CHAPTER I
CHAPTER - I

INTRODUCTION

Section - A

The environment consists of four segments - atmosphere, hydrosphere, lithosphere and biosphere. There is a good relation between the four segments. Change in any one will affect the entire system.

Today the cry of environmental pollution is heard all over the world. Pollution has now become a major threat to the very existence of life on earth. At present there are many environmental issues, which have grown in size and complexity day by day, threatening the survival of mankind on earth. How were several Japanese killed by eating fish from Miamata bay in the sixties? Why did 3000-4000 people die in London in 1952? Why are historic marble stones in Greece, Italy and India damaged by rain water? Why did Mediterranean sea turn into a dead sea, unable to support aquatic life in the fifties? Why is the Ganga river the most polluted river in India? Why did thousands and thousands of innocent people die in Bhopal in 1985? These are some typical environmental issues. Of course, the issues are linked with ecological, social, political and economic questions which are also to be taken into account.

The word pollution has got its origin from "Pollure" which is a Lattin word. Its literal meaning conveys the sense of contamination of the environment. Any disturbance in the ecological balance by disproportionate addition
or depletion of component preserving the ecological system may be termed as pollution. There is an evidence that our universe began between five to six billion years ago, possibly in an explosion. By that time matter was in the form of elementary particles, such as electrons, protons and neutrons. Soon these particles combined to form the elements helium and hydrogen and later other elements were formed. It is estimated that our sun and planets were formed a billion years latter, which could make our earth 4.8 million years old. There were no living organism at that time. According to cell physiologists after the formation of hydrogen and helium gradually the organogenic elements like carbon, nitrogen, oxygen, sulphur, phosphorus, halogens and some metals are formed. In the third stage organic molecules like \( \text{CH}_4, \text{CO}_2, \text{CO}, \text{H}_2\text{O}, \text{H}_2\text{S}, \text{N}_2, \text{NH}_3, \text{H}_3\text{PO}_4 \) etc were formed from organogenic elements. In the fourth stage biomolecules like aminoacids, sugars, nucleic acids, bases etc were formed from organogenic molecules. In the fifth stage biopolymers like proteins, polysaccharides etc were formed. After the formation of above stages the first living system appeared on the surface of earth. This life first came into existence in water as a droplet of protoplasm (protos - first + plasma - anything formed) from non-living materials as a result of certain chemical and physical changes in them under certain special circumstances. Protoplasm is, therefore, the first formed living substances, and once it came into existence its continuity has been maintained through successive generations with gradual changes of forms from simpler to more complex type of plants and animals existing over many millions of years.
Serious damage to our environment including enviromental pollution is a mere two-hundred-years old phenomenon since the industrial evolution. Life have started in this planet about three billion years back, man-like creatures appeared about three million years ago and the human civilization is about ten thousand years old and yet the environment was never in serious threat. But to-day, after two hundred years of industrial activity, we have reached a stage where there are distinct possibilities of (i) some natural resources getting totally exhausted, (ii) many plant and animal species getting extincted, (iii) irreversible changes occurring to our climate. All of these have widespread, cumulative and chronic adverse effects.

**ATMOSPHERE:** Atmosphere is one part of the environment. It is the protective blanket of gases surrounding the earth which sustains life on earth and saves it from the hostile environment of outer space. It absorbs most of the cosmic rays from outer space and a major portion of electromagnetic radiation from the sun. It also transmits only near ultraviolet, visible, near infrared radiation (300-2500 nm) and radio waves while filtering out tissue-damaging ultraviolet radiation below 300 nm. It plays a key role in maintaining the heat balance of the earth. It is also the major source of oxygen (essential for life on earth) and carbon dioxide (essential for plant photosynthesis). Unfortunately, with the progress in science and technology, man has been dumping waste materials into the atmosphere, which are posing a problem for survival of mankind itself on earth.
LITHOSPHERE:- Lithosphere is also a segment of environment, which is the outer mantle of the solid earth, consisting of minerals occurring in the earth's crust and the soil. The earth crust comprises a complex mixture of minerals, organic matter, air and water. The soil is the most important part of the lithosphere. Man is digging the earth, abstracting the mineral and utilizing for his industrialisation progress and other various comfort. In this way man is destroying the balance of environment.

BIOSPHERE:- Biosphere denotes the realm of living organisms and their interaction with the environment, viz atmosphere, hydrosphere and lithosphere. Both biosphere and environment are being influenced considerably by each other. Thus the oxygen and carbondioxide level of atmosphere depend entirely on the plant and animal kingdom. The biological world, in general, is intimately related with energy flows in the environment and water chemistry.

HYDROSHERE:- The composition of hydrosphere published in the "The World Water" is shown in table-1. About 94% of total water is stored in the oceans which is saline and therefore not usable as such. We the living organism are using very small percentage of fresh water from hydrosphere. Hydrosphere includes all types of water recourses - oceans, seas, rivers, lakes, streams, reservoirs, glaciers, polar icecaps and ground water. Besides ocean water, about 2% of the water recourse is locked in polar icecaps and glaciers while only 1% is available as fresh water for human consumption and other uses. The sources are rivers, lakes, streams on the surface and ground
water.

TABLE-1

Composition of Hydrosphere.

<table>
<thead>
<tr>
<th>Source</th>
<th>Volume (in thousand cubic kilometres)</th>
<th>Percentage of total volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. World's ocean</td>
<td>1,370,323</td>
<td>93.93</td>
</tr>
<tr>
<td>2. Underground water</td>
<td>60,000</td>
<td>4.12</td>
</tr>
<tr>
<td>3. Zone of active exchange</td>
<td>4,000</td>
<td>0.27</td>
</tr>
<tr>
<td>4. Glaciers and polar icecaps</td>
<td>24,000</td>
<td>1.65</td>
</tr>
<tr>
<td>5. Lakes</td>
<td>230</td>
<td>0.016</td>
</tr>
<tr>
<td>6. Soil moisture</td>
<td>83</td>
<td>0.005</td>
</tr>
<tr>
<td>7. Atmospheric vapour</td>
<td>14</td>
<td>0.001</td>
</tr>
<tr>
<td>8. Rivers</td>
<td>1.2</td>
<td>0.0001</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,458,651.2</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

The history of ancient civilizations growth and decline is intimately linked with the quantum of water supply. The major uses of water now-a-days are for irrigation (30%) and thermal power plants (50%) while other uses are domestic (7%) and industrial consumption (~12%).

Surface water gets contaminated by pesticides and fertilizers in agricultural run off water, human and animal wastes in sewage and industrial wastes. Waterborne diseases from sewage alone have killed millions of people in developing countries. So water pollution is becoming the major headache for the modern civilization.

Taking into consideration the different segments of environment viz atmosphere, lithosphere, hydrosphere,
the environmental pollution or contamination can be broadly divided as follows:

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POLLUTION

<table>
<thead>
<tr>
<th>Physical pollution</th>
<th>Chemical pollution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal pollution</td>
<td>Radioactive pollution</td>
</tr>
<tr>
<td>Noise pollution</td>
<td>Pollution by chemicals</td>
</tr>
<tr>
<td>Air pollution</td>
<td>Water pollution</td>
</tr>
<tr>
<td></td>
<td>Fresh water pollution</td>
</tr>
<tr>
<td></td>
<td>River water pollution</td>
</tr>
<tr>
<td></td>
<td>Marine water pollution</td>
</tr>
</tbody>
</table>
```

WATER:— Water is the most vital recourse for all kinds of life on this planet and is directly linked with human welfare. It is also the recourse, adversely affected both qualitatively and quantitatively by all kinds of human activities on land, in air and in water.

The life fluid of cell is the protoplasm. The most abundant inorganic constituent of protoplasm is the water. In its active state protoplasm remains saturated with 75-90% of water. With decreasing water content its vital activity diminishes and gradually comes to a standstill, as in dry seeds. So water is absolutely essential for all life in most of the biochemical reactions that occur in the metabolism and growth of living cell. This water exists in the earth in three different states of aggregations, such as solid, liquid and gas. The solid state of water is called ice, stored in glacier and
polar caps. In the form of liquid it is found on the earth surface in the rivers, reservoirs, seas and under the earth surface too. Lastly in the form of gas it is found in atmosphere as water vapour.

Water is the only substance which exists on the surface of earth in all the three states - solid, liquid and vapour - under natural condition. It has a simple chemical formula, $H_2O$ and has most anomalous properties which makes it distinct from other liquid. These anomalous properties appear to have been specially designed for specific environmental and biological significance. It has a higher melting point of $0^\circ C$, higher boiling point of $100^\circ C$ and higher heat of vapourisation of 540 cal/gm and higher dielectric constant of 78.4 D at $25^\circ C$ in comparison with other liquids. A few of such significant anomalous properties of water are presented in Table-2.

Water in its simplest form, exists in the gaseous state. A molecule of water vapour consists of an oxygen atom joined to two hydrogen atoms in the direction of two corners of a tetrahedron. The $H-O-H$ angle is equal to $105^\circ$ (Fig-1). In chemical terms, the $O-H$ bond is $sp^3$ hybrid bond with some p-character.

Unlike the gaseous state, in liquid and the solid state water does not exist as free molecules. In liquid state water molecules are attached to each other by the electrostatic force between the partial negative charge on the oxygen atom of one water molecule and the partial positive charge on a hydrogen atom of the other molecule. This type of electrostatic attraction is called hydrogen bond having a bond length of $1.77 \text{Å}$, Fig-2. ($1 \text{Å} = 10^{-8} \text{CM}$).
<table>
<thead>
<tr>
<th>Property</th>
<th>Comparison with normal liquid</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>State</td>
<td>Liquid rather than gas like H₂S, H₂Se and H₂Te</td>
<td>Provides life medium.</td>
</tr>
<tr>
<td>Heat capacity</td>
<td>Very high</td>
<td>Moderate environmental temperature, good heat transport medium.</td>
</tr>
<tr>
<td>Latent heat of fusion</td>
<td>Very high</td>
<td>Moderating effect tends to stabilize the liquid state.</td>
</tr>
<tr>
<td>Latent heat of vapourisation</td>
<td>Very high</td>
<td>Moderating effect important in atmospheric physics and precipitation-evaporation balance.</td>
</tr>
<tr>
<td>Density</td>
<td>Anomalous, maxi. 1.000 gm/ml for liquid water, solid state has lower density</td>
<td>Freezes from the surface, controls temperature distribution.</td>
</tr>
<tr>
<td>Dielectric constant</td>
<td>Very high</td>
<td>Thus a good solvent.</td>
</tr>
<tr>
<td>Hydration</td>
<td>Very extensive</td>
<td>Thus a good solvent and scavenger of environmental pollutants.</td>
</tr>
<tr>
<td>Dissociation</td>
<td>Very small</td>
<td>Provides neutral medium but with some availability of H⁺ and OH⁻ ions.</td>
</tr>
<tr>
<td>Heat conduction</td>
<td>Very high</td>
<td>Can provide an important mechanism in stagnant systems such as cells.</td>
</tr>
<tr>
<td>Surface tension</td>
<td>Very high</td>
<td>Helps penetration into rock crevices where on freezing it fragments rocks and helps in soil formation.</td>
</tr>
</tbody>
</table>
In the crystal structure of ice, each water molecule is surrounded by four nearest neighbours in such a way that each group has one molecule at the centre and the other four at the corners of a tetrahedron. The molecules in a group, as well as the groups, are held by hydrogen bonds. Due to the existence of hydrogen bonds ice has an open structure with a large empty space as in honeycomb. The presence of empty space in solid water (ice) is responsible for its lower density compared to that in the liquid form. As ice melts at 0°C, a number of hydrogen bonds are broken down and the space between water molecules decreases. So the water molecules move close together. The density of water increases, therefore from 0°C to 4°C at which it is maximum. This density maximum just above the freezing point results in the freezing of rivers and lakes from the surface downwards. This saves the aquatic life. Due to some of the special characters water makes it distinct from other liquids.

**HYDROLOGIC CYCLE**:- The hydrologic cycle links up all part of hydrosphere into a single whole, Fig-3. The sea water, surface water and moisture content of soil are evaporated due to solar rays. Green plants are giving off water vapour in the process of transpiration, respiration etc. The water enters to the atmosphere as vapour and gets collected lastly in cloud. This gives us fresh water in the form of rain and snow. Part of the rain and melted snow seeps into soil. The rest flow as surface run off through slopes, ravines etc. into numerous rivulets that discharge into rivers. Rivers mostly get discharged into sea or lakes. Again it supplies fresh water in
FIG. 1 - STRUCTURE OF WATER IN GASEOUS STATE

H — O — H

FIG. 2 - HYDROGEN BONDS IN WATER
the form of cloud on precipitation. The sources of water collected by plants are surface water, soil moisture, atmospheric water, ground water etc. The plants give off water vapour to the atmosphere in the process of respiration and transpiration. Animals are also getting water from plants, rivers, ponds, wells etc. Animals leave water vapour by the process of respiration and sweating to the atmosphere. In this way water in nature maintaining a cyclic order (Fig-4).

MAN'S INTERFERENCE:— Man is the most intelligent one among the living organisms present in any type of food chain. So man always plays over the entire plants and animals kingdom as well as entire natural products present on the earth. Let us take an example of water. Man’s use of water resources is closely and constantly linked up with the operation of nature’s great hydrologic cycle. Man uses water not only for drinking and culinary purposes but also for bathing, laundering, heating and air conditioning, for agriculture, stock raising, gardening, for industries, for electric power generation, for cooling, for steam power, for fire protection, for disposal of wastes, fishing, swimming, boating, for wildlife propagation, navigation and other recreational purposes. It is however to be born in mind that regardless of how the water resources are used, water is not removed from the cycle in the process of use, but man can transfer water from one arc or chord of the cycle to another. In this process, imbalance in the existing water resources is created. Thus, due to these manifold use of water resources, fresh natural water gets contaminated by man and hence water gets polluted.
FIG. 3 BROAD HYDROLOGIC CYCLE IN NATURE.
FIG. 4 THE HYDROLOGIC CYCLE IN BIOSPHERE
WATER POLLUTION - THE INCREASING MENACE

Though the defilement of water as a result of human activities is a phenomenon as old as hills, the increasing industrialisation, urbanisation and developmental activities and consequent pollution of water has brought a variable water crisis. Today most of the rivers of the world receive millions of litres of sewage, domestic waste, industrial and agricultural effluents containing substances varying in characteristics from simple nutrients to highly toxic substances.

Of late there has been growing concern in our country and abroad over the pollution of sewage and trade effluents discharged from human habitations and industrial establishments. The waste water without proper treatment, when discharged into a stream or lake, pollutes the water there. When discharged on land, the land is also affected, if the waste water has characteristic harmful substances. Further it will percolate and contaminate the groundwater if the groundwater table is high and during percolation, the waste water is not effectively filtered and "cleaned" by the soil. There are also evidences that the marine water has started experiencing pollution.

Although pollution is continuously produced by human activities, it is usually recognised only when it adversely effects other living organisms. The important signs of water pollution are bad taste of drinking water, offensive odours from lakes, rivers and ocean beaches, unchecked growth of aquatic weeds in water bodies, decrease in number of fish in fresh water, river water and sea water, oil and grease
floating on water surfaces. These disturb the normal uses of water for public water supply, recreation and aesthetics, fish, other aquatic life and wild life, agriculture, industry etc.

CONSEQUENCES OF WATER POLLUTION:

Water pollution affects in two ways: (i) toxic chemicals and harmful microbes in waste water cause health hazards, and (ii) nature's response to pollution by aerobic digestion of the pollutants cause decrease in oxygen concentration in water which is detrimental to aquatic life and may ultimately lead to eutrophication of the water body if the oxygen depletion is serious.

From an ecological point of view, Odum classified the pollutants into three main classes, viz, non-degradable, biodegradable and thermal. Nondegradable pollutants include substances such as D.D.T., long chain phenolic chemicals, mercurical salts, heavy metals etc. The nondegradable pollutants in water like heavy metals, pesticide residues etc. enter into the food chain through planktons to fishes and so on. In this process, the concentration of pollutant in the tissues of organism increases. This process is called "biomagnification". Organisms higher percentage in the food chain bio-accumulate more. Man being at the top of the food chain, accumulates such pollutants to the maximum extent. Domestic sewage and many other chemical pollutants are biodegradable types. These biodegradable pollutants when discharged into a water body, are attacked by aerobic (oxygen demanding) bacteria present there with the help of dissolved oxygen. Consequently, decrease of concentration of dissolved
oxygen takes place. When the oxygen level is very seriously depleted, anaerobic bacteria takes over and pollutants are degraded in the absence of air. Aquatic plants and animals also die due to want of oxygen. Anaerobic digestion produces methane gas and along with it molodorous sulphur compounds. The resultant total absence of oxygen and sludge produced in the digestion process causes the ultimate death of the water body which is called "eutrophication". All inland water bodies do undergo slow eutrophication in the natural process, but this is accelerated if large loads of organic pollutants and nutrients enter the water body. Thermal pollution is yet another major concern. Various industries and thermal power plants use large quantities of water for cooling purposes and therefore, contribute towards thermal pollution. The electric power industry alone accounts for about 80% of the cooling water. Nuclear power station also contributes major part of thermal pollution. Thermal pollution refers to the rise of water temperature. The discharge of hot water from the condensers of thermal stations cause variation of temperature in the streams, unless the flow in the stream is large. It is found that fish are sensitive to temperature changes and die on sudden exposure to hot water. Certain type of photoplanktons are also sensitive to temperature variation. So special precautions have to be taken while locating Thermal power station and nuclear power stations.

The quality of water is of vital concern for mankind. At present, the menace of water-borne diseases and epidemics still looms large on the horizons of developing countries. Polluted water is the culprit in all such cases.
The outbreak of minimata disease and Itai-itai disease among the Japanese fishermen in 1956 as a result of the consumption of fish contaminated by mercury and cadmium respectively have brought to light the great concern of water pollution. In a survey conducted in 1980, the World Health Organisation estimated that some 25 million people died every year from diseases caused by unsafe and inadequate drinking water and poor sanitary condition. The picture of water pollution in India is really grim. According to the estimate of scientists of the National Environmental Engineering Research Institute, Nagpur about 70% of available water in India is polluted and about 73 million mandays are lost per year due to water related diseases.

**SOURCES OF WATER POLLUTION:**

Basically, there are three main sources of water pollution viz domestic, industrial and non-point source (e.g., pollution from agricultural runoffs). Waste water from domestic source (Municipal sewage, etc.) generally contains many organic and many faecal matters along with disease carrying caliiforms. They are mostly biodegradable but some organic substances like linear alkyl sulphonates (present in detergents) are not so. The industrial waste water is likely to contain various types of pollutants depending upon the industrial process. Some of them are toxic and not easily biodegradable. In term of Biochemical Oxygen Demand (BOD), a very important parameter for assessment of water quality, the pollution load is about 50% each for industrial and domestic waste water at present. Considering the present status of industrialisation of the
state, the above figures are expected to be more or less of the same order for Orissa. The non-point source of pollution consists of runoffs from agricultural fields etc. containing large quantity of chemical fertilizers, pesticides and faecal matters. The non-point sources of pollution are difficult to control. On account of the relatively lower use of agricultural chemicals, the pollution load from non-point sources in our state and the country is expected to be less than that in more advanced countries. While the chemical fertilizer used in India is of the order of 16 kg/ha, the world average is about 54.54 kg/ha.¹⁶

The pollutants contributed to the aquatic environment by different point and non-point sources are diverse and can be broadly categorised as:

(i) disease-causing organisms (viz. human and chemical wastes);

(ii) synthetic organic compounds (household and industrial chemicals, pesticides etc.);

(iii) inorganic compounds (acids, alkali, heavy metals, mostly from industrial effluents);

(iv) Radio active substances from nuclear power plants;

(v) oxygen demanding wastes (sewage and certain effluents of industries);

(vi) plant nutrients (through sewage and agricultural runoffs);

(vii) sediments (through soil erosion); and

(viii) thermal discharges (from power plants).
Besides the point and non-point sources of pollutants, some of the common sources of pollutants which pollute the water systems of Indian rivers, ponds, lakes, reservoirs etc are given below.

1. The waste materials deposited on roadsides, lands etc of villages and towns are washed away during rainy season. This washing materials are deposited at last either inside ponds, rivers, lakes, reservoirs or sea.

2. The drainage water which is discharged by the people of towns and villages to rivers, ponds etc increases the pollution load of water.

3. The effluent water of different factories are mixed with the quality water of rivers and ponds also increases the load of pollution.

4. Men and animals in villages leaves their stool and urine by the sides of ponds and rivers. This stool and uninated soil are washed away by rain water to the rivers, ponds thereby increases the pollution load.

5. Animals, specially buffaloes and cows are getting their bath in rivers and ponds. For which different microorganisms of diseases are spreading among healthy persons and animals.

6. The deadbodies of living organisms which are being thrown to the body of water increases the pollution load.

7. Plants situated on the banks of rivers and ponds discard their leaves to the water body. These leaves are decomposed at last by different microorganisms. Due to these reasons odour of the water body changes.

8. Along with bathing people are washing their clothes, spitting to clean their mouth and teeth, cleaning their utensils,
cleaning their cloacal apparatus after leaving their stool, collecting jute fibres from green jute plants by keeping them under the water dipped for seven to fifteen days. All these activities causes pollution of water body.

9. If the waste materials of drains or waste materials of cattle or animals etc. are deposited within a distance of 15 metres around ponds or wells, then on raining the washing of these wastes can leak easily to the ponds and wells through soil. These leakage water increases the pollution load of that water system.

These are some common sources and causes due to which the quality of water changes. The parameters by which one wishes to specify the quantitative standards of polluted water are:

(i) Physical water quality parameters such as temperature, colour, taste, odour, turbidity, foam and froth, conductivity, solid content etc.

(ii) Chemical parameters of water quality like dissolved oxygen, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), pH, alkalinity, acidity, redox potential, ammonia, nitrate, nitrite, phosphate, sulphate, chloride, silica, calcium, magnesium hardness, sodium, potassium, iron, heavy metals, detergents, pesticides, insecticides and herbicides etc.

(iii) Biological water quality parameters viz. protozoa, cali-form, bacteria, fungi, virus, algae etc.

River water pollution in India:-

Most of the Indian rivers are polluted by wastes from factories, sewage system discharged from city/town situated
at the banks and also from the agricultural runoffs. These rivers are full with water during monsoon period. During rest of the year the streams are thin which highly limits their purifying capacities. Most of the cities in India are lacking in sewage treatment plants. So raw sewage are dumped into the rivers. The sewage for decomposition uses up the dissolved oxygen of the river water which is essential to sustain life in water.

The principal industries whose waste water and effluent are harmful to the river systems in India are textile, paper and pulp, sugar, distilleries, vegetable oils and coal washeries, chemicals and tanneries. It is also common practice in India, that any substance which cannot be burnt or buried is thrown into the river. The coastal area is the dumping ground of these wastes, including garbages, oils and other wastes. Some of the main sources and causes of the pollution of river water has been discussed earlier.

River water pollution in India has reached a crisis point and the list of polluted rivers is a long one. Many of our rivers including the Ganga which were once considered pure and sacred, are now among the most polluted rivers in the world. Some of the Indian rivers polluted by the effluents of different industries and sewage system of nearby town/city are given below.

The river Kali, near the city of Meerut in the state of Uttar Pradesh, is polluted by the effluent of industries like sugar mills, distilleries and factories producing paint, soap, glycenies, rayon, silk yarn, tin etc.

The river Jamuna near the capital of our country is polluted by the waste water of D.D.T. factory, Indraprastha
power station and sewage of Delhi city.

The river Ganga near the city of Kanpur in the state of Uttar Pradesh is polluted by the waste washings of tanneries, textile mills, jute mills and also due to great bulk of domestic sewage discharge.

The river Gomati near the city of Lucknow in the state of Uttar Pradesh is polluted by the sewage of Lucknow city and effluent of industries like paper and pulp mills.

The river Dajora near the town Bareli in the state of Uttar Pradesh is polluted by the waste water of synthetic rubber factories.

The river Damodar between Bokaro Steel city and Panchet in the state of Bihar is polluted by Fertilizer plant, fly ash from steel mills, suspended coal particles from washeries and thermal power station.

The river Sone near the town Dalmianagar in the state of Bihar is polluted by the effluents of pulp, paper and steel industries.

The river Siwan in the state of Bihar is polluted by the industrial wastes of paper, sulphur, cement and sugar mills.

The river Hoogly near the city of Calcutta in the state of West Bengal is polluted by the effluents of industries like power station, paper, jute, textile mills, chemicals, paints, varnishes, metal, steel, hydrogenated vegetable oils, rayon, soap, match, shellac, polythene industries and moreover by the sewage of Calcutta city.

The river Bhadra in the state of Karnataka is pol-
luted due to pulp, paper and steel industries situated in the nearby area.

The river Coom, Adyar and Buckingham Canal near Madras city in the state of Tamilnadu is polluted by the domestic sewage and effluents of automobile workshops.

The river Cavery in the state of Tamilnadu is polluted by the sewage and wastes disposed by industries like tanneries, distilleries, paper and rayon mills.

The river Godavari in the state of Andhra Pradesh is polluted by the waste water of paper mills situated on the bank of the river.

The river Kulu in between Bombay city and Kalyan town in the state of Maharashtra is polluted by the effluents of chemical factories, rayon mills and tanneries.

The river Suwao near Balarampur in the state of Madhya Pradesh is polluted by the effluents of sugar mills.

Similarly the important rivers in Orissa are also more or less polluted by the town/city and industrial wastes. Some important informations about these rivers are given in Table-3.

**SOME POLLUTED RIVERS OF ORISSA**

**Rusikulya:** The river Rusikulya passes through the district of Phulbani and Ganjam. It is the source of irrigation and drinking water supply to Berhampur city, Bhanja Vihar, Rare earth complex and Chhatrapur town. It is polluted by the wastes of sugar factory at Aska in the middle basin and Chloroalkali plant at Ganjam on the north bank of the river mouth. The Rusikulya mouth can be compared to the Manmata Bay of Japan due to
### TABLE-3

**Some Important Information About the Major Rivers of Orissa.**

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mahanadi</td>
<td>Parsiya in Raipur dist.</td>
<td>141,589</td>
<td>851</td>
<td>44,740</td>
<td>66,640</td>
<td>Sorenath, Mand, Hasdeo, Ib, Jonk, Ong, Tel.</td>
</tr>
<tr>
<td>Brahmani</td>
<td>Nagri village in Ranchi district of Bihar.</td>
<td>39,033</td>
<td>800</td>
<td>22,640</td>
<td>18,310</td>
<td>Karo, Sankha, Tikira, Singada, Sankhoi and Chilanti.</td>
</tr>
<tr>
<td>Baitarani</td>
<td>Ganasika village in Keonjhar dist.</td>
<td>12,789</td>
<td>365</td>
<td>14,150</td>
<td>5,755</td>
<td>Arrdi, Siri, Salandi, Kusai, Kukurkata, Tel, Kanihari, Gohira, and Remal.</td>
</tr>
<tr>
<td>Subarnarekha</td>
<td>Chhotanagpur plateau of Ranchi dist. in Bihar.</td>
<td>19,300</td>
<td>395</td>
<td>17,000</td>
<td>7,940</td>
<td>Kanchi, Karkari and Khadkei.</td>
</tr>
<tr>
<td>Bhudhabalanga</td>
<td>Similipal hills of Mayurbhanj district in Orissa.</td>
<td>4,837</td>
<td>164</td>
<td>5,660</td>
<td>2,177</td>
<td>Sore, Gangahar, Palpala and Kadra.</td>
</tr>
<tr>
<td>Rusikulya</td>
<td>Daringbari area of Phulbani district.</td>
<td>7,753</td>
<td>146</td>
<td>8,495</td>
<td>1,800</td>
<td>Padma, Badanadi, Godahada, and Bhaguva.</td>
</tr>
</tbody>
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<tr>
<th>Name of the river. Origin.</th>
<th>Drainage Area in sq.km.</th>
<th>Length of Mainstream in km.</th>
<th>Peak discharge in Cumecs.</th>
<th>Annual flow in Mm³</th>
<th>Main Tributaries.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bansadhara</td>
<td>10,800</td>
<td>221</td>
<td>4,700</td>
<td>3,500</td>
<td>Paladi, Gangudi, Sananai, Paddagodda, Dhamni, and Chudalhaua.</td>
</tr>
<tr>
<td></td>
<td>(8,015 in Orissa)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nagaveli</td>
<td>9,410</td>
<td>217</td>
<td>6,800</td>
<td>2,430</td>
<td>Jhanjabali, Vagaval, Subharnamukhi.</td>
</tr>
<tr>
<td></td>
<td>(3,746 in Orissa)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indravati</td>
<td>7,512</td>
<td>185</td>
<td>6,792</td>
<td>2,800</td>
<td>Bhaskel.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kolab</td>
<td>7,639</td>
<td>88</td>
<td>7,358</td>
<td>2,615</td>
<td>Sabari.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machkund</td>
<td>9,140</td>
<td>192</td>
<td>4,044</td>
<td></td>
<td>Gurepreonala.</td>
</tr>
</tbody>
</table>

*Values in parentheses are those collected from the Irrigation department of Govt. of ORISSA.

Cumecs = Cubic metres per second; M = million.
leakage of mercury from the chloroalkali plant.

**Kolab Saberî**:- It flows in the district of Koraput, MIG factory at Sunabeda, fodder farm, Regional Research Station, seed multiplication farm at Similiguda, Aluminium factory and township of NALCO are the main sources of pollution to this river. Also some small scale industries on the bank add to the pollution load of this river. Recently Upper Kolab dam and Saliguda reservoir has been constructed across this river.

**Mahanadi**:- The river Mahanadi is the largest river in Orissa and passes through the districts of Sambalpur, Bolangir, Cuttack and at the boundary of three districts namely Phulbani, Dhenkanal and Puri. This river is polluted by the effluent of Orient Paper Mill at Brajrajnagar via the river Ib and paper mill, textile mill at Choudwar near Cuttack. The river is also polluted by the domestic sewage water discharged into it of Sambalpur, Sonepur town and Cuttack city. According to recent report of Das and Dash the alkalinity and mercury are the cause of development of cracks in Hirakud dam. These are due to the discharge of waste water of Orient paper mill into the river at Brajrajnagar. Mercury in minute quantity is also poisonous both to flora and fauna present in water. Many ideas have been proposed for the cause of the crack in Hirakud dam. The officially accepted version is that it has happened due to the alkali aggregate reaction. Certain types of silica aggregates slowly react with the alkali of the cement in the presence of water to form "gels". As a result of which swelling takes place and strain develops in the structure.

**Kathajori**:- The river Kathajori is a distributary of the
Mahanadi and it is polluted by the heavy sewage and the waste water of Cuttack, the most crowded city of Orissa, through Bajrakabati nalha.

Budhabalanga:- The river Budhabalanga passes through Mayurbhanj and Balasore districts. Near Baripada town, the river is polluted by the discharge of industrial and domestic wastes into it. In the delta region it is polluted by the toxic waste chemicals of paper mills. Near Balasore town the river is polluted by effluents of the industrial complex, Railhead and sewage of the town.

Subarnarekha:- The river is named so as its sand contained fine particles of gold. It passes through Bihar, West Bengal and Orissa and finally merges with the Bay of Bengal. The effluent and sewage from most polluted city Jamshedpur is discharged into the river through the Kharkhai river. It is also receiving a lot of wastes as it passes through the area like Uranium Corporation at Jadugoda, Ghatsila copper complex and Musabani copper and iron mines. The higher percentage of boron and copper in the river water near Ghatsila is a great headache for all concerned now. Near Biridihi area of Jamshedpur higher percentage of iron, oils, grease and low pH are observed with the river water which is not suitable for domestic and irrigation purposes.

Brahmani:- The river Brahmani is the second largest river in Orissa. It passes through four major districts viz. Sundergarh, Sambalpur, Dhenkanal and Cuttack and finally meets the Bay of Bengal at Dhamara. It is the most polluted river in Orissa, receiving huge amount of effluents and sewage from Rourkela.
industrial complex and Talcher industrial complex. The details of the industries and towns which are polluting this river are given in Table-6(A). The details about the river Brahmani and its pollution load has been discussed in subsequent chapters.
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16. Khusoo, T.N., Presidential address at the 73rd Session of Indian Science Congress, New Delhi, P-115, Jan 3 to 7 (1986).


An appreciable number of reports are available on limonobiotic studies of riverine and lake ecosystem of India. However no detail report on ecological studies in aquatic ecosystem of Orissa in relation to urbanisation and industrialisation is available. However many newspapers report that more than six people die every day on an average in Orissa due to ailment arising primarily out of drinking polluted water.\(^1\) Studies on fresh water ecosystem in Orissa are very few.\(^2\) Ecological studies of rivers and lakes have yielded useful data for the understanding of the nature of the ecosystem and it throws a flood of light on the changes which have been brought about the intense human interference.

Water quality criteria for aquatic life has been investigated in various fresh water streams, ponds, lakes and rivers by many workers.\(^3\)(a-e) Variation in water quality of some Kashmiri lakes has been studied by Zutshi.\(^4\) Raina et al.\(^5\) have assessed the pollution load of the river Jhelum. Water quality index has also been determined to ascertain the purity of water.\(^6\) A general survey of the plankton and chemical constituents of river Volta of South Africa,\(^7\) Montreal river,\(^8\) River Thames,\(^9\) River Nida, Poland,\(^10\) Rhine and Rone river,\(^11\) Lake Lanao, Philippines,\(^12\) Goose lake\(^13\) and Densu reservoir\(^14\) have been extensively studied outside India.
In India, pioneering studies on limonology of river and lake ecosystems have been done by many workers. Reports by Chakravarty et al\textsuperscript{15} on the river Yamuna, David\textsuperscript{16} on the river Gandak, Ray et al\textsuperscript{17} on the river Ganga and Yamuna, Pahwa and Mehrotra\textsuperscript{18} on the river Ganga have been published. A physico-chemical study of the water of river Ganga in a stretch of 12 Kms in Varanasi city region with special reference to dissolved oxygen and heavy metals has been done by Mathur and co-workers.\textsuperscript{19} Considerable amount of studies on chemical and bacteriological aspects of the water of different lake and reservoirs have been carried on. Investigation reports of Srinivasan on mountain lakes of Madras,\textsuperscript{20} Vyas on Pichhola lake, Udaipur,\textsuperscript{21} David et al on Tungabhadra reservoir\textsuperscript{22} followed by Munawar,\textsuperscript{23} Zutshi et al,\textsuperscript{24} Mathur,\textsuperscript{25} Mishra and Yadav,\textsuperscript{26} Sashikanta and Anand,\textsuperscript{27} John,\textsuperscript{28} Sharma and Pant,\textsuperscript{29} Gopal et al,\textsuperscript{30} Mishra and Bhatnagar,\textsuperscript{31} Dutta and Choudhury,\textsuperscript{32} Majumdar,\textsuperscript{33} Goel et al,\textsuperscript{34} Sashikanta,\textsuperscript{35} Yadava et al,\textsuperscript{36} Verma and Dutta,\textsuperscript{37} Munsi on various lakes are available.

Upadhyaya and Ray\textsuperscript{38} have made a comparative study of the quantum and nature of pollution in six rivers namely, the Dhobikhola, the Manahara, the Nakhu, the Balkhu, the Bishnumati, and the Bagmati of Kathmandu valley by determining various physico-chemical parameters of the water samples. Tiwari and Ali have determined the water quality index of the above rivers of Kathmandu valley also.\textsuperscript{38(a)} Recently Dash et al\textsuperscript{39} and Pattanaik\textsuperscript{40} have reported about the water quality of the river Mahanadi and Brahmani of the state of Orissa.
Diurnal variation in physico-chemical characteristics of water have been studied by George, Verma, Khan and Siddique, Saxena and Adoni, Vijaylaxmi and Venugopal, Mishra et al, Ganapati, Bhora et al, Kumar et al, and Datta Munsi in different ponds, lakes and rivers of India.

Biological aspects of pollution and use and abuse of different indicator organisms have been studied by Cooke, Ingram, Ganfin, Surber, Beck, Palmer, Watanabe, Hawkes, Srivastava, Dean and Burlington, William, Brinkhurst, Sarkar and Krishnamoorthy, Keulder, James and Evison, Kushlan and Hunt, Jiji Bai and Sasi, Patil et al, Nautiyal et al, and Kulshrestha and co-workers.

Ecological studies of the river and the lake system with reference to pollution load have been made by Heukelekian, Maloney and Robinson, Goldrech et al, Dutka et al, Thomas, William et al, Ozimek and Sikorska, Hendry et al, and Hendry and Harswell. However water pollution in India prior to 1970 were few (Ganapati and Chacko, Rai) but gained momentum during Nineteen seventy onwards. A lot of work have been reported by Munawar, Sastry et al, Arora et al, Kumar et al, Rai and Kumar, Hussain, Srivastava and Sahai, Kaul, Sharma et al, Verma et al, Sreenivasan et al, Jena et al, Handa et al, Sinha and Ghose, Singh and Kshirsagar.

Publications are now available on sewage disposal and its effect on aquatic ecosystem by Goel and Trivedy, water pollution due to chromate industry by Nanda Kumar and Babu, effect of tannery waste disposal by Chandra and Gopal.
Krishna, impact of distillery effluents by Sankar et al., effect of mining by Desai from India. Kudesia made a comparative study on major rivers of India with particular reference to pollution load. The rivers include the Ganga at Garhmukteswar, the Yamuna at Delhi and Haryana, the Brahmaputra at Assam, the Narmada at Hoshangabad (M.P.) and the Cauvery at Karaikal in Tamilnadu.

Pollution by heavy metals is instantly recognised with the Minimata disaster in Japan in 1953 due to mercury accumulation on the body of fishermen (Smith and Smith). Since then enough literatures are now available on the monitoring of heavy metals in water, sediment and in tissue of aquatic organisms and their toxicity all over the world (Kaiser and Tolg, Luckey et al.). Studies on heavy metals in aquatic environment in India have been made by Paul Raj, Rao Ramani, Laxmikanta et al., Ganeshan, Wing and Doane, Patil and Patil, Godkari and Marathe, Sitasaswad, Shaw et al., Shaw and Panigrahi, Hegde, Fuleskar, Tare and Choudhuri and Mathur et al.

Studies on bacteriological analysis of aquatic ecosystem and physicochemical analysis of waste water have been carried out in India and abroad by Keller, Robinson et al., Upadhyaya et al., Patil et al., Trivedy et al., Nautiyal et al., Mahadevan and Krishna Swamy. However studies on effect of industrial effluent and waste water disposal on the physico-chemical, bacteriological characteristics, and particularly organic waste disposal and their
characteristics are rare. Scanty reports on this line are available by Ganapati and Chacko, Chandra Prakash and Dinesh Chand, Mckinnery et al, Raghavan, Triedge, Young and Rivera, Mishra et al, Kshirsagar, and Dhabadgaonkar.

Fragmentary reports on hydrobiological studies on the lakes and the rivers of Orissa are available (Choudhury et al, Patra and Nayak, Nayak and Patra, Dash et al). Although there are two major industrial complexes on the bank of the river Brahmani and also many small scale and medium scale industries are located on the bank of other rivers but extensive reports are not available on their effect on the riverine system.

The above review is not a complete bibliography of the studies on chemical and biological aspects of different water sources and their pollution load. The compilation of all such works will be very exhaustive. But the literature cited in this collection are indicative of the type of work already done.
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<th>Details</th>
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