CHAPTER I

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It is said in ancient scriptures that “Jalam Jeevamrutham”. This shows the importance of water to life.

Water forms a necessary constituent of all animal and plant tissues and that life cannot exist even for a limited period in the absence of water. The protoplasm of most living cells contains about 50% water. Most of the biochemical reactions that occur in the metabolism and growth of living cells involve water. Most of the water present in living organisms acts as an irrigant, distributing nutrients and removing waste products. Most diseases connected with water result from irregularity in the rate of blood flow, the composition of the intestinal and cellular aqueous media and partial dehydration or hyper hydration. Water is acting as a solvent and dispersing and lubricating medium and is also a versatile reactant. Water is also required in industries for power generation, navigation, irrigation of crops, disposal of sewage, etc. Water is an important part of our environment. All the living creatures depend upon water in one way or other. Water is the most vital resource for the existence of life on earth. No other natural resource has had such an overwhelming influence on human history. But
this most precious resource is getting deteriorated. Human activities have played a prominent role in degrading air, water and soil. The air we breathe, the water we drink, the soil we stand and the food we eat are polluted. Civilization itself cannot survive if the natural environment collapses and man must balance the resources of the planet if he wants to survive [Camp Thomas, 1929].

Many human activities require water. The property of water of dissolving many substances makes it very useful in industries and in daily use. After use in home, agriculture and industry, water gets contaminated. The used water may contain waste and harmful substances called pollutants. Pollutants are residues of substances made by us as waste products which pollute the environment in one way or other. Potable water is rare. So water must not be wasted. It should be conserved. Conservation means careful and economic use. It also means less wastage. In order to conserve water, efforts should also be made to minimize the pollution of the sources of water. The quality of water is now the concern of scientists all over the countries of the world. The recent decision of WHO emphasizes that water given to people should meet high requirement of modern hygiene and it must be free from toxic substances and pathogenic organisms. Water balance is causing
changes due to human activities like industrialization, deforestation and over population [Trivedi PR, 1989].

Domestic waste water and the method of their disposal are of prime concern in urban areas. Solid wastes are the potential source of contamination as they are partly burnt and partly incorporated into soil and pose serious danger to the ground water. Most industries generally produce water containing heavy metals along with hazardous organic and inorganic effluents. These chemicals contaminate ground water and severely pollute it. The industrial effluents include poisonous chemicals ranging from suspended solids, heavy metals, cyanides, several acids and alkalis to fluorocompounds. Pollutants from agricultural sources comprise pesticides and fertilizers and their breakdown products. Thermal pollution of water is caused by the discharge of hot water from cooling towers of power plants and other industries. Effluents from different sources contaminate valuable freshwater sources such as lakes, rivers, streams, ground water and ocean water. Pollutants impart color, turbidity and unpleasant taste and odour and foamness to water and contribute to eutrophication. A large number of infectious diseases are spread through contaminated water. Water pollution is detrimental to aquatic life and also affect the composition of flora and fauna. Consequently food chains and food webs are disturbed. Some
chemical pollutants are so poisonous that they kill the aquatic organisms. Some others are persistent and pass through the food chain [Freedman B, 1989].

1.2 STRUCTURE AND PROPERTIES OF WATER

Water is an unusual substance. Its physical properties and behaviors are very different from those of most other liquids.

The water molecules consist of two parts of hydrogen and one part of oxygen. Pure water is a colourless, odourless, bluish green clear liquid having no odour and no taste. The pure water has freezing point 0°C and boiling point 100°C. The dielectric constant and electrical conductivity at 18°C are 81.0 and 4.3 x 10^-8 ohm^-1 cm^-1. If pure water is heated from 0°C to 4°C, its volume does not increase but contracts and thus attains its maximum density at 4°C. Similarly if water is allowed to freeze, it expands instead of being contracted, and this is the reason that big ice slabs float on the surface of water bodies freely. Water is a universal solvent because of its high dielectric constant. The dielectric constant of a substance is a measure of the attraction of opposite electric charges for each other in that substance. For liquid water at 18°C the dielectric constant is 81. This means that two charges in water attract each other with a force only 1/81 as strong as in vacuum. The
combination of a high dielectric constant and the fact that water molecules tend to attach themselves to ions results in water having an extraordinary capacity to dissolve ionic substances. When a compound such as NaCl is dissolved in water, the attraction between the sodium ions and chloride ions is weak because the dipolar water molecule aligns their positive and negative sides in such a way that the attraction is partially neutralized. In addition each positively charged sodium ion is surrounded by several water molecules with the negative sides attached to the ion. The positive side of other water molecules attach themselves to chloride ions. This formation of hydrated ions also weakens the attraction of sodium and chloride ions for each other. Thus water can dissolve and hold large amounts of those compounds and elements that form ions in solution. Most organic compounds do not form ions and thus will not dissolve easily in water. They will dissolve intensely in liquids such as benzene that have low dielectric constants [Mark J Hammer, 1975].

Water molecules are characterized by hydrogen bonding because hydrogen atoms donate its only electron for a covalent bond with oxygen, Thus hydrogen atom turns to a very small nucleus and so it is not reported by the electron shell of the oxygen of another water molecule. The hydrogen
bonds have been shown in two water molecules as below [Weston RS & Turmer CU, 1917].

Among the various types of intermolecular interactions, the hydrogen bond plays the most significant role in determining the structure and properties of molecular systems of importance to chemistry and biology. The phenomena of hydrogen bonding has been investigated extensively by a variety of spectroscopic and other physical methods.

Pure water contain hydrogen and oxygen in ionic form as well as in the combined molecular form. The ions are formed by the dissociation of water.

\[ \text{H}_2\text{O} \leftrightarrow \text{H}^+ + \text{O}_2\text{H}^- \]

where the plus and minus sign indicates the charge on the ionic species. Although the ionic form of hydrogen in water is usually expressed in
chemical equations as $\text{H}^+$ it is normally in the form of $\text{H}_3\text{O}^+$ which denotes a hydrogen core surrounded by oxygen with four electron – cloud pairs.

Water is a solvent for many salts and some types of organic matter. The thermal agitation of ions in many materials is great enough to overcome the relatively weak charge attraction that exists when surrounded by water, thus allowing large numbers of ions to dissociate into aqueous solution. Stability of ions in the aqueous solution is permitted by the formation of hydrated ions. Each positively charged ion, cation, attracts the polar ends of the negative water molecules and binds several molecules in a relatively stable arrangement. The number of water molecules attached to a cation is determined by the size of the cation. Negatively charged ions, known as anions, exhibit a much weaker tendency for hydration. The anions attract the negative ends of the polar water molecules and the sizes of the ions in their hydrated form are important with respect to many processes that occur in the ground water environment [Werner Stumm and Morgan J, 1924].

### 1.3 AVAILABILITY OF WATER RESOURCES ON EARTH

About 97.3% of the reserve on earth is saline water. Only 2.7% is fresh water. Of that nearly 70% is frozen in the ice caps of Antartica and
Greenland and most of the balance is present either as soil moisture or lies in deep underground aquifers as ground water not accessible to human use.

In India, 12% of the people get clean drinking water, the rest 88% quench their thirst from polluted lakes, tanks, rivers and wells due to which more than three million people get affected or die of enteric diseases every year [Trivedi PR, 2004].

Every activity of man involves some use of water. Often the water that is withdrawn is returned to the water sources either with pollutants or with an increase in temperature, or both and if taken from large water courses, this water is used over and over again by downstream communities, with further impairment in quality each time. In agriculture a large portion of the water is lost by transpiration and evaporation [Petty John WA, 1972].

Water polluted with human sewage is likely to contain germs and viruses and is not safe for drinking and swimming. As a consequence, the prevention of water borne human diseases remains the most important reason for water and sewage treatment. There are also many wastes that are by – products in the manufacture of chemicals and whose composition and toxicity are largely unknown [Ramakrishnan S, 1998].
The obvious approach to problems of water quality is to identify the impurity, develop methods of analyzing for its presence and concentration in water, determine the limiting concentration in water for a particular water use, and estimate whether this concentration will be exceeded for a particular case. The best and cheapest solution for a particular problem is to control the impurity at the source where it is manufactured or used before it is discharged to the receiving water [Kudesia VP, 1980; Shuval HI, 1970].

When water comes in contact with minerals, dissolution of the minerals begins and continues until equilibrium concentrations are attained in the water or until all the minerals are consumed. The solubilities of minerals that are encountered by ground water as it moves along its flow paths vary over many orders of magnitude [Steven JE, 1981]. Thus depending on the minerals that the water has come in contact with during its flow history, ground water may be only slightly higher in dissolved solids than rain water, or it may become more times salty than sea water. Ground water can be viewed as an electrolyte solution because all its major and minor dissolved constituents are present in ionic form. The concentration of the dissolved inorganic constituents is increasing by man’s activities [Hem JD, 1991; Samuel DF, 1981].
1.4 WATER RESOURCES PROBLEMS OF KERALA

Kerala is blessed with water resource, 44 rivers originate from Western Ghats which has a length of more than 35 km. Of these 41 rivers fall in the Arabian Sea, 3 rivers flow to the east and fall in the Bengal Bay.

Even though Kerala receives 3000 mm of annual rainfall, availability of safe drinking water is a problem, especially in summer. 74% of the urban and 48% of the rural population is getting protected water supply. The sources of drinking water in many of the rural and urban areas is ground water, but ground water gets polluted due to garbage, domestic sewage, industries, effluents, leach pits, salt water intrusion, etc. Since public water supply is scarce in peak summer, measures must be taken to irradiicate the pollution of the sources of ground water. Disposal of man made wastes adds additional pollutants to ground water and soil, thus degrading the quality of ground water so that it is no longer potable. People depend upon open wells, ponds, streams and rivers for their drinking water needs. Untreated water contains bacteria and virus which cause diseases [Clark John, 1977].

Kerala gets average 3000 mm of rain per year but still there is water scarcity. Water scarcity is caused by population growth, environmental change and degradation and unequal distribution of water resources. Water
is getting scarce due to rising of population, rapid urbanization and growing industrial demands. The world’s population in 2003 is estimated to be 6.45 billion. Nearly 170 million people are being added to it annually and will increase up to 10 billion by the year 2025. The high growth rate of population is posing a serious threat to the future prospects of human well being. If the population continue to grow at this rate, it will perhaps be too large to be supported by the limited resources of earth in a few decades. People dump wastes, untreated sewage and chemical discharges, which pollute the sources of water like the rivers, lakes, ponds and the underground reserves. The ever increasing demand for water has resulted in two billion people craving for this fundamental resource worldwide [Kudesia, 1980].

The amount of water available per person in India has decreased steadily. According to the Ministry of Water Resources, it is expected to decrease further in 2050. India already faces an alarming situation. Its fragile water resources are stressed and depleting while various sectorial demands are growing rapidly even as about 200 million people in the country do not have access to safe drinking water and nearly 1.5 million children die each year due to water borne diseases. Presently six of India’s major river basins
fall into water scarce category. By the year 2025, five more river basins are feared to be water scarce [Trivedi PR, 2004].

1.5 SOURCES OF WATER

The basic source of water is precipitation. This is the water falling from the atmosphere to the surface of the earth as rain, snow, etc. Part of the rain and melted snow seeps into the soil under the influence of gravity through the pore spaces of soil or fractures of rocks. This actually becomes ground water. Only one-tenth of the annual rainfall turns into effective ground water. The rest becomes what is called surface runoff, which flows down slopes and gather in ravines and gullies into numerous rivulets that discharge into rivers. Ground water does not occur everywhere below the earth’s surface [David KT, 1995].

1.6 WATER QUALITY

Pollution has come hand in hand with development. Generally water contains Ca, Fe, Mg, Mn, Si, fluoride, nitrate, phosphates, sulphates and chlorides. When the quantity of these parts increases they affect the body systems and cause destruction of health. Arsenic salts create cancer; cadmium affects kidney while barium carbonate has had bad effects on veins, nerves and heart. If the quantity of iron exceeds 30mg/l, then vomiting
starts. Silver containing water causes liver and lung diseases. Excess of fluoride affects teeth and causes a disease called ‘fluorosis’. The presence of manganese in water causes loss of memory, impotence and eye diseases. Vanadium spoils the fertility of soil and creates cancer in the body while Beryllium gives inflammation in pulmonary tissues. Mercury poisoning systems include loss of vision, hearing and intellectual abilities. There is no treatment for it and damage is permanent [Hughes, 1985].

Besides industrial waste, the use of pesticides like DDT has posed a serious water pollution problem and a potential hazard not only to livestock and wildlife but also to fish and other animals. The most hazardous property of the pesticides particularly organochlorine, is its persistence in the soil which causes long time effects.

According to a study by the National Institute of Oceanography, Goa, Bombayites discharges more than 2,000 million cubic meters of sewage into the sea each year. The story is the same in all big cities. Even in smaller towns, municipalities are having a different time with the ever-growing problem of pollution, which has, of late assumed frightening dimensions. We have still to recognize that good environment is the fundamental right of every citizen as it is essential for its physical, mortal of social health [Ciaccio, LL et al., 1971].
Although several drastic measures have been taken during the last few years, the problems of pollution continues to pose a serious challenge as the threat of nuclear war. In the evolution of human race man has reached a stage when he has acquired the power to harness and transform nature in various ways. Unless the power is used discretely the whole human race and environment stands in danger of annihilation [Jenkins SH, 1974].

Similarly heavy metals and plasticides accumulate at the base of the sea and eventually reach us through the food chain. Lately there has been an unusual increase in the concentration of phosphates in the sea which has adversely affected the sea’s ecosystem completely [Barry L, 1991].

Information on environment should form an integrated part of the school curriculum so as to enable children to understand the inner dependence of various components of the system of which they form a part. Mass media could be used for publicizing the facts and providing information of the environment.

Water pollution is turning India’s famous lakes into dirty ponds and its major rivers into sewers threatening the health of millions of rural folk at the receiving end of the city wastes. Reports from PTI bureau indicates that the problem is increasing in almost all states, particularly in Kerala and
Maharashtra, whose capital is virtually ['g.heared'] by filthy, stinking creeds with floating oil sticks that have destroyed the breeding grounds of fish.

Mercury pollution which was responsible for the deadly Mina Mata disease in Japan, has been noticed in two places in waters and sediments of the Thana Creek in Bombay and the Rushikulya river in Orissa recently [Kudesia, 1980].

Effluents from industries have changed the color of the waters of several southern rivers that were crystal clear only a few years ago. The Damodar is black, the Chaliyar in Kerala, is brown, and Ganga at Kannauj, Kanpur and other places is either brown or dark brown.

In the whole of India, there are only 5,000 large and medium industrial units that can pollute but their contribution to total pollution load is less than 10%. The rest is of domestic origin especially in Bombay and Calcutta.

Rivers are the major source of drinking water for people in the rural areas. With these rivers increasingly polluted by city wastes, the villagers may be left with nothing but contaminated water. This is already happening in Bihar and UP, according to a state government spokesman.
The International Institute of Applied systems Analysis in Austria has warned that water pollution will be India’s major problem in 25 years unless, sewerage and sanitation facilities are improved. It is said that accumulated human wastes could mix with open water resources resulting in epidemics.

All states except Maharashtra, Orissa and Tamil Nadu have adopted the prevention of water pollution Act, 1974 and protection Act of 1984. They have set up their own prevention and control of water pollution Boards [PCWB] but most of their actions are on paper.

In Kerala, more than 500 million liters of industrial effluents are being dumped daily into the river besides untreated human wastes. Retting coconut husks in brackish waters and stagnant ponds adds to the pollution. Water in Kuttanad, the rice bowl of Kerala, has been severely polluted by massive application of pesticides in paddy fields. In one crop season, 1000 tonnes of pesticides of 46 different formulations are used and they are leached out into the water ways.

Five of the ten major rivers- Chaliyar, Chalakkudy, Periyar, Pampa and Kallada – are affected by pollution. Thus water pollution is a serious
problem in India and effective ways have to be chalked out according to the needs of different places.

The main problem now before the world is that of safe drinking water which is fast assuming alarming proportions. The disturbing fact is the increasing susceptibility of drinking water sources to pollution. The technological expansion has brought into the hands of even the smallest farmer, two of the current agricultural best sellers – fertilizers and pesticides. Their increasing use over the years has resulted in the contamination of water sources. The chlorine, bromine, sodium, potassium, phosphorus, nitrogen, etc. present in these pesticides and fertilizers find their way into the waters through the soil rendering it unsuitable for human consumption.

The oils, soaps, detergents from industries and city wastes have disturbed the vegetation and animal life in sea and rivers, etc, because the layers of oil, etc. on the surface water have decreased the quantity of DO. Water is transparent due to which it absorbs sunlight which is being taken up by plants to make food. If water will be colored, it will check the vegetation and which will finally end the animal world under water as they take plants as food for their survival. Unfortunately, the numbers of these pollutants are growing so rapidly that it has not been possible to identify them as fast as they are produced and the development of analytical
methods for determining their concentrations and assessing their toxicities is inadequate.

The principal objective of water pollution abatement are to safeguard the health of the people, to prevent fish kills, to prevent odour nuisances, and to remove unsightly flood banks and floating materials.

Of late, measures have been initiated for conservation and management of the available water resources in the country. At a micro level, rain water harvesting is also being taken up. Some state governments have already amended building bye-laws to make rainwater harvesting mandatory for new buildings. To some extent, waste water is also recycled for use.

1.7 SOURCES OF WATER POLLUTION

Most of the pollution problems are caused by human activities. For agriculture man uses chemical fertilizers, pesticides and insecticides which create great problem to the ecology and environment. Industrial effluent, domestic sewage, infiltration from sewage canal, in urban areas infiltration from leachpits to the domestic wells are all serious problems of environment. The soil gets polluted. The seeds which the trees produce also
become polluted. Man eats this polluted matter and gets sick. The ecology is disturbed [Pervey R, 1982].

Water pollution adversely changes the quality of water, disturbs and destroys the balance of ecosystems and causes hazards to public health. Water becomes polluted by the presence or addition of inorganic or organic substances or biological agents. Soil erosion, leaching of minerals from rocks, decaying of organic matter are natural sources of water pollution [Baven, 1980].

1.7.1 Sources of Man-made Pollution

They can be classified according to the way in which the pollutants are introduced into the water. When the total or principal flow is conveyed in well defined channels such as municipal or industrial discharges, it is called a point source.

Diffuse or non point sources are difficult to measure. Sprayed fertilizers and pesticides are important examples of diffuse sources.

1.7.1a) Domestic Pollution

This includes discharges from houses, commercial and industrial establishments connected to the public sewage system. The composition of
the sewage vary in space and time. Sewage contains human and animal excreta, food residues, cleaning agents, detergents and other wastes. It is always rich in bacteria and other substances. It also contains other biological pollutants. The polluting strength is usually characterized by its BOD. BOD is the amount of oxygen taken up by the microorganisms present in water. A high level of BOD indicates intense level of microbial pollution [Arora BR, 1985].

1.7.1b) Industrial Pollution

The composition of the industrial water depends on the nature of the industry and processes of waste water. The trade wastes and effluents [flowing out from sewage tanks] of industries play a significant role in pollution of waters. The types of industries are given below.

1) Paper and pulp
2) Distillery
3) Potassic Fertilizers.
4) Electroplating plant
5) Asbestos
6) Silt
7) Alcohol.
8) Detergents
9) Steel
10) Tanning
11) Cane sugar
12) Oil
13) Pesticides and herbicides.
14) Radioactive wastes.

The chemicals used are alum, resin, chlorine, caustic soda, soda ash, dyes, magnesium bisulphate and sulphuric acid besides clay [Trivedi PR, 2004].

The lignin should not be allowed to discharge as it completely destroys the fauna and flora and impairs the productivity [Goel PK, 2003].

Heavy suspended materials should be brought to minimum level through settling tanks which reduce BOD. The taste and odour producing substances can be removed by treating waste water with activated carbon [Kudesia VP, 1980].

1.7.1c) Agricultural Pollution

Today India is passing through ‘Agricultural Revolution’ or ‘Green Revolution’. During the past few years, there has been a considerable increase in agricultural production due to high yielding varieties of seeds, chemical fertilizers and insecticides.
According to Central Food Technological Institute, Mysore, as much as 50% of our food is lost due to pests and insects. The first synthetic insecticide came to use only 30-35 years old was DDT which was discovered first in Switzerland in 1930. All the chemical compounds which kill insects, harm them, interfere in their reproduction and normal living are called pesticides.

A portion of the fertilizers are taken up by the plants. The rest get accumulated in the soil. The insecticides / pesticides also get accumulated in the soil. By rain water and irrigation water, they are carried to the nearby streams, from there to the rivers and ultimately reach the sea. From surface water sources, they enter ground water sources. This is harmful to domestic wells and public water supply schemes.

Fertilizers comprise one or more of major plant nutrients, mainly N, P and K. They increase algal growth in lakes and ponds, algal blooms are formed. When these algae decay after some time, micro organisms need oxygen for the purpose. Hence the water body gets deoxygenated which make it unfit to support aquatic life. Due to the lack of DO in water, animals like fishes die. This is called eutrophication. When all the oxygen of the water body is thus used up, nitrate-reducing bacteria will release oxygen from nitrate ions. Ammonia is formed. Then sulphate reducing bacteria will
release H₂ S from sulphate ions. Metal sulphides are formed, foul smell occurs. When methane is formed by the reduction of organic matter, anaerobic condition result. Organisms which can survive in such conditions will increase. Biodiversity is destroyed. Shift in ecological balance takes place.

Pesticides include insecticides, pesticides, fungicides, nematicides, rodenticides, herbicides and soil fumigants. They cover a wide range of formulations and chlorinated hydrocarbons, organo phosphates, metallic salts, carbonates, thiocarbamates, acetic acid derivatives, etc. Many pesticides are biodegradable and their residues have a longer life. The most persistent ones are organo chlorine compounds. They pass through food chains and accumulate mainly in fatty tissues. By mode of action of pesticides means the way in which the chemicals act upon the systems of an insect to cause its death. Chemical poisons affect the normal functions of some specific cells and tissues in the same way as is the case with higher animals. Generally, the chemical processes in insects are affected by abnormal functions of their organisms. Due to widespread use of chemicals the food consumed by man today is contaminated with the chemicals. These poisonous chemicals are stored in the fatty tissues of human body and it is estimated that about 5-27 ppm of DDT compound is found in tissues of
persons living in centuries where DDT is widely used. The accumulation of DDT in human body is found to be harmful for health. Some chemicals even damage the liver. Endrin penetrates through the skin and produces toxic effects. The highly toxic organo phosphorus compounds are supposed to breakdown quickly in nature. The pesticides reach our body indirectly through vegetables, eggs, etc. DDT has also been found in the bodies of human beings in different countries.

Pesticides like DDT get accumulated in the liver / kidney tissues of animals. This is termed as bio-accumulation. They are stored in the fatty tissues where they are metabolized or excreted at a slower rate. When they enter the DNA helix, mutation occurs.

Food chain theory states that the residue concentrations of pesticides, heavy metals, radio nuclides, etc. was found to increase from plankton to the fish eating birds. This is called biological magnification. Pesticide concentration in the 4th trophic level organisms will be 6.25 times greater than the 1st trophic level organism. DDT has been blamed responsible for the cause of reproductive failure among fishes and birds. In birds like Falcon, DDT accumulation resulted in thinning of the eggs which adversely affects the breeding. DDT has been banned in India and Europe.
In fishes, DDT accumulation resulted in fish mortality. A variety of animals have developed tolerance to the insecticides. With time the pesticides may (1) break down (2) be redistributed within the application site (3) move offsite. Offsite movement includes movement to ground water, surface water and the atmosphere. Breakdown and movement occur simultaneously. How long pesticide lasts or persists in the environment is determined by resistance to breakdown. All pesticides react in the environment in the presence of sunlight. In soil and sediments, microorganisms are primarily responsible for pesticide breakdown. Some pesticides may enter plant roots and foliage and breakdown through plant metabolism. In water, breakdown is usually by hydrolysis, often mediated by pH. In aquatic systems pesticide breakdown by microorganisms may also be important. Metabolic reactions are catalyzed by enzymes. The complete breakdown of pesticides and other organic substances is called mineralization.

Transfer from water or a plant surface to air is called volatilization. They can move into the air as particles, adsorbed into dust, or as droplets or aerosols during application.

Plant uptake can be important to pesticide movement. Pesticides that are taken up by plants are not available for movement into ground or
surface water sources. If the plants are harvested some pesticides may move from the site with the crop. Many pesticides leave residues in various living systems for prolonged periods of their life span and are presumably responsible for a variety of known and unknown toxic symptoms. Even their minute quantity, their variety, toxicity and persistence have an adverse effect on ecological systems. In tropical conditions, the biological transformation of pesticides is liable to be relatively faster due to heat, light, scanty or heavy rains, delayed or early rains. Broadly the effects include disturbances in the equilibrium existing between insect pests and their parasites, increase diseases substantially, bioaccumulation, development of pesticide tolerance, disturbance in reproductive physiology, behavioral abnormalities in birds, insects, effects on population of birds, wild life, etc, effect on beneficiary insects, contamination of food and human bodies, etc. Sub lethal concentrations of hydrocarbon pesticide residues are now known to be capable of interfering with the calcium metabolism of birds, perhaps through the inhibition of the enzymes carboxic anhydrase. As a result, insufficient calcium is made available during the process of the formation of the egg shell and the egg shells are very thin. The egg shells break when the birds sit on to hatch. This adversely affects the breading.
The delay in egg laying is believed to result from inhibition of liver enzymes by the pesticides with accompanying depression of estrogen levels in the blood.

Chlorinated hydrocarbon pesticide may affect the photosynthesis and growth of plankton. Use of excessive volatile herbicides has often killed or injured vegetation in neighboring areas.

Bio-accumulation has significant impact on the dynamic equilibrium that exists between predators and pray. Both animals and plants have the ability to concentrate many types of pesticides in their body. Pollutants like pesticides ingested within the organisms are not effectively restored or excreted like the remainder of the food biomass. Accumulation of the biocide residues in animals and plants have created great hazards. Residue may persist in the environment for many years, exposing successive generations of animals. In aquatic ecosystems, direct uptake from waters and sediments appears to be the dominant process for many persistent pollutants [Nelson DM, 1991].

There are some plants which contain chemical substances like alkaloids and inflavonoids which act as insecticides. Alkaloids such as nicotine from tobacco (Nicotine spp.), rotenone from Derris (Derris elliptical)
and pyrethrins and cinerines (Pyrethroids) from pyrethrum [chrisanthemum cinerariacifolium] are good plant insecticides. Most plant insecticides act as contact poisons being absorbed through the cuticle of the insects [Desh Mukh AM, 2003].

The plant Millettia pachycarpa contains two insecticidal compounds known as rotenone and sapaivine which act as contact and stomach poisons. Rotenone is not harmful to man. The plants belonging to the “solanacea” or “potato family” are also insecticidal plants. They contains alkaloids called “solanaceous alkaloids” Nicotine, an alkaloid obtained from tobacco acts as a contact insecticide. Nicotine is responsible for killing of many insect pests. Plants like castor [Ricine’s communis], common basil (Ocimum basilium), Caraway (Carum Carve), Anise (Pimpinella Anism) and several others have effective insecticidal properties against many domestic and agricultural pests.

The environment can be saved from agro chemical pollution if organic fertilizers and naturally occurring plant insecticides are used instead of the agrochemicals.
1.7.1d) Thermal Pollution

The main sources are electric power plants and nuclear power stations. Water is used as coolant in these units and hot water is released to the original source raising its temperature. Sudden rise in temperature kills fish and other aquatic animals and increases the respiration of algae and other organisms.

1.7.1e) Radioactive Pollution

Radioactive pollution is a special form of physical pollution related to all major life-supporting systems - air, water, and soil, its nature of contamination is different from those of others. Its effects are also of special kinds. Radioactivity is a phenomenon of spontaneous emission of protons, electrons, and gamma rays, as a result of disintegration of atomic nuclei of some elements. During the decay of the atom, daughters are formed which may or may not be radioactive. Each radioactive nuclide has a constant decay rate. Half-life is the time needed for half of the atoms to decay. This may vary from a fraction of a second to thousands of years. The nuclide with long life are usually the main sources of environmental concern.

Sources of environmental radiation are natural and man-made. The former comprise cosmic rays that reach the surface of the earth from space.
and terrestrial radiations from radio-active nuclides such as Ra$_{223}$, U$_{235}$, U$_{238}$, Th$_{282}$, Rn$_{222}$, K$_{40}$, and L$_{14}$, occur naturally in soil and water.

The first atomic bomb was exploded in Hiroshima followed by Nagasaki. Explosions are controlled chain reactions. These give rise to very large neutron flux conditions that make other materials in the surroundings radioactive. These materials include Sr$_{90}$, Cs$_{137}$, I$_{131}$ and unused explosive and activation products. The radioactive materials are transformed into gases and fine particles which are thrown high up into the air like a mushroom cloud. Radioactive particles are carried away by the wind and spread to wide areas. They settle down to cause water and soil pollution even in places far away from the site of explosion. When rain drops containing radioactive particles fall on the ground, radioactivity is transferred to the soil particles. From soil radioactive substances enter the food chain affecting different forms of life including man. Water bodies receive radioactivity mainly through soluble products. Thus aquatic organisms absorb and accumulate them through food chain which ultimately includes man.

The main operation of a nuclear power plant includes introduction of the processed nuclear fuel, followed by fission and activation products. These wastes pose a grave public health hazard wherever they are dumped. The radio-active nuclides are sources of radiation especially when they
become free and pass into the surroundings in any form. Inert gases and halogen escape as vapours and become potential pollutants of the environment as they settle in land or are washed into surface water.

A large number of radio active isotopes such as $^{14}$C, $^{125}$I and other compounds are widely used in scientific research.

Waste waters containing radio active materials reach the rivers and lakes through radio active iodine and phosphorus concentrate in slimes, sludges and micro organisms which enter the human food chain through fish and other aquatic life.

Human beings also voluntarily receive radiation from diagnostic x-rays and radiation therapy for cancers, People working in nuclear reactors, fuel processors and power plants are also vulnerable to radiation exposure.

The effects of radiation pollution depends upon

1. half-life
2. energy releasing capacity
3. rate of diffusion
4. rate of deposition of the contaminant.

Various atmospheric and climatic conditions such as wind, temperature, rainfall also determine their effects.
Human species is the final victim of radio active pollution as he is at the end of all reactions and interactions. He is beneficiary of a large number of food chains, a user of the largest number of resources and enjoys worldwide distribution. He is the only species that actively plays with radioactive materials.

All organisms are affected from radiation pollution. Some species preferentially accumulate specific nuclides. For eg: oyersters deposit $^{45}\text{Zn}$, fish accumulate $^{54}\text{Fe}$, marine animals selectively take up $^{90}\text{Sr}$. Even dairy milk and its products can become highly contaminated. In high doses, radiation can cause almost instant death. In lower doses, it can affect all organs seriously and impair their functions. This is also true for most plants and animals.

There is hardly any safe dose; slight increase in the background radiation level enhances the risk, long or repeated exposure can cause cancer and leukemia and include mutations. The deleterious genes can persist in human, animal and plant populations and may affect their progeny.

As there is no cure for radiation damage, all efforts should be made to prevent radio active pollution. Leakage from reactors, careless handling, transport and use of radioactive fuels, fission products and radio isotopes
have to be totally stopped. The safety measures should be strictly enforced. The waste disposal must be safe. Regular monitoring through frequent sampling and quantitative analysis has to be ensured in the risk areas. Preventive measures have to be followed so that background radiation level does not rise above the permissible limits. Safety measures against accidents have to be strengthened and appropriate steps need to be taken against occupational exposure.

One of the major concern of using radio active materials is the disposal of wastes. Radio active wastes only with sufficiently low radiation can be discharged into sewage.

1.7.2 Effects of Water Pollutants

The impact of pollutants depends upon its properties and amount. Pollutants bring about physical and chemical changes that make the water in rivers, lakes and ponds unfit for drinking and harmful to aquatic life.

(i) The biological effects of chemical pollutants are varied. Compounds of Hg, As and Pb are poisonous. Some compounds are so corrosive that they may even affect waste treatment plants. Organic sulfur compounds interfere with nitrification.
Inorganic nitrates and phosphates stimulate excessive plant growth in lakes and reservoirs, this is called entrophication. The organochlorines from pesticides are highly persistent and pass through food chains. They mainly accumulate in fatty tissues and affect the nervous system. The broad spectrum of pesticides used currently cause mass destruction of aquatic life through their accidental release or excessive use.

(ii) Change in colour is a very common effect produced by the dyes and inorganic substances like Cr and Fe compounds contained in the discharges.

(iii) Turbidity due to very fine suspended matter or colloidal substances making water unfit for drinking and for industrial uses.

(iv) Impairment of taste caused by industrial effluents containing iron, free chlorine, phenol, manganese, detergents, oil, hydrocarbons and decomposition products. Unpleasant odors due to the presence of free chlorine, phenol, H₂S, ammonia, algae and micro organisms.

(v) Foam formation in waters by soaps, detergents and alkalies.

(vi) Eutrophication is a natural process observed in lakes and tanks where the rich growth of micro organisms consumes much of the DO, tending to deprive other organisms. It is generally found at the bottom layers of the
deep lakes. Addition of excess plant nutrients intensifies eutrophication and is harmful to fish and other aquatic life.

(vii) Fluorosis

Fluoride bearing minerals are widely distributed in India and many of the underground and surface waters are contaminated with fluoride ions. High amounts of fluoride are present in drinking water in 13 states in India. Experts have told that the maximum level of fluoride which the human body can tolerate is 1.5 ppm. Water when ingested over a long period of time causes flurosis. It results in various neuro-muscular disorders, gastrointestinal problems, allergies, dental disorders and several skeletal disorders.

It is very important to check the fluoride content of water used for drinking and cooking. Inexpensive defluoridation technology has not yet been developed in India and industrial fluorosis has been reported to affect agriculture and horticulture crops also.

(viii) Sudden elevation of temperature caused by release of hot water from thermal power plants can cause lethal effects on aquatic organisms, particularly fish. Hot water contains less DO and BOD increases.
Accelerated microbial activity leads to the death of fishes. Anaerobic decomposition causes development of offensive odors.

1.7.3 Control of Water Pollution

Treatment of sewage is a crucial one. It involves three steps. In the first, the large and suspended particles are removed, in the second, aeration is supplied to promote bacterial decomposition of organic compounds, followed by chlorination to eliminate bacteria; in the third, nitrates and phosphates are removed. The treated water is then released. Sewage treatment is quite expensive and in many developing countries only the first two steps are followed.

Industrial effluents should also be suitably treated to eliminate the pollutants. These involve neutralization of acids and alkalis, removal of toxic chemicals, coagulation of colloidal impurities, precipitation of metallic compounds and reducing the temperature of waste water to decrease thermal pollution [Hughes, 1985].

Chemical oxidation can be achieved by chlorination or through reaction with ozone. There are many chemicals which are difficult to eliminate [Turmer PR, 1991; Underwood L, 2001; Varshney LK, 1983].
1.8 GROUND WATER POLLUTION

Today human activities are constantly adding industrial, domestic and agricultural wastes to ground water reservoirs at an alarming rate. Ground water contamination is generally irreversible, i.e., once it is contaminated, it is difficult to restore the original water quality of the aquifer [Gilbert J, 1994]. Excessive mineralization of ground water degrades water quality producing unobjectionable taste, odour and excessive hardness [David, K.W. 1995]. Although the soil mantle through which water passes acts as an absorbent retaining a large part of colloidal and soluble ions, with its cation exchange capacity, but ground water is not completely free from the menace of chronic pollution [Reghunath HM, 1985].

1.8.1 Sources of Contamination of Ground Water

Numerous activities including industrial production, agriculture, sewage discharge, commercial and residential activities contaminate ground water sources. The domestic sewage composed of fecal wastes; kitchen and laundry wastes are the major sources of pollution for household wells [David MN, 1979].
Sources of Ground Water Contamination

1.8.1(1) Holding Ponds and Lagoons

These are shallow excavations that range from a few square feet to many acres in area. They are commonly used to hold municipal sewage, hospital wastes and a variety of wastes including industrial chemicals [Hocks T, 1981].

1.8.1(2) Sanitary Land Fills

Sanitary land fills are constructed by placing wastes in excavations and covering the material with soil daily, so that garbage and other materials are not left exposed to produce odors, smoke, vermin and insects. Even though a land fill is covered, leachate almost certainly will be formed by the infiltration of rains [John CR, 1970].

1.8.1(3) Land Disposal Wastes

Another cause of ground water pollution is the disposal of waste material directly on to the land surface. Examples include garbage sludges and domestic wastes. These wastes may occur as individual mounds or they may be spread over the land. If the waste contain soluble products they may be dissolved and infiltrated into the ground water [Haines YY].
1.8.1(4) Septic Tanks, Cesspools and Privies

Another cause of ground water pollution is the effluent from septic tank, cesspools and privies. The close proximity, density of installations can create serious pollution problems, in creviced rock areas effluent may travel from long distances in fracture system and solution channels.

1.7.1(5) Animal Feed Lots

Animal feed lots covers relatively small area but provide huge volume of wastes. Feed wastes pollute ground water with large concentrations of nitrate and bacteria. A variety of water borne diseases like cholera, typhoid fever, bacterial dysentery, gastro enteritis, etc. are attributed to untreated or inadequately treated ground water containing toxic materials and pathogenic forms of bacteria and viruses.

Biological contamination of ground water occur when human or animal wastes enter an aquifer. Standard tests to determine the safety of ground water for drinking purpose involves identifying whether or not bacteria belonging to the coliform group are present. One of the reasons for this test is that these groups of bacteria are easy to recognize. The recent fecal pollution of water sources are indicated by the presence of coliform bacteria ie., Escherichiacoli. The result of coliform test is reported in terms of
most probable number (MPN) of coliform group of organisms present in a
given volume of water.

Fortunately, ground water, except perhaps from very shallow
aquifers, is generally free from pathogenic bacteria and viruses.
Microorganisms can be carried by ground water but tend to attach
themselves by adsorption to the surface of clay particles. In fine-grained
soils, bacteria generally move less than a few meters, but they can migrate
much larger distances in coarse-grained soils or discontinuous rocks.

Most cases of contamination result from poor well construction, from
over-abstraction, or are associated with aquifers which posses large pores
such as gravel deposits, or open discontinuities such as some limestones.
Pollution of this type is only important, however, if the water is to be used
for potable water supply or food processing.

Pathogenic bacteria can be introduced into the subsurface
environment from septic tank systems, seepage from municipal wastes and
stabilization ponds. Bacteria may undergo natural die away or they may be
retained in the soil or transported to the ground water [Bitton G and
Charles PG, 1983].
1.9 AIR POLLUTION

Environmental pollution is a serious problem of the industrialized societies. Human activities have played a prominent role in degrading air, water and soil. Pollution of the atmosphere is particularly dangerous because the released pollutants cause widespread damage to life and property in the propulous urban areas. An air pollutant consists of suspended particles and harmful gases, some of which react in the atmosphere to produce extremely toxic substances. The principal atmospheric pollutants contributed by combustion are SO\textsubscript{2}, nitrogen oxides, CO, CO\textsubscript{2} and various hydrocarbons. Many products of incomplete combustion undergo photochemical reactions with oxides of nitrogen to generate smog.

The chemical industries produce innumerable harmful compounds containing chlorine, fluorine, (especially chlorofluoro ethane) in addition to SO\textsubscript{2}, CO and other gases. Various other industries, blasting and mining activities emit huge quantities of particulate gaseous contaminants.

Air pollution cause respiratory and vascular diseases in human and impede aesthetic perception. They bring about damage to vegetation and livestock and accentuate deterioration of buildings and materials. Atmospheric pollution poses a serious threat in the climatic and atmospheric stability [Benecka and Weiting, 1988].
Industrial air pollution can be minimized by separating pollutants from the harmless gases by converting the harmful compounds to innocuous products before discharging them to the atmosphere.

All living things need air. Human activities introduce several harmful substances to air. Such activities pollute the air. Air pollution must be controlled.

Air contains a number of gases, e.g., Oxygen, nitrogen and $\text{CO}_2$. Very small amounts of gases like He, Ne, Ar, Kr, Xe and Rn are also present. Oxygen combines with metals and non-metals to form oxides. Nitrogen is the major constituent of the air. $\text{CO}_2$ gas is given by animals and plants during respiration. Plants use $\text{CO}_2$ to prepare carbohydrate. He, Kr, etc. are inert gases. These are the inactive components of air [Gupta PK, 2001].

Air always contain water vapor. It is present in the air as a result of evaporation of water from oceans, rivers, lakes and streams. Water vapor is also given out by plants and animals. The land on warming by sun gives out water vapor. The amount of water vapor in air varies from place to place, day to day and day to night. When the capacity of the air to hold water vapor is exceeded it then condenses into water droplet and forms dew or rain. If the temperature in the area is very low, the water droplet freezes and falls as mist or hail or snow. The content of water vapour in the air is called humidity.
Air contains tiny solid particles. The solid particles of sand and soil are carried into air by strong winds. They remain suspended in air for some time. Solids such as pollen from flowers and high seeds are also introduced into air by plants. Fuels are burnt in homes, factories, power stations and various types of vehicles. The smoke introduces various types of solid particles in air. The amount of solid particles in air is different at different places.

The amount of solid particles and water vapor varies from place to place. The other constituents of air remain nearly the same.

Pollutants are harmful or undesirable substances. These pollutants may be harmful to plants or animal or both. When such pollutants are present in air, it is said to be polluted. Air pollution is largely due to human activity.

The wind carries soil, dust, pollen and other particles, which often causes allergy, sneezing and health problems. Factories and power houses produce large quantities of smoke. The smoke contains particles of coal, ashes and some toxic compounds. Similarly, cement, steel plant and some chemical factories produce large amounts of particles that pollute the air. Cigarette smoking introduces smoke into a room. The smoke goes also into the lungs of non-smokers and affects their health. Burning of firewood and cowdung cakes at home produces smoke which is bothersome and even
harmful. By adding a chimney to the stove [Chulka] the smoke can be removed from the house. Vehicles, such as scooters, cars, buses and trucks also produce smoke by burning petrol or diesel, such auto exhaust is a major cause of air pollution.

Other products of burning also cause pollution. All fuels contain carbon. When such a fuel is completely burnt, CO\textsubscript{2} is formed. Most of the time, the fuels do not burn completely. In that case both CO and CO\textsubscript{2} are produced. CO\textsubscript{2} is a poisonous gas. It combines with blood and many proteins of the body and prevents them from doing their duties. In winter, some houses are heated with coal fire, when all the windows and doors are closed, and coal fire is burning, CO\textsubscript{2} gas can accumulate and become very dangerous and even fatal.

Proper ventilation of houses and bed rooms even in winter is essential. Oxides of S and N are also harmful to health. Coal and petrol contain small amounts of S, which on burning gives SO\textsubscript{2}, an acidic oxide that affects skin, lungs and other tissues. The oxides of nitrogen formed at the high temperatures that some engines reach are also poisonous.

In refineries and power plants, it is thus important to remove the oxides of S and N before the gases are let out. Otherwise these will be carried in the wind and rain and will produce what is called ‘acid rain’. Acid
rain will damage cement, steel, marble, bricks and living organisms [Benecka, 1988].

In Mathura, north of Agra, a petroleum refinery was being set up and there was the danger that the refinery could produce and let out SO$_2$, NO$_2$ and other oxides. If these were carried by the wind towards Agra, the Taj Mahal could be easily damaged. Hence special precautions have been taken in the Matura refinery. One way is to scrap down the exhaust gas with water before it leaves the chimney. This scrubbing dissolves all the toxic gases and prevents their escape into the atmosphere [Gupta PK, 2001].

With more industry and progress, the pollution of the air would become a problem. Wisdom lies in anticipating these problems and solving them before they cause damage.

In the past, there were fountains in cities, which had a very important role in controlling air pollution.