ASSESSEMENT OF FRESHWATER POLLUTION

Key words: Acids, Detergents, Metals, Humans

Fig – 22.1

INTRODUCTION

Freshwater, an essential element for all forms of life, is a crucial resource for Asia. The withdrawal of freshwater from rivers, lakes, and underground reservoirs for human consumption has grown tremendously since the later part of the 19th century. Increasing population, urbanization and rapid growth of economic activities is imposing severe demand on the limited freshwater supply. The growing imbalance between supply and demand has already led to shortages owing to completion, which is likely to become more critical with time. Unfortunately, the scarcity of water is also being accompanied by deteriorating water quality owed to pollution and environmental degradation. This carries serious consequences to human health, terrestrial and aquatic ecosystems.

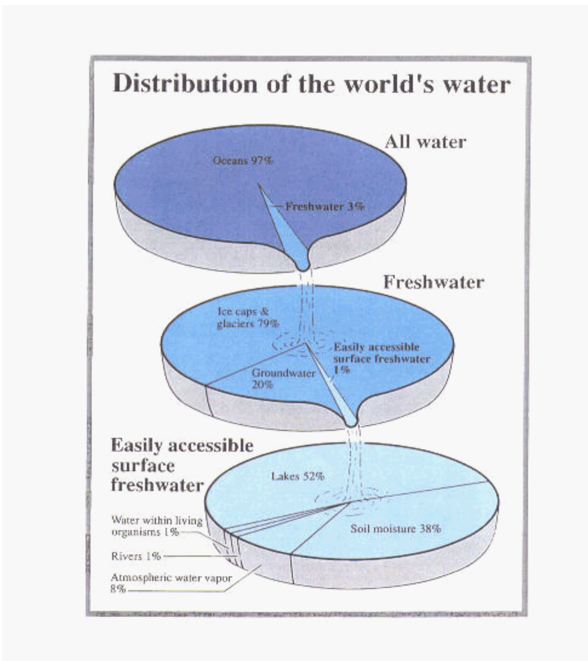

Fig – 22.2

Freshwater pollution is the contamination of inland water (not saline) with substances that make it unfit for its natural or intended use. Pollution may be caused by faecal waste, chemicals, pesticides, petroleum, sediment, or even heated discharges. Polluted rivers and lakes are unfit for swimming or fishing; polluted water is unsafe to drink. There have been listed some 1500 substances as pollutants in freshwater ecosystems, and each of them occurs in the following types of freshwater pollutants. Some of them are:

1. **Acids & Alkalis**

   Unpolluted deposition (or rain), in balance with atmospheric carbon dioxide, has a pH of 5.6. Almost everywhere in the world the pH of rain is lower than this. The main pollutants responsible for acid deposition (or acid rain) are sulfur dioxide (SO2) and nitrogen oxides (NOx). Acid deposition influences mainly the pH of freshwater.

   Nitrogen and sulfuric emissions come from natural and anthropogenic sources. Natural emissions include e.g. volcano emissions, lightning, and microbial processes. Power stations and industrial plants, like the mining and smelting of high-sulfur ores and the combustion of fossil fuels, emit the largest quantities of sulfur and nitrogen oxides and other acidic compounds. These compounds mix with water vapor at unusual proportions to cause acid deposition with a pH of 4.2 to 4.7. That is 10 or more times the acidity of natural deposition.

   The acidification of freshwater in an area is dependent on the quantity of calcium carbonate (limestone) in the soil. Limestone can buffer (neutralize) the acidification of freshwater. The effects of acid deposition are much greater on lakes with little buffering capacity. Much of the damage to aquatic life in sensitive areas with this little buffering capacity is a result of 'acid shock'. This is caused by the sudden runoff of large amounts of highly acidic water and aluminium ions into lakes and streams, when snow melts in the spring or after unusually heavy rains.

   Effects on aquatic life

   Most freshwater lakes, streams, and ponds have a natural pH in the range of 6 to 8. Acid deposition has many harmful ecological effects when the pH of most aquatic systems falls below 6 and especially below 5.

   Here are some effects of increased acidity on aquatic systems:

- As the pH approaches 5, non-desirable species of plankton and mosses may begin to invade, and populations of fish such as smallmouth bass disappear.
- Below a pH of 5, fish populations begin to disappear, the bottom is covered with undecayed material, and mosses may dominate nearshore areas.
- Below a pH of 4.5, the water is essentially devoid of fish.
- Aluminium ions (Al3+) attached to minerals in nearby soil can be released into lakes, where they can kill many kinds of fish by stimulating excessive mucus formation. This asphyxiates the fish by clogging their gills. It can also cause chronic stress that may not kill individual fish, but leads to lower body weight and smaller size and makes fish less able to compete for food and habitat.

- The most serious chronic effect of increased acidity in surface waters appears to be interference with the fish' reproductive cycle. Calcium levels in the female fish may be lowered to the point where she cannot produce eggs or the eggs fail to pass from the ovaries or if fertilized, the eggs and/or larvae develop abnormally (EPA, 1980).

  Extreme pH can kill adult fish and invertebrate life directly and can also damage developing juvenile fish. It will strip a fish of its slime coat and high pH level 'chaps' the skin of fish because of its alkalinity.

  When the pH of freshwater becomes highly alkaline (e.g. 9.6), the effects on fish may include: death, damage to outer surfaces like gills, eyes, and skin and an inability to dispose of metabolic wastes. High pH may also increase the toxicity of other substances. For example, the toxicity of ammonia is ten times more severe at a pH of 8 than it is at pH 7. It is directly toxic to aquatic life when it appears in alkaline conditions. Low concentrations of ammonia are generally permitted for discharge.

2. Anions

The term cyanide refers to a singularly charged anion consisting of one carbon atom and one nitrogen atom joined with a triple bond, CN^-. The most toxic form of cyanide is free cyanide, which includes the cyanide anion itself and hydrogen cyanide, HCN, either in a gaseous or aqueous state. One teaspoon of a 2% cyanide solution can kill a person.
At a pH of 9.3 - 9.5, CN^- and HCN are in equilibrium, with equal amounts of each present. At a pH of 11, over 99% of the cyanide remains in solution as CN^-, while at pH 7, over 99% of the cyanide will exist as HCN. Although HCN is highly soluble in water, its solubility decreases with increased temperature and under highly saline conditions. Both HCN gas and liquid are colorless and have the odor of bitter almonds, although not all individuals can detect the odor.

Cyanide is frequently used in a mining technology called cyanide heap leaching. It is a cheap way to extract gold from its ore. Goldminers spray a cyanide solution (which reacts with gold) into huge open-air piles of crushed ore. They then collect the solution in leach beds and overflow ponds, recirculate it a number of times, and extract gold from it. (Cyanidation)

A problem with this technology is that cyanide is extremely toxic to birds and mammals drawn to cyanide solution collection ponds as a source of water. These ponds also can leak or overflow, posing threats to underground drinking water supplies and wildlife in lakes and streams. Because cyanide breaks down heavy metals, it can form complexes with other metals or chemicals, which can be as toxic as cyanide itself. Especially fish and aquatic invertebrates are particularly sensitive to cyanide exposure. It blocks the absorption of oxygen by cells and causes the species to suffocate. Aquatic lifes are killed by cyanide concentrations in the microgram per liter (part per billion) range, whereas bird and mammal deaths result from cyanide concentrations in the milligram per liter (part per million) range. Concentrations of free cyanide in the aquatic environment ranging from 5.0 to 7.2 micrograms per liter reduce swimming performance and inhibit reproduction in many species of fish. Other adverse effects include delayed mortality, pathology, susceptibility to predation, disrupted respiration, osmoregulatory disturbances and altered growth patterns.

Concentrations of 20 to 76 micrograms per liter free cyanide cause the death of many species, and concentrations in over 200 micrograms per liter are rapidly toxic to most species of fish. Invertebrates experience adverse nonlethal effects at 18 to 43 micrograms per liter free cyanide, and lethal effects at 30 to 100 micrograms per liter. Chronic cyanide exposure may affect reproduction, physiology, and levels of activity of many fish species, and may render the fishery resource non-viable. The sensitivity of aquatic organisms to cyanide is highly species specific, and is also affected by water pH, temperature and oxygen content, as well as the life stage and condition of the organism.

Algae and macrophytes can tolerate much higher environmental concentrations of free cyanide than fish and invertebrates, and do not exhibit adverse effects until 160 micrograms per liter or more. Aquatic plants are unaffected by cyanide at concentrations that are lethal to most species of freshwater fish and invertebrates.

Under aerobic conditions, microbial activity can degrade cyanide to ammonia, which then oxidizes to nitrate. This process has been shown effective with cyanide concentrations of up to 200 parts per million. Although biodegradation also occurs under anaerobic conditions, cyanide concentrations greater than 2 parts per million are toxic to these microorganisms.

3. Detergents

Detergents are organic compounds, which have both polar and non-polar characteristics. They tend to exist at phase boundaries, where they are associated with both polar and non-polar media. Detergents are of three types: anionic, cationic, and non-ionic. Anionic and cationic have permanent negative or positive charges, attached to non-polar (hydrophobic) C-C chains. Non-ionic detergents have no such permanent charge; instead, they have a number of atoms which are weakly electropositive and electronegative. This is due to the electron-attracting power of oxygen atoms.

There are two kinds of detergents with different characteristics: phosphate detergents and surfactant detergents. Detergents that contain phosphates are highly caustic, and surfactant detergents are very toxic. The differences are that surfactant detergents are used to enhance the wetting, foaming, dispersing and emulsifying properties of detergents. Phosphate detergents are used in detergents to soften hard water and help suspend dirt in water.

Detergents are very widely used in both industrial and domestic premises like soaps and detergents to wash vehicles. The major entry point into water is via sewage works into surface water. They are also used in pesticide formulations and for dispersing oil spills at sea. The degradation of alkylphenol polyethoxylates (non-ionic) can lead to the formation of alkylphenols (particularly nonylphenols), which act as endocrine disruptors.

High phosphate detergents such as tri-sodium phosphate (TSP) can be purchased at some paint and hardware stores. Regular cleaning with high phosphate detergents has proven to be effective in reducing lead dust. Lead dust accumulates in window wells and around doors or any other high friction surfaces.

Detergents can have poisonous effects in all types of aquatic life if they are present in sufficient quantities, and this includes the biodegradable detergents. All detergents destroy the external mucus layers that protect the fish from bacteria and parasites; plus they can cause severe damage to the gills. Most fish will die when detergent concentrations approach 15 parts per million. Detergent concentrations as low as 5 ppm will kill fish eggs. Surfactant detergents are implicated in decreasing the breeding ability of aquatic organisms.

Detergents also add another problem for aquatic life by lowering the surface tension of the water. Organic chemicals such as pesticides and phenols are then much more easily absorbed by the fish. A detergent concentration of only 2 ppm can cause fish to absorb double the amount of chemicals they would normally absorb, although that concentration itself is not high enough to affect fish directly.

Phosphates in detergents can lead to freshwater algal blooms that releases toxins and deplete oxygen in waterways. When the algae decompose, they use up the oxygen available for aquatic life.

The main contributors to the toxicity of detergents were the sodium silicate solution and the surfactants-with the remainder of the components contributing very little to detergent toxicity. The potential for acute aquatic toxic effects due to the release of secondary or tertiary sewage effluents containing the breakdown products of laundry detergents may frequently be low. However, untreated or primary treated effluents containing detergents may pose a problem. Chronic and/or other sublethal effects that were not examined in this study may also pose a problem.

4. **Domestic Sewage And Farm Manures**

5. **Food Processing Wastes (Including Processes Taking Place On The Farm)**

6. **Gases (E.G. Chlorine, Ammonia)**

Effluents are often complex mixtures of poisons. If two or more poisons are present together in an effluent they may exert a combined effect on an organism wich is additive. Some gases that can harm aquatic freshwater life are gases such as chlorine, ammonia and methane. Chlorine is very additive in combination with copper. It does not normally occur in the environment except as a yellow gas on rare occasions. It's a manufactured substance and the byproducts of chlorine (organochlorines and dioxins) are persistent in the environment. One of the largest uses of chlorine is in the paper industry. Chlorine is first used to break down the lignan that holds the wood fibers together. Then chlorine is used to bleach the paper to make it white.

The effluent or wastewater containing dioxins and other organochlorines are then dumped into streams and waterways. These ingredients are highly toxic and carcinogenic. Once in the waste stream, they come into contact with other organic materials and surfactants and combine to form a host of extremely toxic organic chemicals.

The water becomes polluted; the fish become contaminated; animals eat the fish and people eat the contaminated animals and fish.

It is so widespread that it would be difficult to find any human being who does not have detectable levels of dioxin in his/her blood.

Some environmentalists call for a ban on the use of chlorine as bleach in the pulp and the paper industry around the Great Lakes.

7. **Heat**

There are various effects on the biology of the ecosystems when heated effluents reach the receiving waters. The species that are intolerant to warm conditions may disappear, while others, rare in unheated water, may thrive so that the structure of the community changes. Thermal pollution can have a great influence on the aquatic ecosystem. Species that are restricted to heated waters, can build up large populations in the receiving waters. Respiration and growth rates may be changed and these may alter the feeding rates of organisms. The reproduction period may be brought forward and development may be speeded up. Parasites and diseases may also be affected.

An increase of temperature also means a decrease in oxygen solubility. Any reduction in the oxygen concentration of the water, particularly when organic pollution is also present, may result in the loss of sensitive species.

Possibly the most damaging environmental effect of a power station is the many organisms that may be sucked in through the water intake. Larger creatures, such as fish, are killed on the intake screens while smaller species pass through the plant. Even algae may be damaged, with permanent impairment of the photosynthetic mechanism. Liquid water changes temperature slowly because it can store a large amount of heat without a large change in temperature. This high heat capacity helps protect living organisms from temperature fluctuations, moderates the earth’s climate and makes water an excellent coolant for car engines, power plants and heat-producing industrial processes. But when water is used in the industry, it is hot and it will be spilled through a discharge pipe into a river. This increase in temperature will reduce the amount of oxygen in the river. That can affect the level of oxygen freely available to organisms, which in turn affects respiration and essentially their way of life. For example, the metabolism rate is largely dependent upon the temperature of an animal's body. Animals display several different types of thermal adaptations to their environment. Two particularly prevalent types include ectotherms and endotherms. In ectotherms (an animal whose body temperature varies with the temperature of its surroundings; any animal except birds and mammals), the body temperature will be low in a cold environment and high in a warm environment. For example, in summer fish may have high metabolic rates because their body temperatures are elevated in the warm water. At the same time they are faced with relatively low oxygen availability because warm water holds less dissolved oxygen than cold water. The interaction of these factors may prove critical. For this reason there is a growing concern among ecologists about the heating of aquatic habitats by effluents from industrial and nuclear generating facilities. Heated water can kill animals and plants that are accustomed to living at lower temperatures.

8. **Metals** (e.g. cadmium, lead, mercury)

Three countries—the United States, Germany, and Russia—with only 8% of the world's population consume about 75% of the world's most widely used metals. The United States, with 4.5% of the world's population, uses about 20% of the worlds metal population and 25% of the fossil fuels produced each year.

Metals are introduced in aquatic systems as a result of the weathering of soils and rocks, from volcanic eruptions, and from a variety of human activities involving the mining, processing, or use of metals and/or substances that contain metal pollutants. The most common heavy metal pollutants are arsenic, cadmium, chromium, copper, nickel, lead and mercury. There are different types of sources of pollutants: point sources (localized pollution), where pollutants come from single, identifiable sources. The second type of pollutant sources are nonpoint sources, where pollutants come from dispersed (and often difficult to identify) sources. There are only a few examples of localized metal pollution, like the natural weathering of ore bodies and the little metal particles coming from coal-burning power plants via smokestacks in air, water and soils around the factory.

The most common metal pollution in freshwater comes from mining companies. They usually use an acid mine drainage system to release heavy metals from ores, because metals are very soluble in an acid solution. After the drainage process, they disperse the acid solution in the groundwater, containing high levels of metals. See also acids & alkalis.

The term 'heavy metal' is somewhat imprecise, but includes most metals with an atomic number greater than 20, and excludes alkali metals, alkaline earths, lanthanides and actinides.

When the pH in water falls, metal solubility increases and the metal particles become more mobile. That is why metals are more toxic in soft waters. Metals can become 'locked up' in bottom sediments, where they remain for many years. Streams coming from draining mining areas are often very acidic and contain high concentrations of dissolved metals with little aquatic life. Both localized and dispersed metal pollution cause environmental damage because metals are non-biodegradable. Unlike some organic pesticides, metals cannot be broken down into less harmful components in the environment.

Campbell and Stokes (1985) described two contrasting responses of an organism to a metal toxicity with declining pH:

- If there is little change in speciation and the metal binding is weak at the biological surface, a decrease in pH will decrease owning to competition for binding sites from hydrogen ions.
- Where there is a marked effect on speciation and strong binding of the metal at the biological surface, the dominant effect of a decrease in pH will be to increase the metal availability.

Generally the ionic form of a metal is more toxic, because it can form toxic compounds with other ions. Electron transfer reactions that are connected with oxygen can lead to the production of toxic oxyradicals, a toxicity mechanism now known to be of considerable importance in both animals and plants. Some oxyradicals, such as superoxide anion (O2-) and the hydroxyl radical (OH-), can cause serious cellular damage.

Some inorganic pollutants are assimilated by organisms to a greater extent than others. This is reflected in the Bioconcentration Factor (BCF), which can be expressed as follows:

BCF = concentration of the chemical in the organism / concentration of the chemical in the ambient environment.

The ambient environment for aquatic organisms is usually the water or sediments. With inorganic chemicals, the extent of long-term bioaccumulation depends on the rate of excretion. Toxic chemicals can be stored into tissues of species, especially fat tissues. Bioaccumulation of cadmium in animals is high compared to most of the other metals, as it is assimilated rapidly and excreted slowly. Also the sensitivity of individuals of a particular species to a pollutant may be influenced by factors such as sex, age, or size. In general the concentrations of metals in invertebrates are inversely related to their body mass. In fish, the embryonic and larval stages are usually the most sensitive to pollutants.

Benthic organisms are likely to be the most directly affected by metal concentrations in the sediments, because the benthos is the ultimate repository of the particulate materials that are washed into aquatic systems.

Metal tolerance

Some metals, such as manganese, iron, copper, and zinc are essential micronutrients. They are essential to life in the right concentrations, but in excess, these chemicals can be poisonous. At the same time, chronic low exposures to heavy metals can have serious health effects in the long run.

Tolerance to metals has also been recorded in invertebrates and in fish. After exposure for 24 hours to a copper concentration of 0.55 mg/l, rainbow trout showed a 55 per cent inhibition of sodium uptake and a 4 per cent reduction in affinity for sodium, which resulted in an overall decrease in total sodium concentration of sulphydryl-rich protein (Lauren and McDonald 1987a,b). The protein was considered to be a metallothionein. These low molecular weight proteins contain many sulphur-rich amino acids which bind and detoxify some metals. The pretreatment of an organism with low doses of a metal may stimulate metallothionein synthesis and provide tolerance during a subsequent exposure (Pascoe and Beattie, 1979).

Many rivers are polluted with heavy metals from old mine workings and some species of algae become very tolerant to polluted conditions. A survey of 47 sites with different concentration of zinc found the filamentous green alga 'Hormidium rivulare' to be abundant everywhere, tolerating zinc concentrations as high as 30.2 mg Zn/l.

Toxicity of metals

For the protection of human health, the maximum permissible concentrations for metals in natural waters that are recommended by the Environmental Protection Agency (EPA), are listed below:

Maximum Permissible Concentrations (MPC) of Various Metals in Natural Waters For the Protection of Human Health

Metal	Chemical Symbol	mg m^{-3}
Mercury	Hg	0.144
Lead	Pb	5
Cadmium	Cd	10
Selenium	Se	10
Thallium	Tl	13
Nickel	Ni	13.4
Silver	Ag	50
Manganese	Mn	50
Chromium	Cr	50
Iron	Fe	300
Barium	Ba	1000

Source: EPA (1987); Federal Register 56 (110): 26460-26564 (1991).

This table gives an idea of the relative toxicity of various metals. Mercury, lead and cadmium are not required even in small amounts by any organism.

Because metals are rather insoluble in neutral or basic pH, pHs of 7 or above give a highly misleading picture of the degree of metal pollution. So in some cases it may underestimate significantly the total of metal concentrations in natural waters.

9. **Nutrients** (especially phosphates, nitrates)

Aquatic plants (like any other plants) need two essential nutrients to grow: nitrogen (N) and phosphorus (P). In a healthy lake the nutrients occur in small amounts. But in large quantities, they can cause a major water pollution problem. Too many nutrients stimulate the rapid growth of plants and algae, clogging waterways and sometimes creating blooms of toxic blue-green algae. This process is called eutrophication. The result of this is that when the plants and algae die and decompose, they use up large amounts of oxygen (O2). So the amount of oxygen that is available for fish and other aquatic species will be reduced. In extreme cases it can lead to a completely oxygenl ess environment that can support nothing except a few species of anaerobic bacteria. It also can kill fish and other aquatic life and reduce the aesthetic and recreational value of the lake.

The nutrients include nitrates found in sewage and fertilizers, and phosphates found in detergents and fertilizers. Human inputs of nutrients from the atmosphere and from nearby urban and agricultural areas can accelerate the natural eutrophication of lakes, a process called cultural eutrophication.

Nutrients from urban sources may be derived from domestic sewage, industrial wastes and storm drainage. The contribution of nitrogen and phosphorus per person per day averages 10.8 g N and 2.2 g P, though there is a considerable range. In the 1940s detergents were developed containing sodium tripolyphosphate, which softens water by neutralizing calcium and keeps dirt in suspension once it has washed off clothes. These are the principal sources of nutrient overload causing cultural eutrophication in lakes. The amount of each source varies according to the types and amounts of human activities occurring in each airshed and watershed.

10. Oil And Oil Dispersants

11. **Organic Toxic Wastes** (e.g. formaldehyde, phenols)

Organic pollution occurs when large quantities of organic compounds, which act as substrates for microorganisms, are released into watercources. During the decomposition process the dissolved oxygen in the receiving water may be used up at a greater rate than it can be replenished, causing oxygen depletion and having severe consequences for the stream biota. Organic effluents also frequently contain large quantities of suspendid solids which reduce the light available to photosynthetic organisms and, on settling out, alter the characteristics of the river bed, rendering it an unsuitable habitat for many invertebrates. Toxic ammonia is often present.

Organic pollutants consist of proteins, carbohydrates, fats and nucleic acids in a multiplicity of combinations. Raw sewage is 99,9 per cent water, and of the 0,1 per cent solids, 70 per cent is organic (65 per cent proteins, 25 per cent carbohydrates, 10 per cent fats). Organic wastes from people and their animals may also be rich in disease-causing (pathogenic) organisms.

Origins of organic pollutants

Organic pollutants originate from domestic sewage (raw or treated), urban run-off, industrial (trade) effluents and farm wastes. Sewage effluents is the greatest source of organic materials discharged to freshwaters. In England and Wales there are almost 9000 discharges releasing treated sewage effluent to rivers and canals and several hundred more discharges of crude sewage, the great majority of them tot the lower, tidal reaches of rivers or, via long outfalls, to the open sea. It has been assumed, certainly incorrectly, that the sea has an almost unlimited capacity for purifying biodegradable matter.

The effects of organic effluents on receiving waters

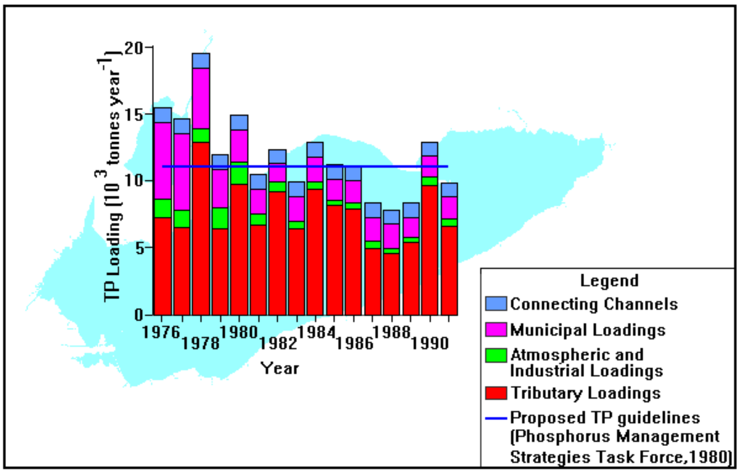

Fig – 22.3

When an organic polluting load id discharged into a river it is gradually eliminated by the activities of micro organisms in a way very similar to the processes in the sewage treatment works. This self-purification requires sufficient concentrations of oxygen, and involves the breakdown of complex organic molecules into simple in organic molecules. Dilution, sedimentation and sunlight also play a part in the process. attached micro organisms in streams play a greater role than suspended organisms in self-purification. Their importance increases as the quality of the effluent increases since attached microorganisms are already present in the stream, whereas suspended ones are mainly supplied with the discharge.

Effects on the biota

Organic pollution affects the organisms living in a stream by lowering the available oxygen in the water. This causes reduced fitness, or, when severe, asphyxiation. The increased turbidity of the water reduces the light available to photosynthetic organisms. Organic wastes also settle out on the bottom of the stream, altering the characteristics of the substratum.

12. Pathogens

A pathogen is an organism that produces a disease. It is an organic pollution (biological hazard) and occurs from fecal contaminations. Fecal contaminations of water can introduce a variety of pathogens into waterways, including bacteria, viruses, protozoa and parasitic worms.

Bacteria

A very well known pathogenic bacteria is Salmonella. There are some 200 immunologically distinguishable types of Salmonella known to be pathogenic to humans. But there are many more that infect animals, including livestock. Cross-infection between people can occur via water pollution. The spreading of untreated sewage wastewater on land and its use for the irrigation of crops can also be a source of infection.

Currently there appears to be an increase in the spread of Salmonella and this has been related to modern living conditions, such as mass food production (e.g. of poultry) and communal feeding.

13. Pesticides

14. Polychlorinated Biphenyls

15. Radionuclides

ASSESSMENT OF FRESHWATER POLLUTION:

The "Conventional" Pollutant Measures are:

- Oxygen (BOD, COD, DO)
- Solids content (TSS, Conductivity, Secchi disk, settleable solids)
- Nutrients (phosphorus, nitrogen) /Algae/Eutrophication
- Acidity (pH)
- Bacteria (e.g., fecal coliform)
- Temperature

Major approaches to Biomonitoring/assessment in the last 30 years:

- **single metric** – biotic indices
- **multivariate (**predictive models (RIVPACS, AUSRIVAS, BEAST)**)**
- **multimetric indices-**index of biological integrity IBI & AQEM system

Streams can become polluted by water entering from agricultural land or industrial sites, and the quality of the water will be reflected by the types of creatures that can survive. Some of the worms can manage in very heavily polluted water (Tubifex is a good example), while some of the insects require clean conditions.

Biological Indicators

Bilogical indicators can be defined as organism/organisms or attributes of the community which can be used to provide information on:

- state of the environment
- change from 'normal conditions'
- Highlight the pressure causing a change.

Characteristics of an Ideal Indicator

- taxonomically sound and easy to identify
- widespread distribution
- numerically abundant
- large body size
- ecological requirements known (autecology)
- narrow ecological demands

Types of indicators

- sentinel organisms
- community level indicators
- organism level indicators
    - biochemical indicators
    - life history response
    - morphological deformities egs.

In order to stimulate industrial development and economic growth, many African countries have relaxed their anti-pollution regulation where it existed and environmental laws are rarely a constraint. The consequence is industrial pollution problems. The detection of agro industrial pollution is urgent in Africa to insure the protection of water resources against organic, inorganic pollutants and pesticides which are released in freshwater ecosystems. Methods for the detection of water pollution are chemical and biological. Chemical analyses do not detect punctual pollutions, are costly and not sustainable for third world countries. Several organisms are used as water quality indicators. These include bacteria, ciliates, diatoms and macroinvertebrates. Macroinvertebrates are potential markers of water pollution as some members are sensitive to different levels of pollution. The abundance of these organisms, their wide distribution, the ease with which they are identified, and their sedentarity have contributed to their utilization in water pollution assessment. Most reports of the use of macroinvertebrates in freshwater pollution monitoring are from Europe, North America and Asia. These data are rare in Africa which is biogeographically different. Studies of freshwater organisms for public health purposes have mainly focused on medically important snails. The development of sampling technique which can bring both molluscs and others macroinvertebrates is necessary in the biological evaluation of freshwater pollution.

Macroinvertebrates.

Macroinvertebrates are a key indicator group.The larger freshwater invertebrates (macroinvertebrates) spend most of their time in the same part of the stream. They are numerous and easy to catch, and once caught and identified they can give clues to the pollution history of that particular part of the stream. By sampling different locations it is possible to locate the source of any polluting incident – upstream will not be damaged, but downstream will have been affected.

Biotic Index.

There is a general rule that better water has a larger number of different invertebrate species, and by counting the number of different types of creatures it is possible to get a rough idea of water quality. By going further and identifying each species found it is possible to quantify this information. It is possible to arrive at the Biotic Index.

Advantages of macroinvertebrates in water quality assessment

- wide diversity (species & functional groups) and abundance
- relatively sedentary-occurrence of most can be related to conditions at place of capture
- life cycle of 6 months or longer-provides overview of prevailing physical/chemical conditions

- sampling is relatively easy and cheap
- they respond to environmental stress-integrate the effects of short-term perturbations.

Disadvantages of using macroinvertebrates in water quality assessment

- biological expertise is needed to identify some groups
- autoecology of various groups needed as absences may be related to habitat or life cycle factors
-

Macroinvertebrates respond to environmental stress conditions such as:

- oxygen depletion
- direct toxicity
- loss of maicrohabitat
- siltation of habitat
- food availability changes
- competition from other species

Process of bioassessment using macroinvertebrates involves the following steps:

- sample collection
- sorting
- identification
- data analysis
- reporting

Chemical Analysis

The alternative way of studying water pollution is by direct chemical analysis, and while it will be specific about the nature of the pollutants it can only help when the stream actually contains them. Once the damage has swept downstream the water will be replaced, but the invertebrates living in the affected area will have been harmed, and they will take a long time to recover. This means that occasional sampling of stream macroinvertebrates can be used to discover pollution events that occurred in the past.

Indicator Species.

If we are able to recognise one or two of the 'indicator species' you will not have to go to the trouble of identifying all the other creatures. If Stonefly larvae are present then the water is good, if they are absent but there are still Mayfly larvae then the water is reasonable. If neither of these is present then there has probably been a problem and a more detailed study might be called for.

Case study:

The Value of the Freshwater Snail Dip Scoop Sampling Method in Macroinvertebrates Bioassessment of Sugar Mill Wastewater Pollution in Mbandjock, Cameroon
Innocent Takougang, Phillipe Barbazan, Paul B. Tchounwou and Emmanuel Noumi
Int. J. Environ. Res. Public Health 2008, 5(1), 68-75

Fig – 22.4

Macroinvertebrates identification and enumeration may be used as a simple and affordable alternative to chemical analysis in water pollution monitoring. However, the ecological responses of various taxa to pollution are poorly known in resources-limited tropical countries. While freshwater macroinvertebrates have been used in the assessment of water quality in Europe and the Americas, investigations in Africa have mainly focused on snail hosts of human parasites. There is a need for sampling methods that can be used to assess both snails and other macroinvertebrates. The present study was designed to evaluate the usefulness of the freshwater snail dip scoop method in the study of macroinvertebrates for the assessment of the SOSUCAM sugar mill effluents pollution. Standard snail dip scoop samples were collected upstream and downstream of the factory effluent inputs, on the Mokona and Mengoala rivers. The analysis of the macroinvertebrate communities revealed the absence of *Ephemeroptera* and *Trichoptera*, and the thriving of *Syrphidae* in the sections of the rivers under high effluent load. The Shannon & Weaver diversity index was lower in these areas. The dip scoop sampling protocol was found to be a useful method for macroinvertebrates collection. Hence, this method is recommended as a simple, cost-effective and efficient tool for the bio-assessment of freshwater pollution in developing countries with limited research resources.

Human and Environmental Health Effects

Fertilizer, animal manure, and waste-treatment plant effluent all contain nutrients that stimulate excessive plant and algal growth in freshwater bodies. When the plants die and decompose, dissolved oxygen is depleted, causing die-offs of fish and other species living in the water. Persistent organochlorine insecticides, such as DDT, deposited in lake sediments can bioaccumulate, harming the fish and birds that eat them. Pyrethroid insecticides, though derived from chrysanthemums, are extremely toxic to aquatic organisms. Estrogen-mimicking substances such as some pesticides and industrially produced chemicals have been shown to interfere with the reproductive system of fish.

Human and animal faecal waste contain disease-carrying organisms such as the bacterium *Escherichia coli (E. coli)* and pathogens that causes cholera, typhoid, and cryptosporidiosis. Cholera is rarely seen in the United States, but *E. coli* outbreaks are not rare, and in 1993, more than fifty people died, and an estimated 400,000 became ill from a massive outbreak of cryptosporidiosis in Milwaukee, Wisconsin. The outbreak was attributed to a failure in drinking water treatment, allowing the cyst form of the parasite, introduced by animal waste, to pass into tap water and be ingested. Ten outbreaks of cryptosporidiosis were reported in the United States between 1990 and 2000.

Mercury bioaccumulates in fish and can damage the nervous systems and brains of humans. It can interfere with normal behavior in birds, such as loons, causing them to spend less time looking for food or incubating eggs. About one-quarter of breeding adult loons have higher-than-normal (10 parts per million) levels of mercury. To protect people from eating contaminated fish, states and local governments post fish-consumption advisories when contaminant levels become unsafe. There were 2,800 advisories posted in the United States in 2002, alerting people to high levels of mercury, PCBs, chlordane, dioxins, and DDT in fish.

Prevention and Abatement

Once water is contaminated, it is difficult, expensive, and sometimes impossible to remove pollutants. Technologies to remove contaminants from groundwater are air stripping, granular activated carbon, and advanced oxidation. Air stripping involves pumping out the contaminated water, then heating it to evaporate the contaminant. The cleaned water is reinjected into the ground. Pumping out contaminated water and absorbing the pollutant on activated charcoal can remove less volatile compounds. Ninety percent of trichloroethylene was removed from NASA's launch complex thirty-four groundwater cleanup site on Cape Canaveral Air Force Station by thermal treatment. In this method an electric current heats soil and water, evaporating some water and the contaminant, which is carried out of the ground by the force of the steam and collected in recovery wells.

Preventing pollution is obviously important. Drinking water suppliers have discovered that watershed protection is cost-effective because it reduces pollution and cuts the cost of drinking water treatment. A watershed is the area that drains into surface or groundwater and keeping that area free from development and agricultural runoff are among the goals of watershed protection. Municipal wells have been contaminated with traces of ethylene dibromide and trichloroethylene. After learning about watershed protection, citizens voted against proposed changes to zoning that would have increased the number of new homes and increased the potential for groundwater pollution.

Source:
http://nptel.ac.in/courses/120108002/22