INTRODUCTION

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A little over 70% of the earth surface is covered with water. The freshwater occupy relatively a small portion of earth's surface, freshwater habitats includes ponds, lakes, rivers, streams, swamps, marshes and springs. Since time immemorial freshwater has always been of vital importance to man. Man and Environment are inseparably linked and interact with each other. Mankind is now confronted by two inseparable problems of awesome magnitude, the uncontrolled growth of world population and serious hazards of environmental pollution. The major problem which causes alteration in our environment is pollution. The pollution is mainly caused due to population explosion, civilization, urbanization, deforestation, industrial revolution and due to the resultants of our technological society with high standards of living. The principal functions of rivers for society are supply, usage and disposal. The rivers supplies drinking water for men and animals, water for washing, for irrigation, agriculture and for industries. The water is said to be polluted when it is changed in its quality or composition, directly or indirectly as a results of human activities that, it becomes less suitable for drinking, domestic use, agricultural purpose, fisheries and for other purposes for which it would otherwise be quite suitable in its natural state (Odum, 1971).

The problem of water pollution is as old as human civilization. The wastewater from domestic, industrial and agricultural activities is discharged into rivers. Water pollution constitutes one of the most hazardous problem and our 80% rivers are suffering from unacceptable pollution due to addition of various types of pollutants into them.

Chief pollutants which cause water pollution in India are :

1. Municipal sewage disposal
2. Industrial waste and effluents
3. Insecticides and pesticides
4. Radioactive waste from atomic reactors
5. Thermal waste from industries
6. Agricultural run off
7. Silt formed by erosion of soil
8. Oil

Due to domestic and industrial discharge, a variety of chemicals have been monitored in aquatic environment. These chemicals have been known to be mutagenic, teratogenic, neurotoxic and biocidal to various types of organism including man. (McKee and Wolf, 1971).

The poisonous substances in industrial effluents, pesticides, herbicides, fertilizers, radioactive waste and agricultural runoffs on reaching river directly or indirectly, destroys the spawning grounds by affecting the eggs and damaging feeding grounds by disturbing the life of food organisms. The effect of pollutants on fish life depends upon three factors namely nature of pollutants, susceptibility of fish to the pollutant and nature of water body (Srivastava, 1989).

In India there are many industries such as sugar, distillery, paper, tannery, textile, pesticide, antibiotics, pharmaceutical, fertililzer, petrochemical etc. Alcohol distilleries which constitute second largest industry in the country have increasingly alarmed by environmentalist and the press like in recent years. Industries cause pollution of terrestrial and aquatic ecosystem due to untreated effluents. The industrial waste generally contains high quantities of dissolved solids and suspended solids. They cause high concentration of C.O.D. and B.O.D. and low or high pH. The toxic heavy metals, oil and grease, wide variety of organic substances and minerals including cynaides, arsenic, mercury, cadmium and carcinogens cause gross pollution of Indian rivers and other water resources.

Water pollution is one of the most important problems being faced by both developed and developing world together. Earth's water resources are limited and erratic supply and pollution further restricts the availability of water for diverse human use like drinking, cooking, cleaning, recreation, aquaculture and industry. Seventy per cent of India's water resources are declared to be polluted (Agarwal, et.al. 1982). Millions of people either die or get decapacitated directly or indirectly due to water pollution, besides loss of man hours and aquaculture potential. Most of the rivers in the world (more prominently in India) are full of filth and stench of polluted waters almost every kind of stagnant water body is slowly becoming polluted and thousands of reservoirs all over the world have either become extinct or are facing slow death and extinction. Water pollution is also one of the most investigated subject in past one hundred years with millions of scientists and technocrats all over the world monitoring, controlling or carrying out research on water pollution at any given moments.

Industrial discharge contain different chemicals as pollutants. A pollutant is either a chemical (a nutrient, radioactive substance, an organic compound) or geo chemical (soil particles) substance. Some of the important adverse effect of water pollutants are :

1. Loss of aesthetic and recreational value of water, 2. Spread of disease, 3. Deterioration of taste, 4. Undesirable effects on aquatic plants and animals, 5. Loss of aquatic production (Fish, Prawn etc.), 6. Corrosion of structures, 7. Adverse effect on industrial use of water, 8. Deterioration in agricultural soil, 9. Accumulation of toxic substance in aquatic ecosystem and ultimately in man, 10. Adverse effect on availability of safe, clean water, 11. Long term psychological and social impacts. Following industrial effluent have special characteristics. Tanneries have effluents with high dissolved and suspended organic matter, high salt contents (Sulphide salts), colours calcium and chromium.

Textile mill effluent have high pH, colour, high sodium organic matter, highly variable characteristics, dissolved and suspended solids, fibre, high temperature. Electroplating effluents have low pH, metallic toxicants, cyanide, cadmium, chromium, zinc etc.

The various types of water pollutants can be broadly classified as follows :

I. Organic pollutants, such as oxygen demanding waste, disease causing waste, sewage and agricultural run-off.

II. Inorganic pollutants : Inorganic pollutant comprises of mineral acids, inorganic salts finely divided metals or metal compounds, trace elements, cynaides, sulphates, nitrates, organometallic compounds and complex of metals with organics present in natural waters or induced by industrial effluents and agricultural runoffs.

The direct discharge of industrial effluents into the rivers and the run off from the field into ponds, lakes and rivers are causing serious concern about water pollution particularly with respect to inland fisheries. These effluents and their toxic effect on aquatic animals by depleting the dissolved oxygen altering the pH, salinity, carbondioxide content and thereby directly or indirectly affecting the life cycle as well as the metabolic activity of the aquatic animals at the biochemical level. Our present knowledge to toxicity of industrial effluents are still limited to few. (David and Ray, 1966; Stephen, et.al. 1987).

Industrial effluents such as distillery, tannery, pulp and paper and textile mill effluents have been major concern in water pollution abatement programme in India. Primarily because of the discharge of large quantities of effluents in the nearby water bodies causing fish mortality by means of suspended solids. (Sprague and Melease, 1968). The physico-chemical characteristics and the impact of tannery effluents on the water bodies were analysed by, Eye and Lawrence (1971); Kothandaraman et.al. (1972) and Guru Prasada Rao and Nandakumar (1981). The textile industry being one of the largest industry in our country now occupies an unique place on the industrial map of India. The textile mill consumes large volume of pure water for various processes such as desizing, kiering, bleaching, mercerising, dyeing and discharge equally large volume of waste water containing different types of pollutants. The degree of pollution is generally assessed by studying physical and chemical characteristic of water body. Painter (1971) has pointed out that proper understanding of nature of physical and chemical characteristics of effluents are essential for devicing method of their treatment and disposal. Blinski and Jonas (1973) reported that mortality of fish occurred due to discharge of large amount of industrial effluent, thus interfering with oxygen consumption.

Shumway and Palensky (1973) reported that effluents are responsible for changing taste and odour of the water.

The freshwater forms are very important media for the production of protein rich fishes, prawns and crabs. But the freshwater media are ecologically deteriorating due to discharge of industrial effluents (Thingran, 1974). Hence it is necessary to know the safe concentration of industrial effluent before discharging into water bodies (Verma and Mathur, 1974). The suspended solids present in the industrial discharge is also responsible for mortality of fish. (Verma and Dalela, 1975). In India, an enormous growth of industries has been recorded in recent past. During the process of industrial production certain non-degradable and harmful substances are released as industrial waste, which are being added to the water resources. As a result most rivers in India have now became victims of pollution due to industrial waste discharge. (Govindan and Sundaralingam, 1979).

Toxicology of copper and cadmium to *Mytilus edulis* L. (Bivalvia) in brackish water was studied by Sunila (1981). Vishwaranjan and Muthukrishnan (1982) studied toxicity of tannery effluent to the mosquito *Culex pipens quinquefasciatus*. Toxicity of waste water entering into the lake was assessed by using the fish *Puntius conchenius*. No mortality was observed in 10 and 15% effluent throughout the study period. There was hundred per cent mortality in 100% polluted water within 24 hr. (Pande and Das, 1983). Human activities are increasing the level of heavy metals in natural aquatic system. Mine drainage, industrial and domestic effluents, agricultural run off, acid rain etc. are all contributing to the metal load in natural waters. The most important feature which distinguish metals from other toxic pollutants are that, they are non-biodegradable, once they have entered the aquatic environment, their potential toxicity is controlled to a large extent by their physico-chemical form (speciation). (Strain, 1984). Ellagard and Gilmore (1984) studied the effect of different acids on the blue gill sunfish, *Lepomis macrochirus* and reported that the quantity rather than quality of acids is the primary factor in fish toxicity brought about by acid precipitation. Fraser and Clark (1984) reported the effect of a settled industrial domestic sewage works effluent form percolating filters on the embryo viability and hatching success of rainbow trout, *Salmo gairdneri*.

Patel and Pande (1985) recorded the pollution load due to discharge of effluent of an alumina plant, by studying different physico-chemical parameters. Nikam (1986) studied the impact of distillery effluents on two freshwater fishes *Tilapia mossambica* (Peters) and *Rasbora daniconius* (Ham). Patil et.al. (1986) found that fishes were absent in the stream receiving the effluent from the gelatine factory. Tana and Nikunen (1986) studied the physiological responses of rainbow trout (*Salmo gairdneri*) in a pulp and paper mill receiving water during four season. Higher concentration of Na, Ca, Cl and SO_4 and total solids in the ground water, river water located up and down stream of thermal power station and in vicinity of waste water carrying channels. Stephen et.al. (1987) studied toxicity of industrial effluents to freshwater catfish, *Mystus kelitius*.

Tannery effluents polluted the river Cauvery and therefore pretreatment of effluent before discharging into the river is recommended, (Dhanpal and Sivakumar, 1988). Dutta and Zutshi (1988) studied the effect of sewage effluent on the eggs of *Cyprinus carpio* (Lin) and reported the effect on incubation time, hatching mortality and abnormality of hatchling. Mane (1988) studied the effects of aquatic pollution on the physiology of digestion of commercially important common edible fish in the Panchaganga river.

Abnormal physico-chemical characteristics of the industrial effluents are responsible for mortality of fish (Mishra, et.al. 1988; Mishra and Saksena, 1988 and Pawar, 1988). Sastry and Kamatchimmal (1988) Ranjithakani (1988) studied physical, chemical and biological parameters of water and the effluent discharged by tannery into Kalingarayan channel at Erode, the degree of pollution of the discharged effluent in river system was documented and tolerance level of microalgae was observed, which suggest the use of microalgae in the biological treatment of effluent. Gandheeswari, et.al. (1989) analysed the water sample from tannery effluent affected water body and stated that, the existence of many species, when DO is totally exhausted, indicate that, rotifers are tolerant species which thrive well in polluted water. Kaviraj (1989) detected the heavy metal concentration in prawn and fish collected from Hooghly estuary.

Pollution due to sugar factory and distillery effluent causing deterioration of local water bodies. (Srivastava, 1989). The rate of ciliary activity of *Lamellidens marginalis* was modified due to combined effect of Hg and Zn. (Prakasan, et.al. 1989). Patra, et.al. (1990) studied the effect of paper mill effluent on hatching and survival of spawn of a major carp *Labeo rohita* (Ham) and reported that, the exposure to low concentration of effluent has reduced the time of hatching by 200 to 300 minutes and the rate of hatching is upto 90% whereas, the mortality rate of hatchlings is 80% to 90% when exposed to effluents. According to Haniffa and Selvan (1991) the dyeing effluent was found to be more toxic than bleaching effluents when the fish *Oreochromis mossambicus* was exposed to bleaching, dyeing and mixed textile mill effluent.

Ghosh and Konar (1992) reported that, the growth and fecundity of fish was greatly reduced when treated with sugar mill complex effluent. Khambe (1992) studied the effects of effluents on edible fishes of Krishna river near Sangli (Maharashtra). Histopathological and histochemical changes are brought out by textile mill effluent on the reproductive tissues, especially ovary of fish *Heteropneustes fossilis* when exposed to the effluent (Murugesen and Haniffa, 1992). Subramanian and Varadaraj (1993) studied the impact of tannery effluent on the biochemical constituents in the haemolymph of freshwater prawn, *Macrobrachium idella* (heller) and reported that decrease in the protein, free amino acids and free sugars of haemolymph was more as the concentration of the effluent increased. Varadaraj et.al. (1994) studied the effect of tannery effluent on the biochemical constituents in different tissue of *Pila globossa* and reported that, all the tissue metaboliltes (total free amino acids, total protein, glycogen, lipids) in liver gills, mantle and foot decreased on the dose of the effluent and duration of exposure period.

Prakash (1996) studied the relationship between the concentration and mortality rate of teleost fishes (*Tilapia* and *Lebistes* spp) when exposed to detergent, soap and fertilizer and found that, hundred per cent mortality rate was seen in lower concentration of detergent. Lethal effect of soap water was observed only at higher concentration. Charanjit et. al. (1996) studied the toxicity of electroplating effluent to Zebra fish, *Brachydonio rerio*, and it was found that, it was unable to survive in 10% concentration of the effluents. The discharge of such highly toxic effluents directly or indirectly into sewer, natural drains or rivers is expected to disturb the aquatic life and create an ecological imbalance.

Industries need a wide variety of raw material and chemicals which are later discharged via their effluents. These wastes are considered to cause damage to the micro-organism and thus inhibit the self purification of the stream apart from liberating hydrogen sulphite which is lethal. The effect of physico-chemical characteristic of a textile mill effluent such as colour, pH, total alkalinity, dissolved oxygen, biological oxygen demand, chemical oxygen demand, electrical conductivity, hardness, chlorides, iron, zinc, sodium, potassium and calcium were analysed. It was observed that, these values are more than ISI standards for the effluents. The effluents were found to be highly toxic to fish due to presence of hydrogen sulphide and chlorine (Mishra, et.al. 1988). The fish *Cyprinus carpio* showed abnormal behaviour i.e. high opercular beating and increased surfacing activities when exposed to dairy effluent (Amudha et.al. 1997). It was also found that growth rate and conversion efficiency was reduced, (Amudha and Mahalingam, 1999).

A. Textile Industry :

The basic raw material in a textile industry are cotton wool or synthetic fibres such as rayon, nylon, acrylic, polyster etc. Textile industry comprises of preparation of the yarn weaving, knitting and processing. The various operations involved in a cotton textile mill are combing, spinning, sizing, weaving and knitting. The 'grey cloth' thus obtained after above operation is subjected to the various wet treatment processes such as desizing, scouring, bleaching, mercerizing, dyeing or painting and finishing. All these processes generate considerable volume of effluents and hence form the major source of wastewater.

Environmental effects of the wastewaters.

1. The dyes present impart persistent colour to the receiving stream and interfere with photosynthesis of phytoplankton.
2. The high pH is deleterious to aquatic life.
3. The colloidal and suspended impurities, cause turbidity in the receiving water.
4. The oil present interfere with the oxygenation of the receiving water streams.
5. The dissolved material increase the salinity of the water, thus rendering it unfit for irrigation purpose.
6. The toxic chemicals such as Cr, anilline, sulphide etc. destroy fish and other microbial organism responsible for self purification of water streams.
7. The immediate oxygen demand due to the impurities such as starch, sulphides, nitrites etc. depletes the dissolved oxygen content and adversely affect the aquatic life.

B. Electroplating Industry :

In this process, ferrous or non-ferrous base material is electroplated with Ni, Cr, Cu, Zn, Pb, Cd, Al, Ag, Au etc. to alter the surface properties of the base metal in order to achieve corrosion resistance, wear resistance, improved or decorative appearance etc. Steps involved in the process are surface cleaning, pickling or stripping and plating.

Environmental effects :

1. Plating effluents are highly toxic and corrosive.
2. Cyanides, chromic acid, chromates, salts of heavy metals e.g. Cd, Pb, Ni, Zn and Cu present are toxic to aquatic life. Their toxicity to micro-organism inhibits self purification property of the streams.
3. Fe, Sn etc. impart colour to the receiving stream.
4. Phosphates and nitrates in the effluent help in excessive algal growth which is undesirable.

C. Leather Tanning Industry :

In leather tanning industry, the animal skins and hides are treated to convert them to non-prutresible and tough leather. The following two processes are generally used.

I. Beam house processing : The effluent contains NaCl, dirt, dung, soluble protein, organic matter, alkali, sulphides, lime it gives bad odour.

II. Tan-Yard processing : This is done by two process.

a. Vegetable tanning : The effluent contains ammoniacal and organic nitrogen, ammonium salts and soluble proteins.

b. Chrome tanning : The effluent contain ammonium salts, dyes, NaCl, ammoniacal and organic nitrogen oils etc. and is acidic.

Environmental effects :

1. Tannery effluents contain several constituents which are deleterious, irrespective of the fact that, where they are discharged into river, stream, sewer, land or sea.

2. It imparts persistent dull brown colour and repulsive odour to the receiving water.

3. The acidic and alkaline effluent are corrosive and renders the receiving water unsuitable for irrigation.

4. The chromium and sulfides present in the waste water are toxic to aquatic organisms.

5 The presence of excessive salt and Cr in the waste waters may deteriorate the quality of the ground water in the affected area.

PHYSICO-CHEMICAL PARAMETERS

I. Physical Parameters :

Impinging solar radiation and the atmospheric temperature bring about interesting spatial and temporal thermal changes in natural waters, which manifest in setting up of convection currents and thermal stratification. Discharge of heated effluent also bring about thermal change in natural waters (Thermal pollution). Temperature is basically an important factor for its effects on chemical and biological reactions in water. a rise in temperature of water accelerates chemical reactions, reduces solubility of gases, amplifies taste and odour and elevates metabolic activity of organism (Saxena, 1998).

Temperature is a measure of hotness of any material. The measurement of temperature in water is important basically for its effects on the chemistry and biochemical reactions in the organisms. It is also important in the determination of pH, conductivity and saturation level of gases in water. (Trivedy and Goel, 1987). Cairn et.al. (1975) studied temperature influence on chemical toxicity to aquatic organism. Sarkar (1991) reported the effects of temperature on eggs, fry and fingerlings of *Labeo rohita* exposed to urea. Chauhan and Saxena (1992) observed that toxicity of heavy metals increases as temperature increases.

Turbidity in natural waters is caused by suspended matter like clay, silt, organic matter, phytoplankton, and other microscopic organisms. It is actually the expression of optical property (Tyndall effect) in which the light is scattered by the suspended particles present in water. Scattering of light is dependent upon the size, shape and refractive index of such particles. Turbidity, when largely because of phytoplankton is considered as an index of productivity but, on the contrary when because of suspended matter (from industrial effluents) other than phytoplankton it restricts the light penetration in water resulting in reduced primary production. Mishra and Saxena (1989) reported high turbidity of industrial effluents interferes the transparency of the receiving water body.

A large number of salts are found dissolved in natural waters, the common ones are carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates of calcium, magnesium, sodium, potassium, iron and manganese etc. A high content of dissolved solids elevates the density of water influencing osmoregulation of freshwater organisms, reduces solubility of gases (like oxygen) and utility of water for drinking, irrigational and industrial purposes. It is especially an important parameter in the analysis of water. This factor having high value in such waters is often expressed as gm/ lit. or ppt (parts per thousand). (Saxena, 1998).

Total solids are the measure of the amount of all kinds of solids (suspended, dissolved, volatile etc.) in water. Total solids can be determined as the residue left after evaporation of the unfiltered sample.

These solids denote the suspended impurities present in water. In most of the cases, they are of organic in nature and pose severe problems of water pollution. Industrial waste water contains dissolved, suspended and volatile substance (chemicals and solid wastes). (Trivedy and Goel, 1987). (Subramanium et.al. (1988). Misra and Saxena (1989) and Chauhan, et.al. (1993) reported the TDS, TS and TSS has high values in industrial effluents and has major concern with aquatic pollution.

Colour in water means those hues inherent within the water itself which result from colloidal substances and materials in solution. In natural waters colour may occur due to the presence of humic acids, fulvic acids, metallic ions, suspended matter, phytoplankton, weeds and industrial effluents.

The colour of the industrial effluents depends on various dyes used for different purposes. These colours easily disperse in water (Trotman and Trotman, 1984 and Crook, 1964).

II. Chemical Parameter :

pH (Potentia hydrogenii) Hydrogen ion concentration :

pH measures hydrogen iron concentration in water. It is measured on a log scale and equal to negative $\log_{10}$ of H^+ concentration. pH= - $\log_{10}$ (H^+). A neutral solution has a pH of 7, while a pH less than 7 renders acidic nature and pH more than 7 is alkaline. Factors like exposure of air, temperature and disposal of industrial waste etc. also bring about changes in pH. (Saxena, 1998). High pH is unfavourable to aquatic organisms (Robert, et.al. 1940; Das, 1978). Munshi and Singh (1980) reported effect of low pH on the gills of *Channa punctatus* Peterson, et.al., (1980); Kane, et.al. (1987) observed that low pH has adverse effect on early life stages of fish. Acid rain directly causes acidification of water which alters pH of the water. (Crasser, et.al., 1987).

Oxygen dissolved in water, often referred to as DO, is a very important parameter of water quality and is an index of physical and biological processing going on in water. There are two main sources of dissolved oxygen in water: i. diffusion from air and ii. photosynthetic activity within water. Diffusion of oxygen from air to water is a physical phenomenon and depends upon solubility of oxygen which in turn is influenced by factors like temperature, water movements and salinity etc. Photosynthetic activity is a biological phenomenon carried out by autotrophs (mainly phytoplankton in water) and depends upon autotroph population, light conditions and available gases etc. Non-polluted surface waters are normally saturated with dissolved oxygen, while presence of oxygen demanding pollutants (like organic waste) causes rapid depletion of dissolved oxygen from water. Oxydizable inorganic substances like hydrogen sulphide, ammonia, nitrites, ferrous iron etc. also cause decrease in dissolved oxygen. Eutrophic waters have a wide range of dissolved oxygen content, while oligotrophic one have a narrow range. Oxygen is considered to be limiting factor especially in lakes and in waters with a heavy load of organic material, organism have specific oxygen requirements e.g. 2-5 mg/ litr. For most of the fishes. Low dissolved oxygen may prove lethal for many of the organism. (Saxena, 1998). Mishra and Saksena (1989), studied the physico-chemical parameter of the industrial effluent from textile mill in Birlanagar, Gwalior. They found that the range of D.O. was 1.0 – 4.0 which is low. Similar observation was recorded after studying the D.O. of industrial effluents by Subramaniam et.al. 1988; Pandey, et.al. 1993; Chauhan et.al. 1993; Jesudass and Akila, 1995 and Thorat and Wagh, 1998.

Free carbondioxide in the water accumulate due to microbial activity and respiration of organism. This impart the acidity of the water because of formation of carbonic acid. Free CO_2 is determined by titrating the sample using a strong alkali to pH. 8.3. (Trivedy and Goel, 1987).

Mishra and Saksena (1989) studied free CO_2 from textile mill effluent. Chauhan et.al. (1993) studied free CO2 from tannery effluent. Similarly Pandey et.al. (1993) and Jesudas and Akila, (1995) studied free CO_2 from sugar factory effluent and industrially polluted lake respectively. All of them observed values exceeding the limit set by ISI.

Chloride occurs naturally in all types of water. In natural freshwater; however, its concentration remains quite low. The most important source of chloride in natural waters is the discharge of sewage. (Trivedy and Goel 1987). Inland natural waters in general, have low chloride concentration, often less than that of bicarbonates and sulphates. However, inland saline waters, coastal estuarine and sea water are characterized by moderate to very high chloride content. In natural freshwaters, high concentration of chlorides is considered to be an indicator of pollution due to organic waste of animal origin (animal excreta has high quantity of chlorides along with nitrogenous wastes). Industrial effluents may increase the chloride content in natural waters. Chloride content above 250 mg/ lit. makes a water salty in taste, however a level upto 1000 mg/lit. is safe for human consumption. Saxena (1998). Chauhan, et.al. (1993) studied the chloride content from tannery effluents. Thorat and Wagh (1998) reported that the chloride content in the tannery effluent (untreated) is higher than the treated effluent.

Hardness is the property of water which prevents the lather formation with soap and increase the boiling point of waters. The major cations imparting hardness are calcium and magnesium. The anions responsible for hardness are bicarbonate, carbonate, sulphate and chlorides. Hardness when caused because of bicarbonates and carbonates is called temporary hardness, since it can be removed by boiling the water. Permanent hardness is caused by sulphates and chlorides which is not removed by simply boiling of water. In general practice, the hardness is measured as concentration of only calcium and magnesium (as $CaCo_3$) which are far high in concentration over other cations. As hardness of water prevents lather formation with soap, therefore, hard water is not suitable for bathing and washing. Hard waters have high boiling point and so are not good for cooking too. Industrial effluents may contain bicarbonate, carbonates, sulphates chlorides etc. which are responsible for causing hardness to water. (Saxena, 1998). Mount (1966) studied the effect of hardness and pH on acute toxicity of zinc to fish. Waiwood, et.al. (1978) studied effect of hardness on swimming performance of rainbow trout. Similar observations were recorded by Miller and Mackay (1980). Eyanoer et.al. (1985) reported effects of water hardness and temperature on the toxicity of detergents. Bradely and Sprague (1985) reported accumulation of zinc by rainbow trout (*Salmo gairdneri*) as influence of pH and water hardness. Kallanagaudar and Patil (1997) studied toxicity of Zn, Cu and Ni to *Gambusia affinis* under influence of hardness of water.

Alkalinity of water is its capacity to neutralize a strong acid and is characterized by the presence of hydroxyl (OH^-) ion capable of combining with hydrogen (H^+) ion. A number of bases viz. Carbonates, bicarbonates, hydroxides, phosphates, nitrates, silicates, borates etc. contribute to the alkalinity, however, in natural waters carbonates, bicarbonates and hydroxides are considered to be the predominant bases. Then alkalinity may be expressed as total alkalinity or alkalinity due to individual bases. In natural waters, mostly of the alkalinity is caused due to CO_2. The free CO_2 combines with water partly to form carbonic acid (H_2CO_3) which is further dissociated into hydrogen (H^+) and bicarbonate (HCO_3^-) ions. The HCO_3^- thus formed get further dissociated into H^+ and (CO^{3-}) ions.

Natural waters with high alkalinity are generally rich in phytoplankton, especially the blue greens. In highly productive waters the alkalinity ought to be over 100 mg/lit.

Miller and MacKay (1980) studied the effect of alkalinity hardness and pH of test water on toxicity of Cu to rainbow trout. Bhaskar and Govindappa (1986) reported that alkalinity interfers in carbohydrate metabolism in *Tilapia mossambica*.

The analysis of the industrial effluent to study alkalinity was done by Mishra and Saksena (1989); Pandey et.al. (1993); and Jesudass and Akila (1995) and reported variation in the values of total alkalinity which interfere with the water quality.

Acidity of the water is its qualitative capacity to neutralize a strong base. It is the capacity of a liquid to donate hydrogen ions. It is a measure of quality of the base required to neutralize a given sample to a designated pH. Mineral oxides and weak acids contributes to acidity of water and they influence the corrosiveness and also some chemicals and biological processes. Neville (1979) demonstrated the sublethal effect of environmental acidification on a rainbow trout (*Salmo gairdneri*) . Bhaskar and Govindappa (1986) reported that carbohydrate metabolism was suppressed in *Tilapia mossambica* during acclimation in more acidic water. Abbasi, et.al. (1995) showed that chromium was found to be more toxic in acidic medium to the teleost *Nuria denricus.*

Phosphorus occurs in water both in organic and inorganic forms but since over 85% of total phosphorus is usually present in organic forms (as bound in the organismal matter). Only inorganic phosphorus (as orthophosphate) plays a dynamic role in an aquatic ecosystem. Under oxidizing conditions it is precipitated and lost to the sediments resulting in depletion of phosphorus in water. On the other hand under reducing conditions some phosphorus returns to water in soluble form. Though present in low concentration, it is one of the most important nutrients limiting growth of autotroph and so biological productivity of the system. High phosphorous content causes increased algal growth often as a blooms till nitrogen becomes limiting. The enrichment of phosphorus lead to the process of eutrofication. Domestic sewage, industrial effluents, detergents are main sources of phosphates in water.

Mishra and Saksena (1989) reported that phosphate content of the textile mill effluent was within limit of standard. Pandey et.al.

(1993) studied the phosphate content of Hussain Sagar, industrially polluted lake in Hyderabad. Jesudas and Akila (1995) reported the difference in phosphate content of raw and treated effluent of the sugar factory.

Nitrate is the highest oxidized form of nitrogen and in water its most important source is biological oxidation of nitrogenous organic matter of both autochthonous and allochthonous origin. Domestic sewage and agricultural run off are the chief sources of allochthonous nitrogenous organic matter. Metabolic waste of aquatic community and dead organisms add to the autochthonous nitrogeneous organic matter. Nitrifying bacteria (aminifying bacteria, *Nitrosomonas, Nitrobastor*) play significant role in oxidation of such organic matter. Certain nitrogen fixing bacteria (*Azobactor*) and algae (blue-green like *Anabaena, Nostoe*) have capacity to fix the molecular nitrogen in nitrates. The high concentration of nitrate in water is indication of pollution. This is an important plant nutrient, when present in excess causes more growth of algae, often present in blooms. High nitrate content (740 mg NO_3^- N/lit.) may cause blue baby disease.

Janiyani et.al. (1993) recorded low nitrate content in oil sluges from various sources of refinery. Nitrate content of the sugar factory effluent showed marked difference in treated and untreated effluent (Jesudas, et.al. 1995).

TOXICITY

Toxic pollution term is referred to the pollutants other than the conventional inorganic (nutrients) or organic pollution (sewage, dairy waste, sugar factory waste etc.) and which cause actual or potential toxic effects on various organisms and human being. Heavy metals, pesticides, certain organic compounds, etc. come in this category. These pollutants can reach aquatic ecosystem through a number of sources such as,

1. Industries (Tanneries, electroplating industries, cotton mill, rayon mills, steel industries, metal finishing wastes, petrochemical plants, manufacturing of batteries, paint industries, chemical industries of various kinds, paper and pulp industry etc.
2. Sewage and sewage sludge (Sewage may contain small and more amount of heavy metals depending on its origin, application of sewage sludge on land-metals get concentrated in sewage sludge is a potential source of heavy metal pollution to soils and ground water).
3. From agricultural and forest soil through runoff containing pesticides.

Some of the important toxic pollutant as listed by Mason (1981) are:

1. Metals such as lead, nickel, cadmium, Zn, coppers and mercury, arising from the industrial processes and some agricultural uses, the term heavy metal is somewhat imprecise but includes most metals with an atomic number greater than 20, but excludes alkali metals, alkaline earths lanthanides and actinides.
2. Organic compound such as organo-chlorine, pesticides, herbicides, polychlorinated biphenyls chlorinated alpictina hydrocarbon solvents, straight chain surfectants, petroleum hydrocarbons, poly-nuclear aromatics, chlorinated dibenzodioxin, organometallic compounds, phenols, formaldehyde. They originate from a wide variety of industrial agricultural and some domestic sources.
3. Cases such as chlorine and ammonia.
4. Anions such as cyanides, fluorides, sulphides and sulphites.
5. Acids and alkalis

Toxicity Testing becomes necessary :

1. To find out the adverse effect of toxic compounds on various oganisms as a safeguard to ecosystem and organism in the long run.
2. Toxicity testing is required to be carried out before a particular substance can be released for human use.

3. To fix the limits of discharge of industrial effluents at a concentration, which will not adversely affect the environment.

4. To find out the tolerance limits of various organism to different toxicants.

Toxicity testing procedures : Toxicity is generally put into following types :

1. Acute toxicity : Toxicity caused by a high dose at short term exposure (suddenly).

2. Chronic toxicity : It refers to the toxic effect caused by high or low dose at long term exposure.

3. Lethal : Causing death.

4. Sublethal : Below the level which causes direct death.

5. Cummulative : Increase in the toxicity level or reaching to toxic level by gradual addition of toxicants quantity.

Following types of test are in practice.

Fish Bioassay :

Bioassay is a test in which organisms are used to detect the presence of the effects of any other physical factors chemical factor or any other type of ecological disturbances. The bioassay are extremely common in water pollution studies and are also used by enforcement authorities for resulting the discharge limits or the safe concentration of various wastes and chemical substances. However, the bioassay can also be taken as a tool for identifying the effect of or tolerance of a chemical by organism. The bioassay thus could find a very important role in studying synergetic effect of chemical assessment of efficiency of a waste treatment method etc. The bioassay can be conducted by using any type of organism however fish bioassay are very common and useful.

The aim of bioassay is to find out either lethal concentration of effective concentration causing relatively on Doller effects. Ultimately they are to be utilised for determination of safe concentration of a chemical or maximum acceptable toxicant concentration. In the bioassay test the organisms are exposed to different concentrations of a toxicant for a definite period and mortality, behavioural change or other signals of distress are noted periodically.

In static bioassay test the arrangement are not provided for renewing or changing the test solution during the period i.e. the organisms are exposed to the same toxicant solution for the whole experimental period.

Renewal Bioassay :

In this type of test the test solution may be changed many times during the experimental period.

Out of the 105 elements discovered and confirmed so far over 65 are metals. Owing to their high thermal and electrical conductivity, high density, high melting and boiling points, malleability, ductility and other useful properties. Metal find extensive use in human civilization. The toxic metals occurs in very small quantities in the earth crust hence are called as 'trace metals'. They are sub divided on the basis of their desities, those having densities below 5 gm/Cm^3 are called 'light metals and those with densities above 5 gm/ Cm^3 are called as 'heavy metals. Thus heavy metals like Hg, Pb, Cu, Cd, Zn, Mn, As, Fe, Al and their salts constitute the most widely distributed groups of highly toxic and long retained substances. These groups of pollutants are commonly found in industrial wastewater.

The discharge of heavy metals by industries pose a serious water pollution problem due to the toxic properties of these metals and their adverse effect on aquatic life. Like other metals Zn, Ni, Cr and Cu are stable in the environment and are being used by electroplating, steel and mining industries as well as dry and acid battery manufacturers. According to the survey conducted by Central Inland Fisheries Research Institute (CIFRI, 1981) these heavy metals are well known pollutants which are often encountered in many rivers of India and there is every possibility of fishes, the most important aquatic fauna, being subjected to stress caused by the heavy metals.

Heavy metal toxicity is the area of interest of many workers. kidmor (1964) studied the toxicity of zinc compounds to aquatic animals with special reference to fish. Most heavy metals and their salts are simple inorganic compounds, the toxicity of which is caused by anions, cations or physico-chemical properties of the salts. (Metelev, et.al. 1971). Aquatic ecosystem being continuously exploited as waste dumping ground heavy metal toxicity has become a matter of growing concern. Although zinc is a micronutrient it became toxic and even lethal when present beyond threshold limits. The mode of zinc toxicity to rainbow trout (*Salmo gairdneri*) was reported by Burton and Cairns (1972). Skidmore and Tovell (1972) studied the effect of zinc sulphate on the gills of rainbow trout. Matthiessen and Brafield (1973) reported the effect of dissolved zinc on the gills of the Stickleback, *Gasterosteus aculeatus*. Toxic action of copper on the gills of carp *Cyprinus carpio*, was reported by Labat et.al. (1974), Rosenthal and Sperling (1974) studied the effects of cadmium on development and survival of herring eggs. Bengtssen (1974 and 1975) reported that zinc and cadmium is related to mortality, growth, reproductive behaviour and vertebral damage in minnow *Phoxinus phoxinus*.

Benoit (1976) studied the toxic effects of hexavalent chromium on brook trout *Salvelinus fontanalis* and rainbow trout *Salmo gairdneri*. Reusink and Smith (1976) showed relationship of 96 hr. LC_{50} to lethal threshold concentration of hexavalent chromium, phenol and sodium pentachlorophenate for fat head minnow *Pimephales promelas*. A number of studies have been conducted on the toxicity of heavy metal to fish. (Lobat et.al., 1977; Iyr, 1977; Walsh, et.al. 1977 and Wong, et.al. 1977). Yamomoto et.al. (1978) demonstrated that copper is highly toxic to fishes even at fairly low concentrations and results in the death. Helmy et.al. (1979) studied haematological changes induced by heavy metals in Kuwait mullet *Liza macrolepis*. Chemistry, distribution and toxicology of copper on behavioural, reproductive, development, migratory, metabolic and histological changes on fish invertebrates etc. have been studied by Spear and Pierce (1979). Khangarot and Rajbanshi (1979) observed abnormal behaviour of fish *Rasbora daniconius* exposed to zinc sulfate. Khangarot and Samani (1980) reported toxic effect of mercury on the gills of a freshwater teleost *Punctius sophore* (Ham). Wilson (1981) recorded copper, zinc and cadmium concentration of 8 resident trout related to the acid mine wastes. Chemistry distribution and toxicology of Zn was studied by Speer (1981). Elizabeth et.al. (1981) reported the effect of alkaline and acidic fraction of industrial effluent particularly sugar mill, paper and pulp mill on lymphoid cell of *Rasbora daniconius*.

Toxicity of chromium, copper, Nickel and zinc to freshwater fishes have been studied by Arilo et.al. (1982) and Shastry and Tyagi (1982). Yamagota and Niwa (1982) studied acute and chronic toxic effect of ammonia on erythrocytes of *Anguilla anguilla*. Further it was stated that the prevailing allowable levels of Cr in drinking water, irrigation waters and effluent discharge are too high and may lead to environmental damage. Akhilender et.al. (1983) demonstrated histological changes in gill of the teleost fish *Sarotherodon mossambicus* with reference to mercury toxicity. Kaviraj and Konar (1983) reported lethal effects of mixture of mercury, chromium and cadmium on fish. Balavenkatesubbiah et.al. (1984) studied the effect of cupric chloride on oxidative metabolism in freshwater teleost fish, *Tilapia mossambica*. Toxic effects of copper, zinc and iron was studied by Crespo et.al. (1984) and Mukhopadhyay and Konar (1984). Copper is one of the essential trace metal required in minute quantities by freshwater fishes for growth and development. (Moore and Ramamoorthy, 1984). Somasundaram et.al. (1984) observed morphological changes in the egg and yolk-sac larvae of *Clupea harengus* at low concentration of zinc. Bardley and Sprague (1985) reported the influence of pH, water, hardness and alkalinity on the acute lethality of zinc to rainbow trout (*Salmo gairdneri*). Similar findings were reported on the toxicity of Al, Cd and Fe to eggs and larvae of the zebra fish, *Brachydanio rerio* by Dave and Goran (1985). Gill and Pant (1985) have reported cadmium and organomercurial poisoning in erythrocytes of a freshwater fish *Puntius conchonius* (Ham). Haesloop and Michael (1985) reported accumulation of orally administered cadmium by the *Anguilla anguilla*. Hiraoka et.al. (1985) reported, the most toxic metals to medaka (*Oryzias latipes*) fry were Ag, Hg, Cu and Cd, the second most toxic metals were Zn, As, Cr, Ni and Pb and third most toxic were Se, V, Fe and Co. the least toxic metal was Mn. Similar toxicity of heavy metals have been studied by Taylor et.al. (1985).

Nebekar, et.al. (1985) reported the sensitivity of rainbow trout *Salmo gairdneri* (early life stages) to nickel chloride. Concentration of inorganic and total arsenic in fish from industrially polluted water have been reported by Norin, et.al. (1985). Shivaraj and Patil (1985) found that, cadmium is more toxic than cobalt, during toxicity studies on freshwater fish *Lepidocephalicthyes guntea* exposed to two metals. Acute toxicity of cadmium sulphate, zinc sulphate and copper sulphate on *Barbus ticto* was studied by Wagh, et.al. (1985). Smith et.al. (1985) observed increase in blood fluoride level in *Salmo gairdneri*, on exposure to elevated fluoride levels in water.

Coughlan, et.al. (1986) reported that fry are more sensitive than fingerling of small mouth bass (*Micropterus dolomieui)* exposed to acute and sub-chronic toxicity of lead. Hutchinson and Sprague (1986) demonstrated that the toxicity of heavy metals in general depends on water quality. Michibata, et.al.(1986) studied the effects of calcium and magnesium ions on the toxicity of cadmium to the egg of the teleost *Oryzias latipes* and reported that, calcium ions contributed to the suppression of the cadmium toxicity, while magnesium ions did not. Prahallad and Seenaya

(1986) reported compartmentation and biomagnification of copper and cadmium in industrially polluted Husainsagar Lake in Hyderabad. Peterson, et.al. (1986) studied sublethal effects of biologically treated petroleum refinery wastewater on agonistic behaviour of sunfish (*Lepomis humilis*). Goel and Sharma (1987) reported some haemato-chemical characteristic of *Clarias batrachus* under metalic stress of Arsenic. Kaur et.al. (1987) reported that cadmium is more toxic than zinc to early life stages of common carp *Cyprinus carpio* exposed to two metals. Mahapatra (1987) demonstrated that, toxic heavy metals from industrial wastewater are resistant to biodegradation and get accumulated in the water and sediment and considerably affects the water quality and aquatic life. Manson (1987) estimated the mercury, lead and cadmium in muscles of British freshwater fish and reported that concentration of metals were above recommended standards for human consumption.

Alis and Shamsi (1988) noted change in behaviour as loss of balance, tilting of body, dorsoventrally wagging of caudal fin, jerky movements and aggressions. Martinez, et.al. (1988) studied effects of environmental parameters like temperature, oxygen, carbondioxide on toxicity of industrial effluent on the blood of fish, *Cyprinus carpio*. Rao, et.al. (1988) studied the acute toxicity of reactive textile dyes to eggs and early life history stages of *Cyprinus carpio*. Hughes, et.al. (1989) evaluated a short term chronic effluent toxicity on survival of sheephead minnow larvae. Rathore, et.al. (1989) studied the acute toxicity of textile dyes to *Channa punctatus* and reported that dye metanil yellow is more toxic than that of derma orange at low concentration. Sakthivel (1989) studied the toxic effect of tannery and textile mill effluent on the fish *Cyprinus carpio* and *Oreochromis mossambicus* and reported that high concentration of carbonate alkalinity tannery effluent and huge organic load in tannery and textile mill effluents were responsible for fish mortality. Sampath and Sakthivel (1989) studied the effect of textile dyes stuff effluent on *Cyprinus carpio* and reported that sublethal concentration 1,3,5,7 and 9% reduced the food intake and growth rate and conversion efficiency. Dharwadkar and Deshpande (1990) suggested that there is threat if deposition of heavy metals occurs in city sewer and enter the food chain. Howells, et.al. (1990) studied the toxic effect of aluminium, calcium and silinium on the gills of European freshwater fish. Abbasi, et.al. (1991) demonstrated that cat fish *Wallago attu* has abnormally high resistance to the mortality from chromium (VI) exposure.

Joseph (1992) observed behavioural alterations induced by nickel and chromium in common carp *Cyprinus carpio*. Pandey and Saksena (1992) studied the toxicity of copper sulphate to the fingerlings of *Labeo rohita* (Ham). Sijm, et.al. (1993) studied the effect of the toxicants from sugar and paper and pulp mill effluent on the gill, liver, kidney and blood of *Salmo salar*, *Cyprinus carpio* and *Oreochromis aureus* respectively. Woo, et.al. (1993) have reported the effect of short term cadmium exposure in kidney of tilapia *Oreochromis aureus*. Sastry and Shukla (1994) studied acute and chronic toxicity of cadmium to freshwater teleost fish *Channa punctatus*. Sharma and Sharma, (1994) studied the toxic effect of zinc smelter effluent to some developmental stages of freshwater fish, *Cyprinus carpio* and reported that eggs of *Cyprinus carpio* were more sensitive to zinc effluent as compared to higher developing stages. Abbasi, et.al. (1995) reported that chromium was more toxic at pH 3,5, 11 compared to 7 and 9,. After exposure of teleost *Nuria denricus* to chromium at different pH of water. Arvind and Sharma (1995) studied the acute toxicity of zinc to certain developmental stages of *Cirrhinus mrigala* (Ham) and reported that, eggs were found more resistant to zinc than higher developing stages.

The toxicity of various compounds of the heavy metals have mainly studied in invertebrate, fishes, amphibians and mammals (Bengeri and Patil, 1995; Gowrishankar, et.al. 1995; Joshi and Patil 1995). Virk and Sharma (1995) studied the effect of nickle and chromium on various life stages of *Cyprinus carpio* and reported that nickle was more toxic than chromium. Uptake and elimination of resin acid and physiological responses in rainbow trout exposed to total mill effluent from an integrated newsprint mill was reported by Johnsen, et.al. (1995). Charanjit Singh, et.al. (1996) studied the toxicity of electroplating effluents. Shrivastava (1996) analysed the heavy metals in the industrial wastewater and sludge by ICP-atomic/ emission spectrophotometer and reported that, concentration of few metal ions was beyond the ISI permissible limits. Singh and Singh (1996) reported the death of the food fish, *Puntius sarana* due to changes in the histopathology of liver and kidney, when exposed to industrial effluents. Srinivas and Rao (1996) performed short term acute toxicity of chromium to the freshwater fish *Labeo rohita* (Ham) to study sensitivity of fish.

Meenakshi, et.al. (1998) studied the influence of zinc sulphate on the freshwater fish *Labeo rohita*. The action of chromium in fishes at various metabolic site is commulative and may be responsible for mortality of the fish *Sarotherodon mossambicus* (Srinivas and Rao, 2000). Lohar (2000) reported that the toxicity of metals to fishes varied greatly depending upon the metal itself and species of fish tested.

Chronic toxicity refers to toxic effect caused by high or low dose at long term exposure. Benoit (1975) observed chronic effect of Cu on survival growth and reproduction of the blue gill *Lepomis macrochirus*. Von and Dethlefsen (1975) studied the chronic effect of cadmium and salinity on development and survival of flounder eggs. Panigrahi and Misra (1980) reported that physiological and biochemical changes were directly related to the Hg concentration in the tissue and in the medium, during exposure of *Tilapia mossambica* to sublethal concentration of inorganic mercury for 35 days. Abbasi and Soni (1984) studied the impact of chromium (VI) on the freshwater teleost *Nuria denricus* to various concentrations by computer-aided long term static bioassay and observed that erosion of fin rays, ulceration and finally death of the fish.

Lehtinen, et.al. (1984) reported structural differences in gill and liver tissue of flounder *Platichthys flesus* when chronically exposed to bleached kraft pulp mill effluent. Sastry and Sunitha (1984) studied chronic toxic effect of chromium in *Channa punctatus*. Delamarre and Trunchet (1985) recorded comparative histological microanalysis of cadmium and mercury exposure in a freshwater fish (*Brachydonia rerio*). Haesloop and Michael (1985) reported accumulation of orally administered cadmium by the eel, *Anguilla anguilla* for 30 days. Victor, et.al. (1986) studied toxicity of mercury and cadmium on differentiation and vitellogenesis of the teleost, *Lepidocephalichthyes thermalis* (Bleeker) when exposed in aqueous solution of mercuric chloride and cadmium chloride for 20 days and reported that cadmium is more toxic than mercury.

Radhakrishnaiah (1988) studied the accumulation of copper in the organs such as gill,. Liver, brain and muscles of fish *Labeo rohita* (Ham) after 2 days of exposure to lethal (1.2 mg/l) and after 1,7,15 and 30 days of exposure to sublethal (0.24 mg/l) concentration of copper. It was reported that the concentration of copper increased with period of exposure. Agarwal and Gautam (1988), studied the chronic toxicity of distillery effluent to freshwater fish *Channa punctatus* (Bl) and reported that fish were quite tolerant at the 2% concentration for about 3 weeks of exposure. Varadaraj, et.al. (1993) studied the effect of sublethal concentrations of paper and pulp mill effluent on the haematological parameters of the fish *Oreochromis mossambicus* exposed for 15 days and reported that decrease in RBC and WBC count and Hb content.

Dhande and Patil (1988) observed hyperplasia in fish *Channa punctatus* (Bloch) during heavy metal stress to cope up with the toxic environment. Srinivas and Rao (1998) studied chromium induced histological alteration in the gill of the freshwater teleost fish *Labeo rohita* (Ham).

BIOCHEMICAL STUDIES

In India most of the industrial activities centre around sugar, tannery, textile, paper, distilleries and steel industries, besides rapidly emerging units of antibiotics, fertilizers, pharmaceutical, pesticides and petrochemicals. The industrial waste generally contains high quantities of dissolved and suspended salts, various inorganic nutrients, high BOD and COD, organic chemicals, oils and grease, besides toxic metals.

Toxicity of lead nitrate in carp metabolism was reported by Narbonne (1973) Bhattacharya and Mukherjee (1976) studied the activity of hepatopancreatic protease and esterase in fish exposed to industrial effluents. Cadmium intoxication on tissue glycogen content in freshwater teleost was reported by Shaffi (1978). Shaffi (1980) studied the effects of various concentration of electroplating waste on liver, muscle, brain and kidney glycogen and on serum glucose lactate of nine fish spp. Srivastava (1982) studied the comparative effect of copper, cadmium and mercury on tissue glycogen of cat fish *Heteropneustes fossilis*. Chitra (1983) studied the effect of urea stress on the protein metabolism of the fish *Sarotherodon mossambicus* in brain, liver, muscle and gill tissues. Lowe and Nimi (1984) studied effect of cadmium on glycogen reserves and liver size in rainbow trout *Salmo gairdneri*. Effect of mercury pollution on the general biology and carbohydrate metabolism of *Channa punctatus* was studied by Sharma (1984). Changes in tissue lipid and cholesterol content in the cat fish *Clarias batrachus* exposed to cadmium chloride was studied by Katti and Sathyanesan (1984). Ram and Sathyanesan (1984) reported mercuric chloride induced changes in the protein, lipid and cholesterol levels of the liver and ovary of the fish *Channa punctatus*. Tort and Balasch (1984) reported that, the protein content was significantly lowered in gill tissue in dogfish (*Scyliorhinus canicula*) after subacute zinc treatment.

Adams, et.al. (1985) studied integrated and individual biochemical responses of rainbow trout (*Salmo gairdneri*) to varying duration of acidification stress. Similar observations were recorded by Bhaskar and Govindappa (1985) in *Tilapia mossambicus* on acclimation to sublethal acidic and alkaline media. Bangeri and Patil (1986) reported decrease in liver glycogen of *Labeo rohita* when exposed to zinc. Bhaskar, et.al. (1986) reported that hepatic tissue of fish *Oreochromis mossambicus* showed compensatory changes with an induction of Lipogenesis in alkaline medium and lipolysis in acidic medium. Jana, et.al. (1986) reported increased protein content in liver, kidney, stomach, intestine, testis and ovary and decreased content of it in the muscles when fish *Clarias batrachus* was exposed to heavy metal pollutants.

Kumar, et.al. (1986) studied the effect of dinitrobenzene plant effluent on the carp *Cyprinus carpio* and found it to be very toxic at low concentration and also interferes with the metabolism of the fish. Wagh (1986) studied the seasonal variation in the biochemical compositions of freshwater Cyprinid fish, *Chela clupeoides*. Jana and Bandopadhyaya (1987) reported the effect of heavy metals on some biochemical parameters in fish *Channa punctatus*. Low pH causes modification of carbohydrate metabolism and liver vitellogenic function in brook trout *Salvelinus fontinalis* (Tam, et.al. 1987). Trot, et.al. (1987) observed reduction in all blood parameters, while liver protein glycogen and lipid was not affected in dogfish *Scyliorhinus conicula* after acute exposure to copper. Similar studies were done by Venkataramana and Radhakrishnaiah (1987) in *Labeo rohita*. Anjaneyulu, et.al. (1988) observed increase glycogen, while decrease in protein after exposure of *Anabas scandens* to chromium at different pH values. Vishwaranjan, et.al. (1988) studied the effect of tannic acid on the protein, carbohydrate and lipid levels in the tissue of the fish *Oreochromis mossambicus*.

Balaji and Chockalingam (1989) reported decrease in total carbohydrate, protein and increase in lipid content of gill of air breathing fish *Channa punctatus* when exposed to sublethal concentration of dairy effluent. Jha and Pandey (1989) observed alterations in the total carbohydrate level of intestine, liver and gonads induced by lead nitrate in the fish Channa puctatus. Effects of tannery effluent on the muscle and liver glycogen in a fish *Sarotherodon mossambicus* was studied by Natrajan (1989). Awari and Gaikwad (1990) studied cadmium toxicity to *Ambassis ranga* and observed that oxygen consumption was significantly affected and the tissue hypoxia might have played important role in synthesis of lipid from carbohydrate precursor. Rajan (1990) recorded that protein, carbohydrate and lipid content decreased significantly in muscle, liver and intestine of *Cyprinus carpio* when exposed to sublethal concentration of textile mill effluent.

Somnath (1991) observed significant decrease in the lipid content of the liver, brain and muscles, while its content in the intestine was not affected in fish *Labeo rohita* exposed to acute sublethal concentrations of tannic acid. Jha (1991) reported alteration in the protein and lipid content of intestine, liver and gonad in the lead exposed freshwater fish *Channa punctatus*. Rajkumar et. al. (1991) reported decrease in the glycogen level significantly in the muscles of *Oreochromis mossambicus* exposed to copper. Joseph, et.al. (1992) studied the toxicity of nickel on protein content in tissue of *Cyprinus carpio* communis (Linn.). Khan, et.al. (1992) recorded cadmium toxicity caused significant decrease in cholesterol level in both liver and ovary, while glycogen decreased in ovary but remain unaltered in liver of teleost *Garra mullya* (skyes) exposed to sublethal concentration of cadmium.

Radhakrishnaiah, et.al. (1992) reported increase in blood glucose level and decrease in liver and muscle glycogen of teleost *Labeo rohita* exposed to lethal and sublethal concentration of copper. Chandravathy and Reddy (1994) recorded recovery of protein metabolism in gill and brain of a freshwater fish. *Anabus scandens* exposed to lead nitrate. Ambrose, et.al. (1994) observed decline in carbohydrate, protein and lipid content of tissue such as gill, liver, intestine and kidney of *Cyprinus carpio* var communis under the toxic stress of sublethal concentration of composite tannery effluent. Singhal (1994) reported that blood glucose, liver and muscle glycogen levels were elevated while lactic acid level decreased in blood, liver and muscle of catfish *Heteropneutes* *fossilis* due to chronic lead exposure. Jha and Jha (1995a) studied the biochemical profile of liver, muscle and gonads of the freshwater fish *Heteropneustes fossilis* under chromium stress. Biochemical effect of nickel chloride on liver and gonads of freshwater climbing perch *Anabus testudineus* was studied by Jha and Jha (1995b). Acute effects of chlorinated resin acid exposure on juvenile rainbow trout *Oncorhynchus mykiss* was studied by Kennedy, et.al. (1995).

Surendra Kumar (1996) studied the biochemical composition in relation to body weight in freshwater major carp, *Labeo rohita*. Tariq, et.al. (1996) studied the presence of heavy metals like mercury, arsenic, silver, copper and lead in the skeletal muscle of fish, *Heteropneustes fossilis*, which probably affects the protein, lipid and carbohydrate metabolism in the muscles. Nanda (1997) recorded decrease in protein indicating stress-full condition, which increase in cholesterol indicating hepatic disfunction in liver and brain of catfish, *Heteropneustes fossilis* (Bloch) exposed to nickel toxicity. Amukdha and Mahalingam (1999) estimated the protein, carbohydrate and lipid from fish tissue after exposure of *Cyprinus carpio* to different concentrations of dairy effluents. Maruthi and Subba Rao (2000) recorded significant decrease in glycogen, total protein and lipid in both liver and muscle tissue of fish with an increase in effluent concentration after exposure of fish *Channa punctatus* (Bloch) to distillery effluent. Patil and Dhande (2000) observed degenerative changes in intestine coinciding with overall depletion in glycogen, protein and cholesterol of the testis of teleost fish *Channa punctatus* (Bloch) exposed to sublethal concentration of mercuric, cadmium and cupric chlorides. Magre (2000) stated that, zinc under acidic condition for 96 hr shows significant influence on the pyruvic acid level in liver and muscle of *Cirrhinus mrigala* exposed to different concentrations of zinc at different pH.