CHAPTER I

INTRODUCTION
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Water is the most important natural resource in the world, without it life cannot exist and industry cannot operate\(^1\). However increasing industrialisation, urbanisation and developmental activities have brought veritable water crises in its quality. Therefore, the qualities of water areas are of immense impotence in our environment.\(^2\)

Water on earth is a fixed quantity and there is no appreciable variation from year to year. It is used in many sectors, agriculture and industry consume a large percentage of water. There are various ways through which drinking water is being polluted due to which about seventy percent of world population does not have pure drinking water\(^3\).

According to United Nations Environment Programme (UNEP) expert Letitia Obeng no other single factor could improve the well being of the world's peoples more than the provision of accessibility of pure and clear water\(^4\). The developing world faces water problems almost of crisis proportions. Only one percent of the world's water is available for human use. The rest is locked up in the ice caps, in the oceans and underground. The available water flows round the hydrological cycle. This water is sufficient
for the population of the world but there is problem of its pollution. UNEP says "Heavy inflow of pollutants can break down the nature's capacity to regenerate and clean the water supply."

Pollution of water is responsible for a very large number of mortalities and incapacitations in the world. Polluted water resources has lead to a steady decline in fisheries and also affected irrigated land. Availability of clean water is going to become the greater constraint for tomorrows development. Thus to copeup with this senario man has tried his best and has rapidly advanced efforts to counter act this malady. In past few decades natural and polluted water have been studied in detail all over the world and considerable data are now available on most kind of pollutants and their effects on ecosystem as well as on organisms.

Water is said to be an impure when it contains electrolytes, nonelectrolytes, biological micro-organisms, suspended particles etc. It requires special physical and chemical tests to detect the impurities present even in minute quantities. The scope of analytical techniques has widened considerably with sophisticated instrumentations and
methods being introduced to meet increasingly difficult analytical instruments. The development in this direction has lead to the publications of vast number of papers, describing particularly intensive research work to be taken up by Chemists and environmentalists in particular for integrated assessment of all aspects of the measurements of water quality as a guide to all those concerned with deflecting establishing controlling and reviewing progress of water analysis for whatever purpose it is used.

**UNIQUE PHYSICAL PROPERTIES OF WATER**

We owe our existence on the earth to the following unique or abnormal physical properties possessed by water.

**Specific heat:**

It is defined as the number of calories that are necessary to raise the temperature of 1 gm of substance by 1°C. Specific heat is numerically equivalent to the thermal capacity of a substance. Specific heat of water is 1 provided that heating is around 15°C. It is surprising fact that water has higher specific heat and usually far higher than any other naturally occurring solid or liquid substances. Important consequences of this high thermal capacity are:
(i) Relatively small range of temperature variations occur in the oceans, rivers, lakes, etc. and in tissues which consists of water (ii) The heat liberated by work done by the muscles is less liable to cause overheating before a body temperature regulating mechanism can correct it. (iii) Water is also important in maintaining a constant temperature in tissues because of its large thermal conductivity.

**Latent heat of vaporisation:**

It is the amount of heat withdrawn from the surrounding when liquid water is converted into water vapours at the same temperature. Latent heat of water is 9.7 Kcal/mole at 100°C which is very high value as compared with the other naturally occurring liquids.

We know that the greatest proportion of heat lost from an organism is by the evaporation of water from its surface. No other liquid than water volume for volume could by evaporation remove so much heat from the organism.

**Latent heat of fusion:**

A considerable higher value (1.44 KCal/mole) of latent heat of fusion for water plays a part in biological
phenomena. In the freezing process of water 80 Cal/gram of heat is released and the same amount of heat is required to transform 1 gm of ice into water. The large latent heat of fusion is also one reason, why when natural masses of water such as lakes, ponds, etc. start to freeze the process appears to be slow. Another reason for this is the anomaly of the change of the density as water approaches its freezing point. The maximum density is reached not at 0°C will be lighter than slightly warmer water and tend to collect on the surface. If the cooling agent, usually a cold wind, is acting primarily on the surface of the lake, etc it will be thus freeze only this cold surface layer and loss of heat from the main mass of water upwards through the ice crust is much slower. The ice floats on water surface because its density is only 0.997, that is, the water has expanded 10% on freezing. The aquatic animals can thus survive in warmer water below the ice surface.

The melting point and boiling point:

The melting point and boiling point of water are 0°C and 100°C respectively. Comparison with its homologous in the same group of periodic table (H₂S, H₂Se, H₂Te) suggests
however, that its melting point ought to be about \(-15^\circ C\) and boiling point about \(-80^\circ C\). The fact shows that actual values are so much higher suggest that water behaves as if its molecular weight were much greater than 18. The hypothesis of molecular association or aggregation offers an explanation of this discrepancy and there are many other observations which point out the association of water molecules with each other into larger complexes. This tendency to associate which gives rise to such physiochemical peculiarities is responsible for the fact that water has remained in the liquid phase on the surface of the earth for million of years inspite of the conditions of temperature and pressure which have prevailed.

Some aspects of pollution:

Development of country depends very much on the advancement of industrialisation. It is essential for better living standard of human beings. However the tremendous growth of industries and technological advancement in last few decades have given the man an ability and the freedom to produce changes in environment and small changes are in the composition of atmosphere, in the composition of hydrosphere and ecological balance between
the different species of animals and vegetation which ultimately lead to environmental pollution. Water pollution in modern technological world is not an isolated incident. In consequences are being felt all over the world and bringing threatening to live on earth. There is fast disappearing of lives in ocean and variety of diseases are increasing in industrial cities.

Drinking water for most of the cities comes from rivers and other surface sources such as Lakes, Dams, etc. and these sources are being getting polluted by domestic sewages and industrial wastes etc in cities. Most of the cities in India do not have sewage treatment plants and hence sewages and industrial wastes are directly reaching to the water resources. Sewages decompose and use oxygen present in water depleting its concentration in water and hence aquatic animals, fishes, etc get adversely affected.

Pollution of water caused by organic as well as inorganic pollutants, in which former originates from sewage and latter originates from industrial wastes. Organic pollutants can be removed to a greater extent by suitable treatment. Methods for treatment of inorganic pollutants are however expensive and damage through such pollutants may
persist for long periods. In fact inhibited growth of industries and mines producing blackish wastes is adversely affecting the water resources in the inland areas of different states.

**Sources of water pollution:**

The main sources of water pollution are:

(a) Urban source,
(b) Industrial source,
(c) Agricultural source, and
(d) Natural source.

(a) The Urban sources are of two types:

**Controllable state:**

Normally the sewerage system serves the business and commercial areas, the residential area and Industrial area. The extent to which this system services the city and its surrounding sub-urban and industrial fringe is a measure of controllable source.

The discharge of huge amount of municipal and household wastes into rivers and rivulets or nullahs is one
of the major sources of pollution of water bodies. Most sewerage system mainly contain human and animal wastes. However, the amounts and types of other kinds of refuse from modern living are continuously increasing. Some of which pose processing problems. For example, the synthetic detergents, new complex compounds such as cleaners and water based paints also find their way into it. Sewage, garbage, and organic material dumped into the water bodies kill aquatic lives because of reduction in Oxygen concentration.

Uncontrollable source:

All urban wastes that reach the stream other than through organised sewage system and treatment works are uncontrollable source. This constitutes a great contribution of stream pollution. The uncontrollable source is usually intermittent, associated with the occurrence of rainfall.

(b) Industrial source:

Today industry contributes more water pollution than do household users. The major industrial pollutants are the chemicals, metals, paper and food industries. Wastes from industries such as pulp mills, leather, tanneries, sugar and oil refineries, jute mills, coal washeries, petroleum and chemical fertilizer plants are mostly complex organic compounds.
These are emptied directly into natural water ways. The effluents from industries are resistant to break down result in disastrous consequences upon the existing ecosystems. Rapid industrial development has indeed been responsible for the numerical decline of macrophytes which constitute an important constituent of aquatic eco-system. Chemically polluted water either damages the growth of crops or changes the aquatic vegetation due to artificial nutrients and is totally unfit for live stock to drink. Cyanides, acids, alkalies and other industrial wastes affect the inhabitants of rivers upto several kilometers downstream.

(c) The Agricultural source:

The agriculture drainage chemical fertilisers encourages algal growth and contaminates drinking water particularly with nitrates. Pesticides and fungicides from agricultural runoff when taken in by fish and other aquatic organisms become concentrated in the bodies of the organisms, higher in the food web. For example the concentration of DDT maybe very low in river water. But some fish in the river contain such high proportion of DDT that they become quite unfit for human consumption.
(d) The Natural Source:

The natural sources are storm, wash, seepage from groundwaters, swamp drainage and aquatic life of the streams. Natural rain water has an approximate pH of 5.6. However, during the last 25 years reports from many developed countries have indicated that rain water has much higher acidity. This is brought about by strong acids formed from sulphur dioxide and nitric acid and probably hydrofluoric acid from fluoride. These acidic gases travel long distances. Some of these pollutants over the city ascend skywords and then travel down through precipitation as rain, dew and snow. Acid rain has eliminated fish in hundreds of lakes in USA, Canada and Scandinavia. The portion of rainwater that flows over the surface and called runoff pick up organic and suspended matter, whereas the portion percolating through the ground has got minerological, organic and inorganic matter which it gathers while traveling through the underground strata before reaching the waterstable.

The last 25 years have witnessed several instances of coastal water pollution. The main source of pollution is oil. This oil pollution is due to the wrecking of oil tankers and accidental oil spills. This constitutes a major threat to the ocenic eco-system.
There is also now-a-days thermal pollution of water with the increased utilization of atomic energy as a major source of the power, the problem of thermal pollution is assuming dangerous proportions. The production of electricity by nuclear power requires billions of gallon of cold water to remove waste heat. The warm water emptied into the water ways adversely affects the aquatic organisms. The entire aquatic eco-system is affected by changes in temperature that disrupt the food chain and upset the entire balance among the living organisms. Radioactive pollution of water is another threat to cities where nuclear power plants are located.

Some other miscellaneous sources of water pollution are construction activities, mines, dumps and land fills.

PARAMETERS AS THE INDICES FOR WATER QUALITY

Considering the wide variety of pollutants and parameters for studying underground and surface water pollution, it becomes obvious that the pollutant may vary from place to place, so also the parameters may also vary. There may not be one universal parameter in all circumstances and conditions to study the effect of toxic materials
(pollutants) in water. However, for the purpose of the present work a few basic parameters indicated in the following Table No. 1 have been used.

**Table No. 1**

Some important parameters for water quality

<table>
<thead>
<tr>
<th>Physical</th>
<th>Chemical</th>
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<tbody>
<tr>
<td>Temperature</td>
<td>Dissolved oxygen (DO)</td>
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<tr>
<td>Colour</td>
<td>Chemical Oxygen Demand (COD)</td>
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<tr>
<td>Conductivity</td>
<td>Biological Oxygen Demand (BOD)</td>
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<td>TDS</td>
<td>pH</td>
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<td></td>
<td>Alkalinity</td>
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<td>Chloride</td>
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<td>Sulphate</td>
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<td></td>
<td>Phosphate</td>
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<td>Calcium</td>
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<td></td>
<td>Magnesium</td>
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<td></td>
<td>Iron.</td>
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</tbody>
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**Temperature:**

Temperature is basically important for its effects on the chemistry 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 tastes and odours.

Water in the temperature range of 7°C to 11°C has a pleasant taste and is refreshing. At higher temperature with less dissolved gases, the water becomes tasteless and even does not quench the thirst.  

**Colour:**

Colour of pure water is pale green blue tint in large volume. Colour in natural water may occur due to the presence of humic acids, fluoric acid, metallic ions, such as iron and maganese, suspended matter plytoplankton, seeds and industrial wastes, etc.
**Taste and Odours:**

The taste and odours are present mainly due to dissolved impurities often organic in nature. They are supposed to be 'Chemical senses' as they depend on the actual contact with the receptor organ.

The odours may be of natural origin, caused by living and decaying aquatic organisms and accumulation of gases like ammonia and hydrogen sulphide etc. Many algae also impart taste and odours to water.\(^7\)

**Turbidity:**

Turbidity in water is caused by the substances not present in the form of true solution. True solutions have a particle size of less than \(10^{-9}\) M. Any substance having more than this size will produce a turbidity. Turbidity of water is actually the expression of optical property (Tyndall effect) in which the light is scattered by the particles present in the water. Turbidity in natural waters is caused by clay, silt, organic matter phytoplankton and other microscopic organisms.

Turbidity makes the water unfit for domestic purpose, food and beverage industries and many other industrial uses.
Foam and froth:

It is a suspension or dispersion of gases or air bubbles in a liquid medium. Gas bubbles in foams are enveloped by thin films of liquid on which the stability of foams depends. Foams are caused by the presence of foaming substances such as synthetic detergents, soaps, proteins and many other substances of organic origin. A greater contribution is made by paper and pulp industry owing to the use of LIGNIN and LIGNIN SULPHATE in the process. Foams can be hazardous especially since it can trap the pathogenic micro-organisms.

Conductivity:

Conductivity is the measure of capacity of a substance or solution to conduct electric current. The conductivity of distilled water ranges between 1 to 5 μmhos but the presence of salts and contamination with waste waters increase the conductivity of the water. Consequently a sudden rise in conductivity in the water will indicate addition of some pollutants to it.
Dissolved Solids:

Dissolved solids (also referred to as total dissolved solids) denote mainly the various kinds of minerals present in the water. However, if some organic substances are also present, as more often in polluted waters, they may also contribute to the dissolved solids. Dissolved solids do not contain any gas and colloids. 

PH:

PH is the measure of the intensity of acidity or alkalinity and measures the concentration of hydrogen ions in water. It does not measure total acidity or alkalinity. In fact, the normal acidity or alkalinity depends upon excess of H⁺ or OH⁻ ions. Over the other, and measured in normality or gram equivalents of acids or alkali. If free H⁺ are more than OH⁻ ions, the water shall be acidic or alkaline the other way round.

Oxidation-Reduction Potential (Redox potential):

A substance when looses electron is Oxidised and which gains electrons is reduced. Therefore, the oxidation and reduction processes occur simultaneously in the system. In any system undergoing oxidation or reduction there is a
continual change in the ratio between the materials in the reduced form and those in the oxidized form. When a platinum electrode is immersed in such a system, a potential is developed on it depending upon the ratio of oxidized and reduced states, is called as redox potential.

It is a vital parameter in controlling the biological treatment of the wastes. Many chemical reactions and exchanges in the water bodies and their sediments are highly dependent on redox potential.\(^7\)

**Alkalinity:**

Alkalinity shown by water is due to the presence of salts of weak acid and strong base. The alkalinity in water is caused due to the presence of carbonates (\(\text{CO}_3^{2-}\)), bicarbonates (\(\text{HCO}_3^-\)) and hydroxide (\(\text{OH}^-\)).\(^8\)

**Dissolved Oxygen:**

Dissolved Oxygen is one of the most important parameters in water quality assessment and reflects the physical and biological processes prevailing in the water.

Its presence is essential to maintain the higher forms of biological life in the water; and the effects of a 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. Oxygen can be rapidly removed from the waters by discharge of the oxygen demanding wastes, other inorganic reductants such as hydrogen sulphide, ammonia, nitrites, ferrous iron and other oxidizable substances also tend to decrease dissolved oxygen in water.\(^9\)

Oxygen saturated waters have a pleasant taste while the water lacking oxygen have an insipid taste\(^9\).

**Biochemical Oxygen Demand (B.O.D.)**:

The Biochemical Oxygen Demand (B.O.D.) is the amount of oxygen required by bacteria while stabilising decomposable organic matter under aerobic conditions. The decomposition of organic impurities in presence of bacteria results in utilisation of a part of the dissolved oxygen by the bacteria during their respiratory and metabolic activities. This depletion of oxygen is considered as a measure of the strength of water.

\[
\text{Organic} + \text{Oxygen} \xrightarrow{\text{bacteria}} \text{nutrients} \rightarrow \text{CO}_2 + \text{H}_2\text{O}
\]

All organic constituents of sewage degrade under aerobic conditions. The organics in sewage can be divided into three major groups: Carbohydrates (starches, sugars and cellulose) proteins and fats. The approximate distribution of organics being 40 to 50% carbohydrates, 40 to 50% proteins and 5 to 10% is fat.\(^9\)
Chemical Oxygen Demand (C.O.D.):

Chemical Oxygen Demand (C.O.D.) is used for measuring the pollutional strength of waste water. Most of the organic compounds can be oxidized to carbon dioxide and water by the action of strong oxidising agents regardless of the biological assimilability of the substances.

Hardness:

Temporary hardness is due to the presence of bicarbonate of Ca\(^{++}\) and Mg\(^{++}\) while permanent hardness is due to sulphates and chlorides of Mg\(^{++}\) and Ca\(^{++}\).

In general term, hardness of water is due to the salts of calcium, magnesium, strontium, iron and manganese.

Chlorides:

Chlorides are one of the major constituents found in all natural waters in different concentrations. Human excrete and industrial wastes etc. are rich in chlorides. For public health, chlorides upto 250 mg/litre are not harmful but increase of chlorides beyond this are indication of organic pollution.
Phosphorous:

Phosphorous occurs in natural waters and in waste-waters almost solely as phosphates. These are classified as orthophosphates, condensed phosphates (Pyro-, meta, and other polyphosphates) and organically bound phosphates. They occur in solution, in particles or detritus, or in the bodies of aquatic organisms. The major sources of phosphorus are domestic sewage, detergents, agricultural effluent with fertilizers and industrial waste waters. The high concentration of phosphorous therefore, is indicative of pollution.

Sulphate:

Sulphate is widely distributed in nature and may be present in natural waters in concentrations ranging from a few to several thousand milligrams per litre. Mine drainage wastes may contribute large amounts of sulphate through pyrite oxidation. Sulphate is an important constituent of hardness with calcium and magnesium. Sulphate produces on objectionable taste at 300-400 mg/L concentration.
Calcium:

Calcium is a common constituent of natural waters, resulting from the dissolution of limestone, dolomite, and gypsum, while not usually important from a physiological standpoint, calcium ion is unique in being desirable in moderate concentrations and undesirable either in very low or very high concentrations.

Surface waters and groundwaters may contain up to 100 ppm calcium ion, while seawater normally contains about 400 ppm.9

Magnesium:

Unlike calcium which is physiologically without effect in moderate concentration, magnesium ion in concentration above 125 ppm can produce cathartic and diuretic effects.

Magnesium ion concentration in groundwaters and surface waters may vary from zero to several hundred parts per million but rarely exceeds 30 ppm; seawater normally contains approximately 1200 ppm.9
AIM OF THE PRESENT WORK

River Godavari, affectionately known in this region, as "The Ganga of Marathwada" is one of the main river of Maharashtra. The river is now subjected to heavy pollution due to industrial establishments at Paithan, which is about 40 Km away from Aurangabad.

Paithan is situated on the north bank of Godavari and industrially developing town. The existing paper and pulp mills have their main share in the total quantum of Godavari pollution.

The effluents discharged from these mills are carried away by a Nullah which ultimately reaches to Godavari after travelling a distance of about 5 Km from the site of effluents discharge in it.

These effluents get mixed up with Godavari stream at the north bank and flow down stream alongside this bank.

Our detail and on the spot observations revealed the following facts:

(i) A number of dug wells situated on both the banks of the nullah were found to be highly polluted, give pale brownish to dark brownish colouration to the wells water.
(ii) The point at which this nullah meets Godavari stream and the village Hiradpuri along side the north bank of the river is a distance of about 35 Kms covering 6 villages situated on this bank of Godavari. The dug wells and Hand pumps in these villages are also found to be highly contaminated.

(iii) Where-ever such contaminated water was used for irrigation purposes, the growth of various crops was found to be retarded.

(iv) Consumption of the contaminated water by the cattle leads to premature abortions in them was also reported by the villagers.

It was, therefore, planned to investigate the various parameters of such a polluted water in the dug wells and hand pumps in the villages situated in the vicinity of both the banks of the Nullah as well as on the north abnk of Godavari.

Second part of the present investigation includes a systematic analytical studies of well water pollution caused due to the discharge of effluents from the three main Sugar factories in the Parbhani district.
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