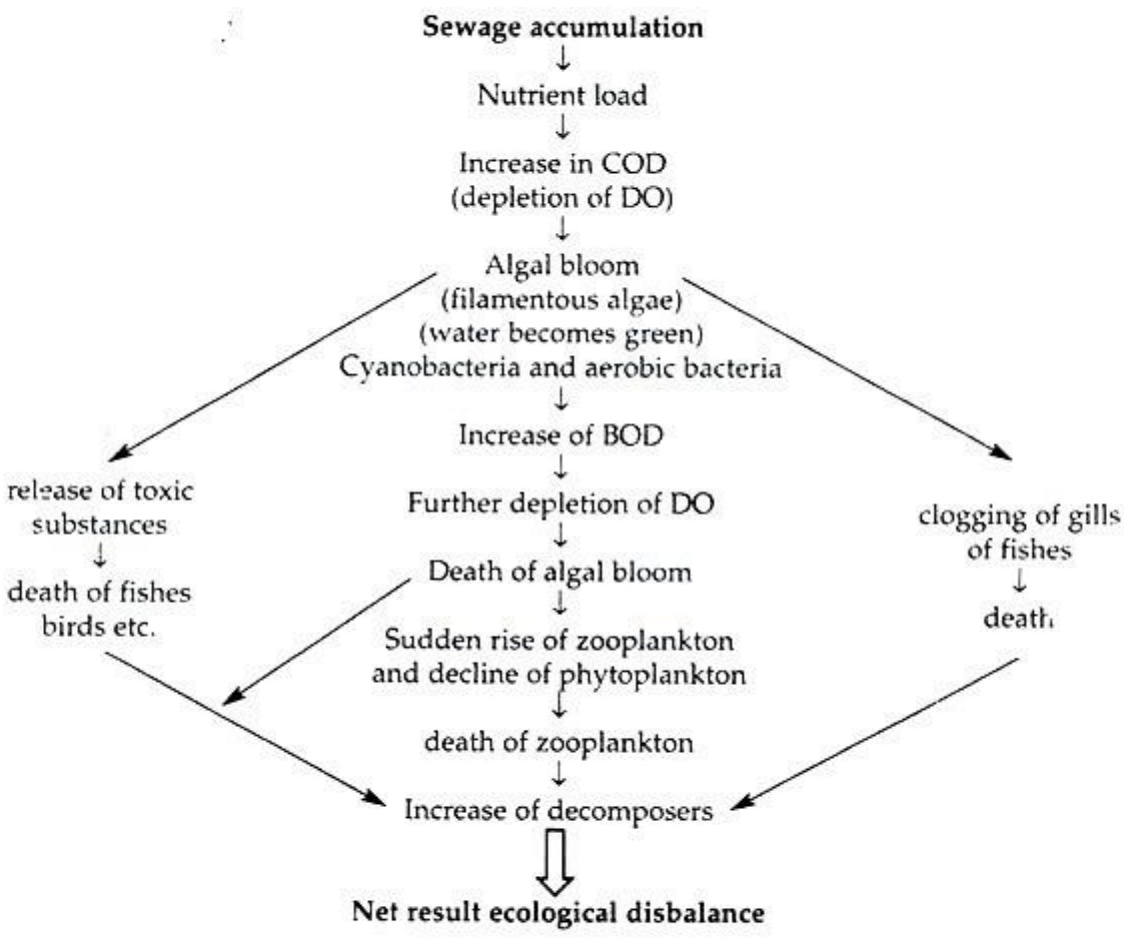
(II) EUTROPHICATION:

Sewage consists of nitrates, phosphates, sodium, potassium, calcium etc. and their addition into water bodies makes it rich in nutrients, especially phosphate and nitrate ions. These nutrients make the water bodies highly productive or eutrophic and the phenomena is called eutrophication.

The word eutrophication stems from two Greek words: eu, meaning 'good' or 'well' and trophic meaning 'food'. According to Hutchinson (1969), eutrophication is a natural process which literally means "wellnourished or enriched".

Addition of nutrients, stimulate luxuriant growth of algae in these waters. Algal bloom (often filamentous algae) floating on water forms a scum or blanket and are generally not utilised by zooplankton.

Some such phytoplankton bloom releases toxic chemicals which kill fishes, birds etc. Decomposition of blooms also lead to further oxygen-depletion in water. The entire process of eutrophication may be summarised in Flow Chart no. 4.1:



Flow Chart No. 4.1 : Process of eutrophication

Unlimited discharge of untreated sewage into a water body hastens the above process greatly. This accelerated process is sometime referred to as cultural eutrophication. Lakes, in which the nutrient level is high and characterised by frequent summer stagnation with algal bloom, are said to be eutrophic.

In their early stages of formation lakes, ponds etc. are generally nutrient-poor and this state is referred to as oligotrophic (Oligo meaning "small" or "deficient in"). Impoundments with intermediate nutrient level are called mesotrophic.

Effects of Organic Pollution:

The effects of sewage are:

1. Changes in faunal composition. Nymphs of stone fly and may fly are the first to disappear. As pollution increases caddis-fly larvae and many fishes requiring high levels of oxygen disappear. They are followed by shrimps, water fleas, leeches, snails and most of the fishes. At very high level of pollution there is very little dissolved oxygen and the animals present are the chironomid larvae (blood worms) and the oligochaete worm, Tubifex.

2. Species diversity decreases.

3. Phytoplankton biomass initially increases.

4. Turbidity increases and sedimentation makes the requirement of COD high.

5. Some decomposing plants and phytoplankton produce toxins. One such toxin, strychnine, secreted by decomposing plants kills animals including cattle.

6. BOD value increases.

7. Mortality of plants and animals takes place.

8. Ecological dis-balance occurs.

9. Water-borne diseases may occur and it may assume epidemic state.

10. Detrimental effect on the commercial and sport-fishing industry due to changes in the species of fish caused due to low dissolved oxygen.

11. Affects recreation and tourism due to excessive growth of algae and other aquatic plants, making the water and beaches unfit for recreation purposes.

12. Abundant algal bloom creates unpleasant taste and odour in water supplies and plugs filters in water treatment plants.

Control of Eutrophication:

Following methods should be undertaken to check eutrophication:

1. Swages must be treated before it is discharged into the water. This would limit nutrient input.

2. Stimulate bacterial multiplication which would reduce the amount of nutrients solubilized in water and check profuse algal growth.

3. Check recycling of nutrients by harvesting and removal of algal blooms upon their death.

4. Removal of excess dissolved nutrients from water by physical or chemical method. Example, phosphorus can be removed by precipitation; nitrogen by biological nitrification and de-nitrification.

5. Where oxygen depletion is a serious concern, mechanical aeration may help, which is a stop-gap measure.

6. Non-point source of load, such as agricultural runoff, can be reduced through land management techniques that prevent soil erosion and avoid excessive use of fertilisers.

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9. Effects of Water Pollution:

All organisms need water for their metabolic activities. It is even used as a habitat by many organisms. Besides direct consumption (washing, bathing, drinking) man uses water for a multitude of purposes like irrigation, industry, navigation, recreation, construction work, power generation and waste disposal.

Different type of water uses require different levels of water purity with the highest level of purity being required for drinking water. Pollutants bring about many physical and chemical changes in water, for instance, suspended particles make water turbid; dyes, chromium and iron compounds change the colour of water; phenols, oils, detergents, hydrocarbons, chlorine etc. impart an unpleasant taste to water.

As it is a vital resource essential for sustaining life, contamination of water has immediate as well as far reaching effects on the health and environment of living organisms.

HEALTH HAZARDS OF WATER POLLUTION:
(a) Phosphorus and Nitrates from fertilizers and detergents contaminate surface waters where they act as nutrients and promote the growth of oxygen consuming algae which reduce the D.O. level of water, killing fish and other aquatic organisms.

(b) Industrial effluents result in the addition of poisonous chemicals such as Arsenic, Mercury, Cadmium, Lead etc. which kill aquatic organisms and may reach human body through contaminated food (i.e. fishes etc.)

(c) Domestic, commercial and industrial effluents (petroleum refineries, paper mills, distilleries, tanneries, slaughter houses) contaminate the water with organic pollutants.

These provide nutrition for micro-organisms which decompose the organic matter and consume oxygen and reduce the D.O. level of the aquatic system there by killing the aquatic organisms.

(d) Non-biodegradable pesticides (especially organochlorines) travel through food chains and ultimately reach human body where they accumulate in the fatty tissues and affect the nervous system.

(e) Water borne infectious enteric diseases like typhoid, bacillary dysentery, cholera and amoebic dysentery are the predominant health hazards arising from drinking contaminated water.

(f) Fluoride containing pollutants cause fluorosis i. e. neuromuscular, respiratory gastro intestinal and dental problems.

(g) Thermal pollution of water reduces the D.O. level of the aquatic system making it incapable of supporting life.

(h) Oil pollutants have been known to be responsible for the death of many water birds and fishes.

10. Control of Water Pollution:

The following measures can be taken to control water pollution:

I. THERMAL POLLUTION:

For minimising thermal pollution, hot water should be cooled before release from factories, and removal of forest canopies and irrigation return flows should be prohibited.

II. PROHIBITION:

Besides reserving separate water supplies for livestock, the following prohibition should be enforced to avoid contamination of the main sources of drinking water.

(a) Bathing and washing of clothes in rivers and streams.

(b) Discharging untreated or treated domestic, commercial and industrial sewage in water bodies.

III. JUDICIOUS USE:

Pesticides (preferably less stable) and fertilizers should be very judiciously used to avoid chemical pollution of water through agricultural farm run-offs.

IV. REUSE OF WATER:

The treated waste water can be reused for several purposes, for instance:

(a) Treated water can be reused for recreation purposes like fishing and boating.

(b) Treated water can be reused as industrial water supply.

(c) Reclaimed waste water can be used for irrigation or municipal purposes.

(d) Treated water can be reused for cooling processes in thermal plants.

(e) In area of acute water scarcity, waste water treated to the highest standards can be reused as potable water (provided there is public acceptance for waste water use).

V. LEGISLATION:

For effective control of water pollution, legal provisions regarding water pollution should be enforced by a special administrative machinery comprising of highly qualified and experienced personnel.

Preservation of Water Samples:

It is essential to protect samples from changes in composition and deterioration with aging due to various interactions. The optimum sample holding times range from zero for parameters such a pH, temperature and D.O, to one week for metals. The preservation techniques for various parameters are summarized in Table 7. 2.

Table 7.2 Water sample preservation.

Parameter	*Minimum Sample size, ml.*	*Container*	*Preservation*
1	2	3	4
pH	100	Polythene	Measure within 0-4 hrs.
D.O.	100	Polythene	
C.O.D.	500	Polythene	Add H_2SO_4 to pH; refrigerate.

Water Sampling:

The significance of a chemical analysis to a large extent depends on the sampling programme. An ideal sample should be one which is both valid and representative. These conditions are met by collection of samples through a process of random selection.

This ensures that the composition of the sample is identical to that of the water body from which it is collected and the sample shares the same physicochemical characteristic with the sampled water at the time and site of sampling.

The relevant factors for any sampling program are:

(a) Frequency of sample collection,

(b) Total number of samples,

(c) Size of each sample,

(d) Sites of sample collection,

(e) Method of sample collection,

(f) Data to be collected with each sample, and

(g) Transportation and care of samples prior to analysis.

For analysis of natural and waste water, two principal types of sampling procedures are employed:

1. Spot or grab samples are discrete portions of water samples taken at a given time. A series of grab samples, collected from different depth at a given site, reflect variations in constituents over a period of time. The total number of grab samples should satisfy the requirements of the sampling programme.

2. Composite samples are essentially weighted series of grab samples, the volume of each being proportional to the rate of flow of the water stream at the time and site of sample collection. Samples may be composited over any time period, such as 4, 8 or 24 hours, depending on the purpose of analysis.

Such composite samples are useful for determining the average condition which, when correlated with flow, can be used for computing the material balance of a stream of water body over a period of time.

It may be stated, in general, that it is more meaningful to analyze a large number of separate samples taken at different times and different locations than to compile and analyse a single representative sample.

Separate samples must be collected for chemical and biological analysis since the sampling and preservation techniques are quite different. For accurate analysis, it is desirable to allow a short time interval between sampling and analysis. As a matter of fact, temperature, pH and dissolved gases (D.O.) must be determined in the field and as quickly as possible after sampling.

Redox reactions are likely to cause large errors in analysis. Thus, soluble iron (I) and manganese (II) are oxidized to insoluble iron (III) and manganese (IV) compounds as an anaerobic water sample absorbs O_2 from the atmosphere.
Microbial activity reduces phenol or C.O.D. values change the NO 3 – NO_2– $NH^+{}_3$ balances, or alters to oxidation Cr (VI) may be reduced to Cr (III), which precipitate readily, Na,SiO_2 and B are leached from glass container walls. Colour, odour and turbidity change with aging of sample. These are some of the problems which can only be solved through careful preservation techniques.
Collection of truly representative sample is as important as sample preservation. A representative single sample is taken from a number of different locations over a long period of time. In general, it is more significant to analyse a large number of separate samples taken at different times and different locations. Then it is to complete and analyse a sample representative sample.

Recon centration techniques.

Carbon absorption method

Freeze concentration

Solvent extraction

Ion exchange.

11. Examples of Water Pollution:

(I) THE GANGA BASIN:
The Ganga basin is the largest river basin in India, with geographical area of 9,00,000 sq. km. and a stretch of 2525 km. It may be compared to the river Nile (6,650 km) and Amazon (6500 km) but it carries the heaviest sediment load (2.4 billion metric tonnes per year).

This huge sediment load is due to (a) high erosion rate of Himalayan rocks (birthplace of Ganga), (b) large size of drainage basin with steep angle of elevation in the Himalayan region, (c) numerous tributaries transporting soil to the main stream, (d) dense population in most part of the basin with their intense agricultural practices.

Each year about 1,15,000 tonnes of fertilizers are washed away with agricultural waste water into the Ganga-they include 88,600 tons of N, 17,000 tons of P and 9,200 tonnes of K. The water holding capacity of the Ganga and its tributaries are getting reduced due to high rate of siltation, leading to devastating floods at regular intervals during the current century.

The Ganga basin in the home of about 37% of the total population of the country. About 84% of the people live in rural areas while 16% are distributed in 692 cities and towns of the basin.

The overall density of population is 300 persons per sq. km., compared to 200 for the whole of India. The highest density of rural population is found in the lower Gangetic plain e.g. in W.B. with 475 persons per sq. km. It has increased to 20,000 persons per sq. km in the industrial belts of Hooghly and 24 paragraph.

The high intensity of cultivation in the rural sectors, high population density and high concentration of factories in towns and cities account for generation of huge amounts of organic and inorganic pollutants in the basin most of which finally find their way into the main stream.

Taking the basin as a whole, the average amount of BOD load comes to 24 g. per person per day in the rural sector and 64 g. per person per day in the urban.

Monitoring of the water quality in terms of the standard parameters reveals that the upper stretch (Rishikesh upstream of Kanpur) is the best clean range (D.O. 8-9; B .O.D. < 2) while Kanpur – 50 km. downstream (45 tanneries, 10 textile mills, 2 jute mills and many chemical and pharmaceutical units) is polluted (D.O. 4-6; B.O.D. 10-50); Varanasi is the second polluted zone (D.O. 8-9; B.O.D. 4-24) while Hoogly near Calcutta is the most polluted zone (D.O. 4-7; B.O.D. 4-50).

The Hooghly river near Calcutta is contaminated with waste effluents from about 150 industries (including 87 jute mills, 12 textile mills, 7 tanneies, 5 paper mills and 4 distilleries) as well as domestic sewage from 360 out falls on both sides of the river.

Hooghly estuarine water does not show any significant pollution level of inorganic but has considerable organics (pesticides) while the sediment is quite rich in toxic metal levels (Diamond Harbour, Cd 6.6, Cr 26.5, Pb 516 mg/kg) and organochlorine pesticides (B.H.C. 25-125 ppb; D.D.T. 0.25-4.5 ppb).

This has adverse impact on the health status of the population residing in the estuarine areas. The population showed higher levels of heavy metals and pesticides in their hair (cd 3-5 ppm, Cr 2 ppm, Pb 50 ppm) respectively.

(II) THE DAMODAR VALLEY: DURGAPUR ASANSOL PROFILE:

The river Damodar originates from Chhotanagpur plateau in Bihar, crosses about 500 km through Bihar and W. Bengal and joins the Hooghly river opposite Falta at a distance of 58 km. South of Calcutta. The Damodar valley from Durgapur to Asansol forms the largest industrial complex in W. Bengal and the eastern region. This area is known as the "River of India".

Its high record of pollution is due to indiscriminate discharge of huge quantities of pollutants generated by industries, mining and mineral processing industries which are concentrated on both sides or in the proximity of the river.

Besides mining, transport and trade, there are some 50 large, 100 medium and 200 small industries units extending from Giddi in Hibar to Durgapur in W.B. along the mid-river stretch of 300 km. The river segments upstream of Giddi and downstream of Bardhaman are much less significant in terms of water pollution.

Indian Iron and Steel Co., Cycle Corporation of India, Carew and Co., Bengal Paper Mill and Durgapur steel plant discharge various types of pollutant (some are non-degradable and persistent) which accumulate in Durgapur barrage water.

The concentration of these toxic pollutants in barrage water are above the permissible limits for surface water. Thus tannin – lignin (0.9 ppm), NH_3 (0.5-6 ppm), phenol (0.002 ppm) are found in barrage water, exceeding their respective tolerance limits.

It should be noted that the barrage water remains the sources of domestic water supply for Durgapur city. The conventional water treatment methods fail to remove organic matter, phenol and toxic metals so that these find their way into domestic water supply.

Furthermore, in the process of water treatment, chlorination enhances toxicity of water by formation of toxic chloramines and chlorophenols through reactions with NH_3 and phenol respectively. Thus the residents of the city are constantly exposed to these toxic pollutants in their domestic water supply.
On the other hand, the downstream river (beyond Durgapur barrage) is contaminated by Tamla Nalah and HFC drain. The Tamla Nalah delivers a heavy pollution load to the river-phenol (0.02 – 2.0 ppm), NH_3 (10-40 ppm), C.O.D. (80-350 mg/I), sulphide (1.5-15 ppm), Hg (0.01-0.05 ppm) which are deposited in the river bed. The sediments containing these parameters in 10 to 100 fold excess act as storehouse of these pollutants and supply these pollutants continuously by leaching action throughout the river course in the region. People in the industrial belt are constantly exposed to health hazards due to synergic effect of water pollution and industrial air pollution. The incidences of liver diseases such as hepatitis, jaundice, dysentery etc. and respiratory diseases such as bronchitis, bronchial asthma, pulmonary tuberculosis etc. are quite high in the INDUSTRIAL BELT

12. Water Pollution Control and Management:

Clean water is essential for healthy environment to support life systems on this planet. The task of delicately balancing the ratio of available and exploitable water resources and sustaining their quality is most relevant in India where rainfall distribution is uneven and confined to 3-4 months in a year.

Moreover, anthropogenic global and local climatic distortions resulting from global warming due to greenhouse gases, denudation of forest canopy, loss of top soil and severe environmental degradation have adverse impact on the monsoon pattern in India.

Hence in-spite of vast water resources in lakes and rivers and good monsoon, India faces perennial problems of floods and droughts and highly polluted water resources.