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SIGNIFICANCE OF PARAMETERS

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"Degree of water quality or its pollution is assessed by the presence of indicative parameters. These parameters decide the suitability of water for various uses and can also help us in deciding the type of treatment required if any to purify the water to the extent intended. Parametric evaluation also helps in interpreting the results of water analysis and assessing the potency of water to pose health risk if any.

We have seen that many constituents of water, particularly some chemical elements and ions are useful as well as harmful for health at various levels. With a view to understanding the overall impact of presence or absence of a parameter on the environment, it is essential to understand the significance of parameters. We shall discuss here the salient parameters, which are more important for use of water for drinking and domestic uses.

11.1 Physical Parameters

These Parameters decide the aesthetic acceptability of water for intended use and are generally known by senses. They include

11.1.1 Temperature

It is basically important for its effects on the chemical and biological reactions in the organisms in water. A rise in temperature of the water leads to the speeding up of the chemical reactions in water, reduces the solubility of gases and amplifies the taste and odours. Corrosion also increases with increased temperature. At higher temperature with less dissolved gases, the water becomes tasteless and even does not quench the thirst.

Change in temperature also affects both fish and lower forms of aquatic life. Temperature also affects the usability of water for beneficial purposes. Cooler water is usually more useful.

11.1.2 Colour

Colour in water is an important constituent in terms of aesthetic considerations. It can be due to dissolved or colloidal natural impurities or mixing of the industrial wastes mainly from textile and paper mills. It may also be due to natural mineral origin, humus material and metallic substances such as Iron and Manganese compounds, algae, weeds and protozoa. The colour causes aversion to use and affects aesthetics. **"True Colour"** is technically defined as that observed after suspended material has been removed by centrifuging. The term **"Appert Colour"** may be used to describe the colour of water prior to removal of suspended matter. Colour from industrial effluents can be due to compounds of heavy metals such as copper, chromium, etc. and may be toxic. As a quality parameter, colour is important in the domestic use of water because it may make water aesthetically undesirable, may cause dull clothes, stain food and plumbing fixtures. Coloured waters may not be accepted for certain uses in the industries.

11.1.3 Taste and Odour

Taste and odour are the result of biological activity in aquatic life. These are present mainly due to dissolved organic and in-organic matter and algae. The odours may be of natural origin, caused by living and decaying aquatic organisms, and accumulation of gases like ammonia and hydrogen sulphide etc.

The chlorine added for disinfection of water reacts with organic matter to form chlorophenels which produce disagreeable taste and odour. Besides many inorganic chemicals are also capable of imparting characteristic taste e.g. sodium chloride-salty, magnesium chloride- bitter.

11.1.4 Turbidity

is due to suspended and colloidal matter in water and is measured in special units, in terms of its capacity to scatter light falling upon it. Turbidity is high in rainy season due to inorganic silt in suspension. During summer it is due to algae and other living organisms. Turbidity spoils the appearance and give it a murkey taste, even when in small concentration. It is an important parameter in the beneficial uses of water. It also gives protection to living organisms (Pathogenic and others) against chemicals (chlorine, bleaching powder etc.) used for disinfection of water. Turbidity in natural waters restricts light penetration for photosynthesis. That is why chemical disinfection is normally carried out after removal of turbidity through clarifiers and filters. Surface waters will always have some turbidity, while ground waters may not have it at all due to natural filtration.

Presence of turbidity is objectionable for almost all uses. It affects the aquatic life by limiting light transmission into the system. Determination of turbidity is an important objective in removal of the turbidity by coagulation, filtration etc. in drinking water treatment plants. For domestic supply, a low turbidity is highly desirable. In determining usability for industries, turbidity is often used as a broad empirical measure of suspended solids.

11.1.5 Foam & Froth

It is a suspension or dispersion of gases or air bubbles in a liquid medium. Foams are caused by the presence of foaming substances such as synthetic detergents, soaps, proteins and many other substances of organic origin. Foam can be hazardous since it can trap the pathogenic micro-organisms.

11.1.6 Conductivity

Conductivity is the measure of capacity of a substance or solution to conduct electric current. Conductivity is reciprocal of the resistance. As most of the salts in water are present in the ionic forms, capable of conducting current therefore, conductivity is a good and rapid measure of the total dissolved solids. As the dissolved solids in the highly mineralised waters are usually more than 65% of the conductivity, the value of dissolved solids, as a general rule can be obtained by multiplying it by a factor of 0.65. However, it is difficult to get accurate values by this calculation, as capacity to conduct the current depends on number and kinds of ions present, their relative charge,and freedom of ions to act as conductors.

The conductivity is generally reported in μ mhos . It is highly dependent on temperature and therefore is reported normally at 25°C to maintain the comparability of the data from various sources. It has got no health significance as such. Conductivity, however is an important criterion in determining the suitability of water for irrigation.

11.1.7 pH

pH is the measure of the intensity of acidity or alkalinity and measures the concentration of hydrogen ions in water. pH scale ranges from 0 to 14 with 7 as neutral, below 7 being acidic and above 7 as alkaline.

Most natural waters are generally alkaline due to presence of sufficient quantities of carbonate. Significant changes in pH occur due to disposal of industrial wastes. pH has no direct adverse effects on health, however, a lower value of 4 will produce sour taste and above 8.5 alkaline taste.

Higher values of pH hasten the scale formation in water heating apparatus and also reduce the germicidal potential of chlorine. High pH induces the formation of trihalomethanes which are toxic. pH below 6.5 starts corrosion in pipes, thereby releasing toxic metals such as Zn, Pb, Cd and Cu etc. It can also cause corrosion of water works structures and house hold plumbing fixtures. In water supplies, pH is an important factor in fixing alum dose in drinking water treatment. Most natural waters have pH values within the range of 5.0 to 9.0.

11.2 Chemical Parameters

Chemical parameters are mostly in the dissolved form in water and have direct impact on the health causing physiological disorders. They also affect the taste of water and interfere with its uses for industry and agriculture.

11.2.1 Alkalinity

Alkalinity of the water is its capacity to neutralize a strong acid and is characterised by the presence of all hydroxyl ions capable of combining with the hydrogen ion Most of the alkalinity in natural water is formed due to dissolution of carbon dioxide in water. It is a measure of the buffering capacity of the water and since pH has a direct effect on organisms as well as an indirect effect on the toxicity of certain other pollutants in the water, the buffering capacity is important to water quality. Examples of commonly occurring materials in natural waters that increase the alkalinity are carbonates, biocarbonates, phosphates and hydroxides. Water with higher alkalinity is much less corrosive. Higher alkalinity produces unpleasant taste to water. It is seldom considered detrimental except for associated hardness and scale effects.

11.2.2 Dissolved Oxygen

Dissolved oxygen is one of the most important parameters in water quality assessment. Its presence is essential to protect aesthetic qualities of water and maintain fish and the higher forms of biological life in the water. The effect of waste discharge in a water body are largely determined by the oxygen balance of the system. Non polluted surface waters are normally saturated with dissolved oxygen. The design of waste treatment is based on removal of oxygen demanding substances so as to maintain the dissolved oxygen concentration. Low oxygen in water can kill fish and other organisms present in water. It is an indicator of water quality and ability of water body to support aquatic life. Low oxygen concentrations are generally associated with heavy contamination by organic matter. Oxygen saturated waters have pleasant taste and hence drinking waters are aerated if necessary. In-sufficient dissolved oxygen in water causes anaerobic decomposition of organic materials. Thus it is vital for maintaining aerobic conditions in natural waters that receive polluted matter. Determination of dissolved oxygen serve as the basis of BOD test. Oxygen is a significant factor in the corrosion of iron and steel particularly in water distribution systems and in steam boilers. Removal of oxygen from boiler feed waters by physical and chemical means is common practice in power industry.

11.2.3 Biochemical Oxygen Demand (BOD)

BOD is the amount of oxygen utilized by micro-organisms in stabilizing the organic matter. On an average basis, the demand for oxygen is proportional to the amount of organic waste to be degraded aerobically. Hence BOD approximates the amount of oxidizable organic matter present in the solution, and the BOD values can be taken as a measure of waste strength, BOD test is useful in stream pollution control management and in evaluating the self purification capacities of streams. The BOD test has been developed for 5 days at 20^{o}C(average water temperature), since a large percentage of the total BOD (70% - 80%) is exerted in the first five days of the test. The BOD test is based upon determination of dissolved oxygen.

The BOD test was developed in 1912 in UK. The average temprature of river Thames was then 20°C and the detention time for water till it reched the sea was 5 days

11.2.4 Chemical Oxygen Demand (COD)

COD is another parameter not used for monitoring water supplies but is sometimes used for evaluation of polluted raw water. It is extremely useful in the determination of industrial waters and very practical in the determination of domestic waste and polluted waters. COD is the oxygen required by the organic substances in water to oxidize them by a strong chemical oxidant. The COD usually refers to the dichromate oxidation procedure. The determination of COD values are of great importance where BOD values cannot be determined accurately due to the presence of toxins and other such unfavourable conditions for growth of micro-organisms.COD test is a very important parameter in management and design of the treatment plants because of its rapidity in determination. COD values cannot be corresponded with that of BOD values. In general, COD is more than the BOD values for most of the industrial wastes. Since COD can be determined in 3 hours versus the 5 days of BOD, sometimes the BOD test is substituted by COD practically. In monitoring a specific source, tests can be run to determine empirically the relation between COD, BOD,organic carbon, or organic matter. Consequently, only COD tests can be run for a quick evaluation of the source in question.

11.2.5 Dissolved Solids

Dissolved solids (Also referred to as total dissolved solids) gives idea mainly about the various kinds of minerals present in the water. In natural waters dissolved solids are composed mainly of carbonates, bicarbonates,chlorides, sulfates, phosphates and nitrates of calcium,. magnesium, sodium, potassium, iron and manganese, etc. It is a measure of the total amount of minerals dissolved in water and is, therefore, a very useful parameter in the evaluation of water quality, water is classified as fresh (< 1000), Brackish (< 5000), Saline (< 30000) and Brine (> 30000) based on its TDS content. Concentration of dissolved solids is an important parameter in drinking water and other water quality standards. They give a particular taste to the water at higher concentration and also reduce its palatability. Higher amounts are also objectionable due to economic consequences. High concentration of dissolved solids near 3000 mg/l may produce distress in cattle and live stock. Plants are also adversely affected by the higher content of solids in irrigation water which increase the salinity of the soil. In industries, the use of water with high amount of dissolved solids may lead to the scaling in boilers, corrosion and degraded quality of the product. High concentration of dissolved salts particularly of sulphate and chloride are associated with corrosive damage water supply. Higher concentration of TDS is likely to contain an excessive concentration of some specific substances that would be aesthetically objectionable to the consumer.

11.2.6 Hardness, Calcium and Magnesium

a) Hardness

Hardness is the property of water which prevent the lather (foam) formation with soap and increases the boiling point of water. Principal captions imparting hardness are calcium and magnesium. However, other captions such as Strontium, Iron and Manganese also contribute to the hardness. The anions responsible for hardness are mainly bicarbonate, carbonate, sulphate, chloride,nitrate and silicates. Hardness is called temporary if it caused by bicarbonates and carbonates salts of the captions, since it can be removed simply by boiling of water. Permanent hardness is caused mainly by sulfates and chlorides of the metals. Hard waters normally originate in areas with thick top soil and limestone formations. Ground water is generally hard than surface water. Hardness has no known adverse effects on health, however, some evidence has been given to indicate its role in heart disease. Hard water is not suitable for domestic use in washing, cleaning and laundering. It is also not desirable in steam boiler and water heaters due to scale formation. Hardness also affects the suitability of water for use in the textile and paper industry hard water has a greater tendency to cause corrosion of pipes and consequently certain heavy metals may be present in the distributed drinking water.

b) Calcium

Calcium comes in water mainly from the rocks by leaching. Soils and rocks containing limestone, dolomite and gypsum are the main sources of calcium. It has as such no hazardous effect on human health. In fact it is one of the important nutrients required by the organisms. Its presence is a principal cause of hardness. High concentrations of calcium are not desirable in washing, laundering and bathing as it does not allow sufficient foam formations. Its presence also accelerates scale formation in boilers and not water heaters.

c) Magnesium

Magnesium also occurs in all kinds of natural waters with calcium, but its concentration remains generally lower than the calcium. The principal sources in the natural waters are various kinds of rocks. High concentration combined with sulphate acts as a laxative and diuretic to human beings particularly those who are not accustomed to high dose. Very high concentrations impart an unpleasant taste to water. Magnesium adds to the hardness of the water and with calcium poses the problem of scale formation in the boilers.

11.2.7 Iron and Manganese

a) Iron

Iron enters raw waters through the earth's crust in the mining areas having iron ores. Although Iron is one of the essential elements in human nutrition, its presence in drinking water supplies is objectionable for a number of reasons. It is not harmful to the health but causes astringent taste, reddish colour and turbidity to water. In water, under some conditions ferrous salts get oxidised to sparingly soluble ferric oxide. This spoils the appearance of white glazed titles, porcelain plumbing fixtures and vessels and clothes which are being washed with it. The precipitated iron also settles in the distribution system and impairs the flow of water. It also favours the growth of iron bacteria in distribution pipes which reduces their carrying capacity by organic growth and its deposition. This also clogs pipes, valves, nozzles and meters.

b) Manganese

Manganese is also essential for health in minute amount but excessive concentration is objectionable like Iron. Manganese in water has a similar origin as iron and also has similar effects as caused by Iron except the bacterial growth. The colour given by its dark brown. Precipitated manganese results in problems of encrustation, and forms coating on piping. The growth of certain nuisance organisms is also favoured by Manganese which imparts taste and odour problems and cause turbidity.

11.2.8 Nitrate, Chloride, Sulphate and Fluoride

a) Nitrate

Nitrate enters water through minerals, sewage and industrial wastes and agricultural run-off. High amounts of nitrates are generally indicative of pollution. Surface waters are having less nitrate where as ground waters are having higher values. High amount of nitrate causes 'methaemoglobinemia' in infants. In this disease the skin becomes blue due to decreased efficiency of hemoglobin to combine with oxygen. Its entry into water sources increase the growth of nuisance algae and trigger eutrophication. Large concentrations of nitrate may result in the potential formation of carcinogenic nitrosamines.

b) Chloride

Chloride in ground water are due to their movement through the salt bearing strata. Surface waters can also receive chlorides from industrial effluents high in chloride content. Urine of man and animals contains chlorides and hence a sudden increase in the chlorides of water can raise doubt about its pollution due to mixing of sewage. Natural mineral origin and sea water intrusion can be major sources of chloride contamination. Industrial effluents may also leach into ground waters or streams. Chlorides themselves are not harmful, but causes taste and corrosion in hot water systems.

c) Sulfates

Sulfates enter water supplies through sulfate bearing underground strata. Atmospheric sulfur dioxide ($S0_2$) formed by the combustion of fossil fuels and emitted by metallurgical roasting processes may also contribute to the sulfate content of waters. Sulfates alongwith magnesium cause purgative effects on bowels. Sulfates can also enter raw water supplies due to their pollution by discharging of effluents from fertilizers and sulfuric acid manufacturing industries. Aluminium Sulfate which is extensively used as a flocculant for water treatment may add sulfate to final waters. High sulfate concentration in water may contribute to the corrosion of metals in the distribution systems particularly in waters having low alkalinity.

d) Fluorides

Fluorides enter raw waters through underground strata containing fluorides. When fluoride is less (1.0 mg/l), it results in dental caries where as when it is excessive (1.5 mg/l) it leads to dental fluorosis. Continuous use of water with excessive fluoride over years may cause cumulative fluorosis with resultant skeletal damage (crippling fluorosis) in man and cattle. There is no acceptable evidence that fluoride in water is associated with a cancer risk.

11.2.9 Sodium

Sodium is the most abundant of the alkali elements and is a natural constituent of raw water. It is present in a number of minerals (Rock Salt) sea water, soils, plants, industrial effluents and domestic sewage. Ground waters are sometime having high amount of sodium due to mineral leaching or sea water intrusion. Discharge of effluent from domestic and industrial sources in another important source in water. Sodium is also present in all foods.

At lower concentrations, there are no adverse effects on the health. In general, sodium salts are not acutely toxic substances because of the efficiency with which mature kidneys excrete sodium. Excessive intake of sodium chloride causes vomiting. Acute effects may also include convulsion, muscular twitching and rigidity. Immature kidneys of infants cannot excrete sodium and hence acute effects result in death due to over dose. At higher levels in drinking water it is harmful to persons suffering from cardiac, renal and circulatory diseases. It is also related to women toxemia associated with pregnancy.

Depending on the concentrations of calcium and magnesium also present in water, sodium may be detrimental to certain irrigated crops. Use of irrigation water containing high proportion of sodium as compared to other cations will increase the exchangeable sodium content of the soil. This will effect the soil permeability and texture and leads to puddling and reduced rate of water intake. Such soils become hard to plough and unsuitable for seedling emergence.

Besides, high concentration of sodium associated with chlorides and sulfates make the water salty and renders it unpalatable.

11.2.10 Potassium

Like sodium, potassium is also a naturally occuring alkaligroup element, however, the concentrations remain quite lower than sodium, calcium and magnesium. The major source in natural freshwater is weathering of the rocks but the quantities increease in the polluted waters due to disposal of waste waters.

Potassium is definitely an essential nutritional element for humans, animals and plants. It is extensively used in fertilizers. It is non-toxic but produces laxative affects and teaste problem at large quantities.

11.2.11 Phosphate

Phosphate is mainly a salt of phosphoric acid and in nature it is found in phosphate rocks, minerals (apatite) and soils(land). Phosphorous being an important constituent of biological system, may also be present in the organic forms mostly in bones and teeth. It is widely used in the production of fertilizers and detergents. Polyphosphates have been used to prevent scale formation and inhibit corrosion. Hence the major sources of phosphate are domestic sewage, detergents, agricultural effluents and industrial waste waters. The higher concentration of phosphates therefore are indicators of pollution. Water supplies may contain phosphates derived from natural contact with minerals or through pollution from agricultural, domestic and industrial discharges. Ground waters are more likely to have higher phosphate concentration.

Phosphate is an essential nutritional factor for all forms of life. It is as such not harmful to organisms. The prime concern of phosphate lies in its ability to increase the growth of nuisance algae and eutrophication. Higher phosphate concentrations also interfere with co-agulation in water treatment plants.

11.2.12 Silica (Silicon)

Silica is a hard glassy mineral found in a variety of form such as quartz, sand and opal. Its formula is SiO_2 , dioxide of silicon. Other silicate minerals are rock, crystals, agate, granite, asbestos, felspar, clay and mica. It is the second most abundant (25.7%) element, next only to oxygen in the earth's crust, by weight. It is one of the most useful elements in its applications in concrete, bnrick, refrectory enamel, pottery and glass.

Despite it over-abundance in nature, it occurs in meagre quantities in waters. In natural waters, silica may be detected as a result of disintegration of rocks containing silica. It appears in water as suspended particles, in a colloidal or polymeric state and as silicates, iron or silicic acids.

Its detailed chemistry and health hazards are still not known. It is believed to be an essential nutritional trace element for animals but its dietary requirements for humans are not established yet. Silica concentration is very important in regulation of growth of Diatoms (a kind of algae) to produce their cell walls. At high conventrations silica may be objectionable in colling tower and in boiler feed water make up because it retards heat. Activated silica is used as a flocculant with alum to remove colour and some organic matter in water. Silica may be added to softwater to inhibit corrosion of iron pipes.

11.2.13 Boron

Boron is not found in its elemental form in nature. It is usually found as a sodium or calcium borate salt. Boron salts are used as fire retardants, in the production of glass, leather tanning and finishing, cosmetics, photographic materials, metallurgy etc.

Boron is an essential element for growth of plants but no evidence is available regarding its beneficial effects to animals. No ill effects on human health are reported so far. However some sensitive crops like citrus show toxic effects at higher concentration of boron in irrigation waters.

11.3 Toxic Substances

Water is an important vehicel for teansmitting potentially **toxic** and **suspicious chemicals** to its consumers. There are three different types of problems associated with such agents. The first is **acute toxicity,** in which, adverse impact of agent is observed quickly usually within minutes, hours or at the most a few days. This type of effect can occur with high dosage of **cyanide arsenic, fluoride** or other so called **poisons.**

The second type of problem is chronic **toxicity,** in which effects may not be observed until exposure to the chemicals has continued for an extended period. This often is true of metals and some organic chemicals that accumulate in the victim over months or years before reaching a body burden high enough to cause observable symtoms or illness. Specific examples that have received considerable attention over the past several years include lead, mercury, cadmium, aresenic and several types of chlorinated hydrocarbons.

The third (and distinctly different) type of effect is **genetic.** Here, there may be no impact on some one exposed to the chemical, but it may surface as an effect on the offspring of that person. Examples are genetic effects of radiation, birth defects from using various specific drugs, pesticides, Pc Bs and other new chemicals.

11.3.1 Heavy Metals

Most inorganic chemicals are metals, the potential chronic effects of them are known for many years. They are usually present in trace amounts in natural waters but many of them are toxic even at very low concentrations. Their concentration increase in water due to addition of industrial wastes and sewage. Some of them get biomagnified in the waters and get accumulated in higher aquatic life like fish and crabs.

Some of the heavy metals are extremely essential to humans, for example cobalt, copper, molybdenum etc. But large quantities of them may cause physiological disorders, many of them are quite serious. Many metals have attracted special attention during the recent past. The **Minamata** tragedy in Japan (1960) resulting from the fish containing methul mercury is a glaring example of **mercury** contamination. Those of greatest concern included **Arsenic Lead, Mercury, Cadmium, Selenium, Chromium, Barium,Silver, Copper** and **Zinc.**

In addition to a large number of industries discharging their metal containing effluents to fresh waters, significant quantities get transported through the agricultural run off containing organometallic pesticides. Corrosion in pipes and release of copper, lead and Cadmium to drinking water is also significant.

Arsenic is present in the waste waters of many industries such as ceramics, tanneries, chemicals, metal preparation and pesticides. It has a tendency to get accumulated in body tissues to cause **Arsenosis.** It effects liver and heart and is also reported to be carcinogenic.

Cadmium is present in the waste waters from electroplatting, chemical industries and mining wastes. It accumulates in the various parts of the body (liver, pancreas, kidney etc.) and is known to cause painful bone disease called **"itai-itai"**

Chromium occurs in higher concentrations in the wastes from electroplatting, paints, chrome tanning, explosive, ceramics and paper industries. It is also added to cooling waters to check corrosion. Hexavalent chromium is more toxic.

Copper is used as a pesticides with sulphate and also as an algicide. Although it passes as such through the body, trace quantities accumulate in liver. It imparts **taste** to the water.

Lead is also a toxic element and it increases in water due to the discharge of industrial waste waters from printing, dyeing, and oil refineries. It accumulate in the body mainly in bones. it is also found in brain, kidney and muscles. It has cumulative effect and sometimes result in death.

Mercury is a highly poisonous substance and comes in natural waters from industrial pollutions. It is used in chlorine, caustic soda, batteries, pesticides, pharmaceutical, cosmetics, pigments and chemical industries. It affects the central nervous system and at higher doses may be fatal.

Selenium is required in small quantities by the body but at higher concentration it produces acute toxicity and death. Selenium is chemically similar to surface and naturally occuring compounds of sulfur mainly sulfides have sufficient quantities of selenium. It is used in industries like paints, dyes, glass, rubber and incecticides.

It produeces chronic toxicity to animals in which lameness, malinformation, loss of hair and emaciation results. At higher concentrations, a portion accumulates in the liver and kidneys.

Zinc is present in high concentrations in the wastes from pharmaceuticals, paints, pigments, insecticides and cosmetics. Zinc is very essential micronutrient and only at very high concentrations it may cause some toxic effects. Zinc salts produce undesirable taste to water.

11.3.2 Organic Chemicals

Many of the organics that have caused concern enter water courses in the discharges from chemical plants. On the otherhand, many others are released by operations that use them for various purposes, for example the **pesticides** that have received so much attention over past 2 to 3 decades, enter streams and lakes principally in run off from manufacturing plants.

A different source of potentially toxic organics that is receiving special attention today is in reactions between inncuous organics present in water naturally and chlorine added to it for disinfection. That is the origin of most **Trihalomethanes** (THMS) in drinking waters includin chloroforms, which has been demonstrated to be **carcinogenic** many potentially serious problems could be encountered with hundreds of other organics in water.

11.3.3 Other Toxic Constituents

There are several constituents of water other than meatls and organics that can be toxic to humans. An important example is **nitrate.** High concentration of that chemical may contribute to **hypertension** in adults and **methemoglobenemia** in babies. Similarly **Fluoride** at higher levels could be harmful causing **fluorosis.** At very high dosage, it can be an active toxicant and cause severe illness or death. Occassional problems can be encountered with **biomagnification** of radioactive chemicals. Cyanide and compounds of cyanide are almost universally present where life and industry are found. Cyanides are used in many industrial processes.

The very poisonous nature of cyanide is well known. Lungs, gastrointestinal tract and skin absorb cyanides. Higher exposure can be fatal but smaller doses are non injurious due to detoxification system. **Sodium** in water is reported to cause **hypertension.** Many more chemicals are developed recently but their harmful effects are not known yet.

11.4 Biological Parameters

All the oganisms which make up the aquatic community are important water quality parameters to some degree. The biological parameters could be subdevided in three groups in terms of nature of their biological importance in the system.

One group of this division will be those organisms found in water which are known to be **harmful to man.** This will include pathogenic bacteria, harmful protozoa, viruses and parasitic worms.

The second group of importance are the intestinal organisms which are discharged by human beings and animals in their fecal material which can be used as an indicator of contamination and the possible presence of **Pathogenic organisms.** The presence of bacterial, viral, protozoan and possibly fungal species which are either pathogens or possess the potential to infect man and other organisms is indicated by the presence of **'Faecal Coliform group of bacteria'.** Although as a group they are not exclusively of faecal origin, they are universally present in large numbers in the faeces of man and other worm blooded animals, thus permitting their detection after considerable dilution. The detection of faecal (Thermotolerant) coliform organisms, in particular Escherichia coli, provides definite evidence of faecal pollution. Supplementary indicator organisms, such as faecal streptococci and sulfite reducing clostridia, may sometimes be useful in determining the origin of faecal pollution as well as assessing the efficiency of water treatment processes.

The third group of includes **algae** and other aquatic plants which indicate the presence of eutrophication and finally there are the indicator organisms ranging from harvestable fish and shell-fish through trash-fish, protozoa, bacteria, algae and various bottom organisms which indicate the well being of the natural life of the aquatic system.

Biological parameters are perhaps of greatest importance from human point of view. All natural waters contain a variety of organisms both plants and animals as the natural flora and fauna. They can be classified as under :

a) Plants : Viruses, bacteria, fungi and algae.

b) Animals : Protozoa, Rotifers, Crustaceans, Worms and larvae.

Such orgnisms are responsible for diseases like Typhoid, Taste and Odours in water supplies, and prolific microbial growths which can lead to detrimetnal quality changes (problem of eutrophication) in surface waters.

In water receiving sewage, domestic waste .and industrial wastes, a plethora of pathogenic organisms may be present. The water borne diseases are spread due to virus, bacteria, protozoa and the helminths. Ideally drinking water should not contain any microorganisms known to be pathogenic. It should also be fred from bacteria, indicative of pollution with excreta.

Species of **protozoa** known to have been transmitted by the ingestion of contaminated drinking water include **Entamoeba Histolytica** (Cause of Amoebiasis), **Giardia Spp** and rarely, **Balantidium coli.** These organisms can be introduced into water supply through human or in some instances, animal faecal contamination. Drinking water should not contain any pathogenic intestinal protozoa.

The infective stages of many parasitic **roundworms** and **flatworms** can be transmitted to man through drinking water. A single mature larvae or fertilized egg can cause infection and it is clear that such infective stages should be absent from drinking water. Diseases like **Dracuncules** (Guinea-worm) and **Schistosomes** are cause by such worms

The free living organisms that may occur in water supplies include **fungi, algae, free living protozoa, cladocera,** copepods and micro-invertabrates such as the **nematodes, chironomids and snails. These organisms are of public disease causing organisms or because they produce toxins.** Some blue-green algae are known to release toxins or may be toxic if ingested. Such **algae** have been reported to produce **gastroenteritis** in consumers. The most commong problems associated with these oganisms are their interference in the operation of water treatment precesses, and their effects on the colour, turbidity, taste and odour of finished water. High concentration of algae in raw water may result in severe clogging of filters, cause taste and odour problems, and increase the chlorine demand. Growth of algae and fungi are common appearance of entrophicated waters and are due to nutrient enrichment. Such growth hinder with recreation, spoil its aesthatic value and cost more in water treatment.

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