GENERAL INTRODUCTION

Water is one of the most important requirements of all living beings for performing essential life function. With the rapid growth of industries in the century, pollution in natural water by industrial wastes has increased tremendously. Due to lack of treatment and improper mode of disposals, the water bodies are polluted and they carry deadly substances. The treatment of wastes water developed in advanced countries is highly mechanized and energy consuming and is neither appropriate nor financially justifiable for developing countries.

Civilization now faces a transitional period, comparable in some ways to the one, which precipitated in agricultural revolution. That revolution occurred because the unmanaged environment did not deliver food in sufficient quantity or quality to meet the expectations of human society. A crucial question for damaged ecosystems is how to determine that the improvements in effluent quality have in fact produced biological and ecological benefits. For undamaged or relatively healthy ecosystems, an important question is how to maintain quality so that no significant harm results from industrial discharges and still permit the industries to produce their products in most efficient and
least costly manner. Biological evidence is required to answer both questions for three principal reasons:

1. Many chemical compounds and other potential pollutants produce adverse biological reactions at undetectable concentrations.

2. Potential toxicants are rarely present in isolation from each other. Generally the toxicants are present in effluents and natural systems as a combination, and the synergistic biological impact of the combination cannot adequately be estimated from a series of chemical analyses alone, even with adequate facilities. In brief, chemicals interact in various ways with organisms and their interactions cannot be predicted with precision with chemical analysis alone.

3. It is a well known that the water quality (hardness, Oxygen, temperature, pH, etc.) has a marked influence on the expression of toxicity. It is therefore, a combination of toxicants, water quality and the organisms present that produces a definite estimate of the probability of harm from a specific set of concentrations and water quality conditions to particular species. As a consequence, merely knowing the
concentration of chemical or other potential pollutants is not likely to produce useful management information.

Besides algae, macrophytes, and benthic macroinvertebrates, fish are considered excellent indicators of the water quality Hellawell, (1986). The presence of a species indicates that the habitat is suitable, and since some of the environmental requirements are known for many species, their presence indicates something about the nature of the environment in which they are found. Thus, the absence of a particular species is less useful as an indication of environmental conditions than the presence of a species. Based on these criteria several schemes of river zonation have been proposed Singh and Kumar (1993), indicating the presence of one and more dominant fish species usually present in a particular zone. From the headwaters to the mouth, these fish species indicate the unpolluted; less polluted, polluted and intensely polluted zones of the streams.

Several other parameters such as fish population size, growth rate, condition factor and diversity are also indicative of the overall health of water and prevailing environmental conditions. Fish populations in polluted environments are subjected to a long-term contaminant stress, which might affect them in several ways,
including modification of reproductive ability, reduced longevity, reduced growth rate, and increased rate of tumor or lesion development. In a study of brown bullhead (*Ictalurus nebulosus*) populations from a highly polluted site and a clean site, Hirethota and Ringler (1993) concluded that unpolluted site consisted of a higher proportion of older bullhead, and the values of average condition factor of the fishes of two sites were also different. Comparison of the condition factor between the populations showed that fish inhabiting the polluted site had higher condition factors. Such a result could indicate some kind of compensatory growth in the polluted site. Further, the condition factor varies with age, sex, and season and between environments, in spite of the poor water quality of the river Yamuna, the value of condition factor in *Channa punctatus* indicates a robust health status of the fish, which might be due to its capability of breathing air has been concluded by (Basheer *et al*; 1993).

Pollution of any type usually affects both abiotic and biotic environment of fishery water. The interrelationships between the fish and the elements of its abiotic and biotic environment are interdependent; any changes in one system of relationships inevitably produce changes in the other. As the nature of
interaction of fish with any particular elements of its environment and the effect of total environment, natural or polluted, on fish, depends to a great extent upon the condition of the fish itself, the topic of water pollution and fish will continue to be a subject of interest and inquiry for future generations of fish biologists and fishery scientists.

Rapid industrialization and constant discharge of influent into water system made heavy metals as important pollutants of aquatic ecosystem. The effects of toxic wastes upon fish and other aquatic forms have stimulated perhaps more interest and research in recent years than any other sub-field of water pollution biology. The necessity of determining the toxicity of wastes to fish and other aquatic forms has resulted in development of the toxicity bioassays into a useful accepted, although far from perfected tool in water quality management.

Contamination of freshwater bodies by heavy metals is an area of current concern over the years. The problem has been dealt with several aspects, especially damages to ecobiosystem, development of bioassay, toxicity evaluation procedures and remedial majors. Several reports are available that document toxicity of heavy metals and their bioaccumulation properties has
been proved by some authors, (Buikena 1982, APHA, 1985 and Akthar et al. 1995).

Pollution of water bodies affects all the biotic communities including fish. Main sources of water pollution are sewage and domestic wastes, industrial wastes, effluents, heavy metals, fertilizers, detergents, and thermal pollution. The effects of water pollution on the physico-chemical and biotic characteristics of the water bodies are too many, as are the sources of water pollution. The general effects of water pollution on fish may be considered as physical effects, oxidation effects, toxic chemical effects, chemical nutrient effects, pathogenic effects, and other effects caused by the accumulation of radioactive substances, etc. Industrial effluents adversely affect our commercial fisheries, because such effluents generally have high temperature, very low DO, high BOD, and many types of toxic substances, including pesticides, other toxic chemicals and heavy metals. Although many laboratory studies indicate the non-lethal, sub lethal, median lethal, and lethal concentrations of common heavy metals, our knowledge regarding the joint and combination toxicities of these heavy metals is quite meager. As fish is excellent indicator of water quality and parameters such as fish population size, growth rate,
condition factor, and diversity are also indicative of the total health of water (V. Gopal et al; 1997). The overall effect of pollution on fish varies with age, season, availability of food, condition of fish, and so on. It is suggested that more studies should be made to probe the effect of pollution on individual fish species as well as on the whole fish populations of our water bodies.

Indiscriminate discharge of heavy metals through industrial effluents and other sources into aquatic water affect fishes and aquatic animals which are of great economic importance to man. The heavy metals cause the greatest threat to the health of Indian aquatic ecosystem (Joshi et al; 2002). The indiscriminate disposal of chemical and heavy metal wastes from agriculture, industries and mining activity has disastrous effects on aquatic biota and the water quality. As such, increasing attention is being focused on the stress caused on aquatic environments. Several ingredients of these wastes disrupt the integrity of the cellular structures and affect the vital physiological processes Brayan (1971). The most dangerous are the heavy metals, which bind to cell membranes affecting the intracellular transport processes in the living forms. Heavy metals are also known to be the potent inhibitors of ATPase. The also showed the sensitivity of cell-
enzymes to heavy metals in animal tissues. These compounds enter an organism and reach the target organ by passing through living membranes and in the process, adversely affect their permeability and degrade the normal enzyme transport. Heavy metals primarily affect liver and kidney, which are involved in the cleansing processes of the body fluids and tissues have been stated by Chaudhary, (1984).

Bury and Hogstrand (2002) studied the influence of chloride and metals on silver bioavailability to atlantic salmon and rainbow trout yolk sac fry. Relative sensitivity of bull trout and rainbow trout to acute exposure of cadmium and zinc has been investigated by (Hanson et al; 2002). In another study he also reported the relation between exposure duration, tissue damage, growth and mortality in rainbow trout, *Onchorhynchus mykiss* juveniles sub chronically exposed to copper and other metal combination. (Hanson et al; 2002B) Canli and Atli (2003) investigated the relation between heavy metal levels and size of six fish species. (Ay O et al; 1999) reported copper and lead accumulation in tissue of the freshwater fish, *Tilapia zilli* and its effect on the branchial Na, K - ATPase activities. (Toledo et al; 2000) reported the concentration of copper, cadmium and lead in
superficial sediments, water and in the fish, *Cyprinodon dearborni*. Rashid (2001) proposed cadmium and lead level in fish *Tilapia nilotica* tissues as biological indicator of lake water pollution. (Cicik *et al*; 2004) reported effects of lead and cadmium interactions on the metal accumulation in tissues and organs of *Oreochromis niloticus*. (Meador *et al*; 2005) reported comparative accumulation of cadmium, mercury and lead in the fishes.

Trace metals are introduced into the environment by a wide spectrum of natural and anthropogenic sources. Metals are non-biodegradable, and once they enter the environment, bioconcentration may occur in fish tissue by means of metabolic and biosorption processes (Carpené *et al*. 1990; Wicklund-Glynn, 1991). From an environmental point of view, bioconcentration is important because metal ions usually occur in low concentrations in the aquatic environment and subtle physiological effects go unnoticed until gross chronic reactions (e.g. changes in populations structure, altered reproduction, etc.) become apparent Kumar and Mathur (1991). Although trace metals are essential for normal physiological processes, abnormally high concentrations can be toxic to aquatic organisms. Due to the insidious nature of metal bioconcentration, it would be too late to apply preventative measures
to reduce the pollution effects by the time the chronic effects become visible.

Most research has been concerned with the physiological effects and bio concentration patterns of individual metals. Trace metals i.e. Cu, Fe and Zn are readily concentrated in different fish tissues (Peres and Pihan, 1991, Pelgrom et al. 1995). It has further been shown that uptake of sub lethal concentrations of these metals leads to altered physiological processes, which reduces the normal functioning of the organism (Groblер et al. 1989; Wepener et al.1992). As effluent from many sources enters natural waters, the negative impact on the aquatic ecosystem is due to a mixture of metals, rather than individual component metals. When metal mixtures are discharged into the environment they may show a number of effects, which are synergistic, antagonistic or additive in nature (Tsai and McKee 1980, Mukhopadhyay and Konar, 1985).

Metal exposure concentrations were selected to represent ecologically relevant concentrations. The Olifants River (Mpumalanga) is known to contain high Cu and Zn concentrations, which are comparable to metal concentrations in large metalpolluted rivers in the northern hemisphere (Wepener et al. 2000). Concentrations selected for this study were based on actual
measured values obtained during a metal monitoring programme in the Olifants River (Seymore *et al.* 1994).

Lead is one of the abundant heavy metals in the earth’s crust, having widespread industrial applications. It has also tendency to form well-characterized crystalline basic salts of both hydrous and anhydrous types, some of which are used commercially as pigments, for example, white lead. In contrast, the organic compounds of lead are generally formed with tetravalent lead. Lead is widely distributed in nature; it is usually associated with other metals, particularly silver and zinc. Although mined and used for centuries, galena still remains the principal source of lead today. Inorganic Lead compounds are widely used in the petroleum industry, the manufacture of storage batteries and the paint and pigment industries. The petroleum industry uses lead alkyls, namely tetraethyl lead and tetra methyl lead, as antiknock additives in petrol and also uses a small amount of litharge (PbO) dissolved in sodium hydroxide to remove undesirable sulphur compounds in the refining of petroleum. The uses of lead pigments have decreased markedly during the last few decades, the paint industry still consumes a considerable amount of lead. Large amounts of lead are used as solder in the soldering of seams and closures in the
sheathing of telegraph, telephone, and power cables. The ammunition industry is an important consumer of lead. The ceramic industry consumes lead in the form of lead oxides and silicates. Crystal glass, optical glass, and glass for electrical purposes contain a large amount of lead, as do the glazes used for china, pottery, and porcelain enamels. Lead is used in eye cosmetics particularly in Asian countries. Lead-tin-antimony alloys are used in the printing industry. There are mainly minor uses of lead compounds but this accounts for only a small proportion of total lead consumption.

Lead is a ubiquitous environmental toxic substance that induces a broad range of physiological, biochemical and behavioral dysfunction. Lead poisoning is thus an environmental disease, but it is also a disease of life style. Lead is known to affect the structure and function of various organs and tissues. Survey of literature reveals adverse effects of Lead in fishes, Chandravarth and Reddy (1994).

Punder and Sharma (1991) studied the effects of lead on the pituitary, testes and ovaries of a freshwater fish *Nemacheilus boti*. After exposure of 30 days they observed degenerative changes in the endocrine glands. Allen (1995) investigated soft tissue
accumulation of lead in the *Tilapia*. The chronic accumulation profile of lead was determined by analyzing liver, brain, gill filaments, intestine and other tissues. Shafi (1995) investigated sublethal effects of mercury and lead on monoamine oxidase in different region of the brain in the freshwater teleosts. He reported highest rise in the energy activity in talencephalon with mercury exposure followed by lead. (Cicik *et al*; 2004) reported effects of lead and cadmium interaction on metal concentration in tissue and organ of *Nile tilapia*.

Nickel is an essential trace element commonly occurring in air, water, soil and biological systems Abbasi and Soni (1991). Nickel is used primarily in steel production of other alloys due to its strength and toughness it adds to the alloy. It is also used extensively in electroplating as Nickel sulphate and Nickel hydroxide is used in Nickel-Cadmium batteries.

Nickel has a vital role in normal metabolic functioning in animals. At the same time, excess of nickel adversely affect them. Effects of nickel on the protein profile of different tissues in freshwater fishes have been studied by Nanda and Behera (1996). Nickel actually forms an essential part of fish’s
trace element demand and also acts as a cofactor in enzyme urease but excess amount of Ni$^{+2}$ is harmful (Saxena et al; 1980).

Zinc is most common pollutant in land water entering with industrial effluents. Toxicity of zinc to fish has been widely studied during last decades, and a considerable no data available (US EPA 1980, Spear 1981). In order to get the information on the range of pollutant toxicity species with generally different susceptibility metabolic activities should be used. It is necessary to obtain the toxicity data on several fish species, possibly including those easily available and common in the area were the toxicant is probably expected. Therefore comparative toxicity studies should be developed in order to identified the species which can gives results more suitable to the evaluation of ecotoxicity of a pollutant under study Vittozi, De. Algeles (1991). Beside the same fish species is different geographical reasons may show different sensitivity to the same pollutant. Zinc toxic characteristic are varying considerably depending on physicochemical parameter of water (Spragu, 1985, Cusimano et al., 1986). Most research has been concerned with the physiological effect and bio concentration pattern of zinc.
Trace metal zinc is readily concentrated in different fish tissue (Mohan and Choudhary 1991, Peres and Pinan, 1991, Pergorn et al., 1995). It has been further shown that uptake of sub-lethal concentration of zinc leads to altered physiological processes with reduces the normal functioning of the organism (Grobler et al. 1989, Wepener et al. 1992).

The recent trend of toxicity studies of heavy metals to the freshwater fish broadly comprises following areas apart from the determining acute toxicity and effects of sub-lethal exposure.

1) Modeling the acute toxicity such as
   a) The uptake depuration (UD) model.
   b) The time integrated concentration (TIC) model.
   c) The concentration time (CT) model

2) Use of fish species as bioindicators from metal concentration of aquatic ecosystem

3) Investigation of effect of metal pollutants on physiological parameters of model fish species proposed to be used as bioindicator.

4) Biochemical responses of exposure to metal concentration in the model fish species.
Adequate literature is available on the toxic effects of heavy metal pollutants on aquatic biota specially fishes. (Martin et al. 1981, Dhanekar et al. 1985). Heavy metals in the aquatic ecosystem occur in the sediment and also in the suspended particulate matter (Sastry and Shukla 1993, Uma Devi 1997) mainly because of increasing mining operations and industrial uses Chandravarthy and Reddy (1994). Environmental problems have always existed throughout human history but widespread recognition has come, understandably, only belatedly, after many years of steadily accumulating pollutants. Pollution of environment by heavy metals is of prime importance since unrestrained release of heavy metals into environment via discharge of industrial effluents, sewage and agro-chemicals into the water resources has not only rendered it unusable but at the same time has produced great harm to fishes. Awareness of the toxicity of cadmium to fishes has stimulated considerable interest in recent years, studies have shown that other metals, vitamins, zeolites, chelating agents and protein diets which alter the parameters in the physiological, biochemical and behavioral aspects in fish individually also influence toxicity of many other toxicant present already in the fish body (Ruparelia et al. 1992, Sastry and Shukla, 1994, Jain, 1999).
The study of toxic substances present in water and their adverse effects including mortality in aquatic organisms, increase with the growing awareness of the hazards of discriminate water pollution. The toxicological studies of pollutants are gaining more significance in recent time and worldwide attempts has been made to identify a hazard from toxic chemical present or released in aquatic environment. The toxicity study is essential to find out toxicants limit and safe concentration, so that there will be minimum harm to aquatic fauna in the near future.

The considerable interest in and apprehension about the role, fate and toxic metals in aquatic environment are the result of several catastrophic events. The best way to ensure minimal recurrence of such events is to understand metal’s physical, chemical, and biological behaviors in aquatic systems and to utilize this knowledge to propose mitigative measures when dealing with the problems of metal contamination. Generally, there are two main reasons for studying the chemical behavior of metals in aquatic environments to understand either the biological or the geochemical cycling of these elements. The biological cycling includes bioaccumulation, elimination, bioavailability, toxicity and biotransformation. The geo-chemical cycling involves the
transport, adsorption, desorption, precipitation, dissolution and complication of metals in aquatic systems.

Amongst several aspects of toxicity studies the bioassay constitutes one of the most commonly used methods in aquatic environmental studies with a suitable organisms. The necessity of determining the toxicity of substances to commercially aquatic forms at the lower level of the food chain has been useful and accepted for water quality management.

Several studies have been conducted in assessing the toxicity of metals to the aquatic biota specially fishes. Effects have also been made to use certain fish species as bio-indicators of metal contamination of freshwater bodies. However very few studies have documented impact of metal combination on the toxicity and physiology of the aquatic biota. The present investigation has been planned and executed to assess the impact of metal combinations on toxicity and physiology of the freshwater fish *Rasbora daniconius*. The toxicity of heavy metals and its rate of uptake from solution depend upon their oxidation states. So, it is important to analyze their concentration as well as their speciation Chakravarthy, (1993) which has become an important tool in assessing environmental contamination and ecotoxicology. (Steve
et al; 1997) in his review have discussed the importance of trace metal speciation in many areas of environment. Similar studies were also carried out by Bourvik (1997) with respect to speciation of heavy metals in the environment.

Toxicity studies have shown more significant metabolic disturbance in aquatic invertebrates due to exposure to the chloride salt than the nitrate, both for cadmium and mercury. In this connection that toxicity and bioavailability of metals may be affected by chemical interactions in the test medium and that caution must be used in interpreting the results. These authors suggested that biological response of test animals to toxic metal is a function of free metal ion concentrations and not necessarily the total quantity of dissolved metal. Acute toxicity of cadmium to freshwater crustaceans, Daphnia carrianata and Echinisea triscialis in relation to food. Since the reaction and survival of aquatic organisms, toxic conditions depends upon several factors such as kind, toxicity and concentration of the toxicant and the temperature, salinity, dissolved oxygen, pH etc. in addition to the type and time of exposure to the toxicant. It is necessary to carry out toxicity on varieties of aquatic species in different seasons.
Static bioassay tests have been widely adopted and used by Doudoroff and Kartz (1953) for evaluating the impacts of chemical and either toxic substances on aquatic environment and organisms living there in. Excitation and increased opercular movements were observed when fishes were introduced in tests solution the death of fish during experimentation was probably the result of more than one mode or action such as protein denaturation, alternation of membrane permeability and active transport due to toxic effect of heavy metals (Radhakrishan et al; 1991, Hansen J. A. et al; 2002).

In bioassay tests experimental organisms are subjected to a series of suspected concentrations to toxicant under adequately controlled conditions. The exposure time period for acute toxicity is generally 24, 48, 72 and 96 hrs. The acute toxicity tests are generally reported in terms of lethal concentrations LC$_{50}$ or median tolerance limits (MTL). The lethal concentration LC$_{50}$ is a concentration, which indicates the percentage of animals killed at a particular concentration. The period of exposure is important in toxicity studies.

The evaluation of acute toxicity is essential for determination of sensitivity of animals to the toxicants and also
useful for evaluating the degree of damage to the target organs and the consequent physiological and behavioral disorders. The tests of acute toxicity of various pollutants were undertaken in the 19th century by some workers studying the lethal effect of industrial wastes on the aquatic life.

The acute toxicity tests are carried out to detect the sensitive species of an ecosystem. The listed twelve basic types of investigation into toxicity, most of them are tests in laboratory. Chief use of toxicity tests is for a preliminary screening of chemicals for monitoring influents to determine extent of risk to aquatic organisms and to determine the components causing death so that it can receive special treatment. The bioassay and acute toxicity tests are frequently used interchangeably. Sprague (1971) described bioassay as a test in which the strength of material was determined by the reaction of living organisms to it.

Acute effects are those that occur rapidly as a result of generally short-term single exposure to a chemical. In fish and other aquatic organisms, effects that occur within a few hours, days or weeks are considered acute. Generally acute effects are relatively severe. The most common acute effect measured in aquatic life is lethality or motility, a chemical is considered acutely
toxic if by its action it kills 50% or more of the exposed population of test organisms in a relation to short period of exposure time such as 96hrs.

Respiration plays an important role in studying aquatic toxicology. Once the heavy metals entered the living system they start their role, primarily they affect metabolism which is concerned with oxygen in aerobic respiration. Mostly the heavy metal pollutants affect the respiratory physiology by changing the oxygen uptake by organism. Kale and Kulkarni (2003) determined the effect of cadmium chloride on oxygen consumption of *R. daniconius* were increasing in the initial period of exposure. Thereafter started decreasing in the oxygen consumption. (Pande *et at*; 1976, 1979) observed the effect of some biocides and insecticides on *Channa punctatus* found that oxygen consumption decreased in the fish after exposure to malathion.

On the other hand, oxygen is almost continuous throughout the life of active animals, as Lavoiser’s realized in the 18th century, life is combustion, but the similarity between life and fire do not really go on deeper than the science. Scientists have shown the far greater complexity of metabolic fires and established in some detail molecular change through which potential energy in
the fuel is channeled into the high-energy phosphate bond ATP. The production of large amount of ATP requires continuous supply of oxygen. The rate of supply depends anatomical and physiological characteristics of the organs of respiration and transport pigments. In addition actual oxygen content of environment may be limiting factor, while other environmental factors like temperature, carbon dioxide or salinity may impose extra demands for oxygen or affects the rates of exchange.

An excellent discussion on various metabolic pathways, their evolution and relationship to oxygen availability can be found in the reviewed minimal dissolved oxygen requirement of aquatic life. Biological literature records include many values of oxygen consumption by various aquatic invertebrates under various environmental conditions such as temperature, salinity, pH, carbon dioxide, oxygen content etc. Rate of respiration in these animals is also influenced by activity, body size, and stage in life cycle and time of day, as well as by previous oxygen experience and genetic background.

Oxygen consumption is very sensitive physiological processes and the changes in respiratory activity has been used as an indictor of stress in toxicant exposed animals (Sharp et. al;
A number of environment factors and stresses such as temperature, oxygen tension, salinity, hydrogen ion concentration and pollutants alter the rate of oxygen utilization. Oxygen consumption of animals is affected by a number of environmental factors. The heavy metals constitute one of the factors affecting the rate of oxygen consumption. Measurement of oxygen consumption has been used to determine the effect of the toxicant on an average metabolism of exposed animals Waiwood and Johnson, (1974). The rate of oxygen consumption in fishes has been considered to be an indication of intensity of metabolism Fry, (1957). The intimate contact of the gill with polluted water may lead to alterations in the normal respiratory area and this in turn would lower down the diffusing capacity of the gill Skidmore and Tovell, (1972). Acute metal toxicity in fish is often characterized by gill damage and hyper secretion of mucus Mallatt, (1985). Ensuing mortalities are, in turn, related to secondary physiological respiratory disturbances, resulting in ion-regulatory and acid-base balance disturbances Goss and Wood, (1988).

Protein, lipid and glycogen are the major biochemical constituents are pronounced in vertebrates, which are cyclic in reproduction, since a great amount of energy must be chanalized to
the gonad during reproductive events, (Thomson and Mc Donald 1990, Trumen and Pekkarinen 1990 and Abad et.al, 1995) while studying the reproduction in Indian bivalves, reported that apart from the influence of exogenous factors (especially temperature and salinity) which are synchronized with the favorable external environment, seasonal variations in the biochemical composition have been reported by Voogate (1983).

The effect of heavy metals on physiological and biochemical parameters is evident from the research work. Heavy metals are reported to induce many changes in biochemical characteristics of the organisms. Biochemical alternations occurring in the body give first indication of stress in the organism and help pollution biologists to a locate the possibility of certain types of pollutants and their mode of actions. The toxic substances once get entered in the body, they certainly damage and weakened the mechanisms concerned, such a damage may be at cellular or molecular level, but ultimately it can lead to physiological and biochemical disorders which may prove fatal to the organisms. Studies on different biochemical parameters have proved useful in determining the adaptive and productive mechanisms of the body to resist the toxic effect of the toxic substances.
Extensive studies have been made on toxicity of heavy
metals including physiological and biochemical responses of the
freshwater fishes. Sehgal and Saxena (1986) reported toxicity of
zinc to viviparous fish *Labistes raticulatus*. (Hilmy et al; 1987)
reported some physiological and biochemical indices of zinc
toxicity in to freshwater fish *Claris lazera* and *Tilapia zilli*. Effect
of lead, zinc, nickel, mercury was studied on vittelogenin levels in
major fish *Claris batricus* by (Panigrahi et al; 1990). (Suresh et al;
1992) performed comparative study on the inhibition of
acetylcolintestinase activities in the freshwater fish *Cyprinus
carpio* after exposure to mercury and zinc. (Radhakrishnan et al;
1993) reported effect of sublethal concentration of mercury and
zinc on energetics of freshwater fish *Cyprinus carpio*. Cosson
(1994) reported heavy metal intracellular balance and relationship
with metallothionin induction in the gills of carp *Cyprinus carpio*
after exposure to silver, cadmium and mercury. (Churasia et al;
1996) reported lead induced thyroid dysfunction and lipid per
oxidation in the fish *Claris. batrachus*. Kargin and Cogun (1999)
analyzed metal interaction during accumulation and elimination of
zinc and cadmium in tissues of the freshwater fish, *Tilapia nilotica.*
(Widianarko et al; 2001) reported toxicokinetics and toxicity of
zinc under time varying exposure in the guppy, *Poecilia reticulata.*

Katti and Sathyanesan (1983) reported lead nitrate induced changes in lipid and cholesterol levels in the freshwater fish Claris batrachus. Further, they studied lead nitrate induced changes in brain constituents of the same fish. Barak and Mason (1990) examined 146 samples of five species of freshwater fishes for the accumulation of mercury, cadmium and lead.

Though wealth of information is available on the effect of heavy metal toxicity to the freshwater fishes, very scanty work has been conducted on the effects of heavy metal interactions to the freshwater fish toxicity, biochemical responses and pathophysiology. Kargin and Cogun (1999) have studied metal
interaction during accumulation and elimination of zinc and cadmium in tissues of the freshwater fish, *Tilapia nilotica*. The chronic accumulation profile of cadmium in the liver, brain, gill filaments, intestine and other tissues was determined for exposure to cadmium along with lead or mercury.

The sediments adsorb the heavy metal thus their availability is potentially affected by environmental parameters. (Richards *et al*; 2001) studied the effect of natural organic matter source on reducing metal toxicity to *Onchorhynchus mykiss* and have demonstrated that natural organic matter reduces the metal toxicity of the fishes. The rainbow trout has also been used in acute toxicity modeling in case of water born metals. They have proposed three acute toxicity models 1) the uptake depuration model 2) time integral model and 3) concentration time model in order to estimate the effect of water born metals in fish as a function of few constants and variables.

Perusal of literature reveals paucity of information on toxic effects of heavy metals on *R.daniconious* and hence the present study has been focused to evaluate the acute toxic effects of metals like, nickel, zinc and lead to the freshwater fish. The freshwater fish *R. daniconious* inhabits the freshwater stream, pond
and Wan river near Parli-vaijnath Dist. Beed. throughout the year
and therefore thought proper to select this fish as bioindicator of
heavy metal pollution of freshwater aquatic ecosystem.

This study has highlighted the importance of
distinguishing between the accumulation of exogenous metal
sources and the changes in tissue concentrations due to endogenous
metal shifts. Understanding and clarifying the mechanisms
involved in uptake and interactions among the different metals in a
mixture could be accomplished by using radioactive metals for
exposure experiments.