CHAPTER 2

REVIEW OF LITERATURE
Environmental pollution by industrial effluents has been a major concern in recent years. The raw materials, variety of chemicals, metals and the technology used are the primary factors determining the quality of released effluent of an industry. The components of the effluent are responsible for its characteristics and are capable of altering the physical, chemical and biological characteristics of the receiving ecosystem. The physico-chemical analysis of industrial effluents helps to understand the quality of effluent and its impact on ecosystem.

The physico-chemical characteristics of different industrial effluents had been analysed by many workers like Verma and Shukla, (1969); Mohanrao and Subrahmanium (1972); Agarwal and Kumar (1978); Baruah et al. (1996); Paneerselvam et al. (2003) and Karthikeyan et al. (2005).

Devi et al. (2001) analysed effluents of two galvanizing industries at the outskirts of Guwahati city and reported extremely low dissolved oxygen concentration (1.5 mg/l and 1.0 mg/l), high chemical oxygen demand (501 mg/l, 550mg/l) and presence of zinc (22mg/l and 20.0mg/l), lead (0.02 and trace amount), chromium (0.05mg/l and 0.05 mg/l), iron (96 mg/l and 105 mg/l). Kokila et al. (2005) reported that zinc electroplating industry effluent was dark brown in colour and highly turbid. It had a low pH of about 4.3, total conductivity of 11258 μmhos/cm, high BOD and COD levels of about 652 mg/l and 280mg/l respectively. These factors made the effluent highly toxic and they also confirmed the mutagenic effect of the effluent. Panda and Sahu (1999) studied various pollutants present in galvanizing industry effluent with their toxic effects. They also discussed the effective methods for treatment of the effluent. The physico-chemical analysis of Hindusthan Zinc effluent was done by Elizabeth and Srividya (2006) and they recorded high values of pH, conductivity and
turbidity and low value of DO. They also recorded high level of zinc (100 mg/l) but absence of metals like chromium, nickel, copper and iron in the effluent.

Bioassays are particularly useful in evaluating toxicity of industrial effluents which are usually a mixture of several compounds. Such compounds interact synergistically and their combined effect is more than the individual additive effects. Harichandan et al. (2003) assessed LC50 values for cadmium chloride on Tilapia as 9.5 mg/l for 24 hours and 9.2 mg/l for 48 hours. Lodhi et al. (2006) assessed the LC50 values of CuSO4 to fresh water prawn as 0.38 mg/l, 0.361 mg/l, 0.343 mg/l and 0.300 mg/l for 24 hours, 48 hours, 72 hours and 96 hours respectively. The data on acute toxic effects of heavy metals on fish have been reported by Boetius (1960), Saxena and Parashari (1983) and Devi and Gopal (1986). Birtwell et al. (1983) reported that mortality rate is rapid in fishes in short duration as a result of low dissolved oxygen. Mitz and Giesy (1985) reported the acute mortality of channel fish I. punctatus due to sewage effluents.

Devi et al. (2001) also studied the toxicity level of two galvanizing industry effluents by assessing the LC50 values for 96 hours in fresh water fish Cyprinus carpio. Yazdandoost (2002) confirmed the comparative toxicity of the following metallic compounds as HgCl2 >CuCl2 >PbNO3 >CdCl2 >ZnSO4 by assessing the LC50 values of these compounds in Tilapia mossambicas for 96 hours. The comparative toxicity study of different industrial effluents (tannery, textile and electroplating) by Muley et al. (2007) revealed that electroplating industry effluent (LC50 =3%-6%) was more toxic than tannery effluent (LC50 =15%-20%) and textile mill effluent (LC50 =18%-22%).

Water pollution can cause alterations in the behavioural aspects of living animals including fishes. According to Sharma et al. (1993) the behavioural changes in fishes are considered to be sensitive indicator of toxicity. Karuppasamy (1979) regarded fishes as the most sensitive to pollutants among aquatic fauna. Wildish et al. (1977) studied behavioural responses of Herrings and found that they avoid pulp mill effluent due to the presence of long chain complex molecule such as lignin. Farlinger and
Beamish (1977) studied swimming behaviour of fishes and subdivided swimming performance of fish into three general categories; sustained swimming that continue indefinitely, prolonged swimming that cannot be sustained indefinitely and burst swimming that lasts only a few seconds. Bardach et al. (1965) and Cancalon (1980) noted decreased swimming and decreased response to stimulation and decrease in locomotion speed in fishes exposed to toxic environment. Panigrahi and Mishra (1978) documented detailed behavioural changes in relation to inorganic mercury poisoning.

Abnormal behavioural responses of fishes were reported by different workers upon exposure to industrial effluents with unfavourable pH. Nakamura (1986) studied swimming behaviour of fish under changing pH and reported that fish exhibited avoidance behaviour towards unfavourable pH. Garg and Garg (1992) recorded changes in behavioural responses in gold fish exposed to an environment with low pH.

Ram and Gopal (1991) recorded neurobehavioural changes in fish when exposed to inorganic chemicals like zinc. Vijayram et al. (1991) observed that paper mill effluent exposed fishes became agitated, excited, and hyperactive and showed dependence on aerial respiration. Palanichamy and Murugan (1991) recorded abnormal behaviour like frequent surfacing, air engulfing, jerking movement and loss of body balance in fish Rasbora elonga exposed to household detergents. According to Sen et al. (1991) metallic pollutants like zinc caused behavioural, morphological and skeletal abnormalities in fresh water fish Channa punctatus (BLOCH). Prasanth et al. (2005) reported surfacing behaviour of fish under toxic condition.

Sharma and Sharma (1995) reported behavioural changes like fast opercular movement, wriggling movement and loss of balance in Labistes reticulatus (Peters) exposed to zinc and cadmium. Loss of equilibrium was also noticed by Saxena et al. (1981) in nickel and cadmium exposed Channa punctatus and Yadav et al. (2007) in Channa striatus exposed to industrial wastes.
Blood is a vital sensitive pathological reflector of animal body; hence haematological parameters are increasingly gaining importance in the study of animal health including fish under the condition of divergent environmental changes to get some information about the severity of stress responses. Earlier literature had suggested alteration in blood parameters in animals including fish under the influence of environmental stress induced by variety of pollutants like Goel et al. (1981) in amino azo dye exposed fish, Rai and Qayyum (1984) in fish exposed to BHC, Haniffa and Selvan (1991) in fresh water fish exposed to the textile factory effluent, Thakur and Sahani (1993) in fishes subjected to organophosphate environment and Pandey and Pandey (2001) in fungicide exposed *H. fossilis*.

Alterations of blood parameters due to heavy metal exposure was reported by various workers like Singh (1995) who recorded, decrease in RBC and Hb%, and increase in WBC counts in fish *Channa punctatus* due to chromium poisoning. The investigation of Bhoopathy and Gunasegar (1999) on blood parameters suggested increase in the number of WBC and Hb%, and decrease in the RBC number in *Oreochromis mossambicus* treated with chromium salt (potassium dichromate). Prasad and Prasad (2001) reported the alterations of haematological components in *Channa marulius* (BLOCH) exposed to selected metals like chromium (as potassium dichromate). Roy and Dubey (2001) reported initial increase and subsequent decrease in haemoglobin level associated with decline of TEC and marked increase in TLC in fish *Heteropneustes fossilis* exposed to trivalent chromium.

Significant reduction in Hb content and RBC count in *Cirrhinus mrigala* and *Channa punctatus* exposed to lead was reported by Ramalingam et al. (2000) and Hymavathi and Rao (2000). Previous to this, similar results were obtained by Schmitt *et al.* (1993) and Iqbal *et al.* (1997) in lead exposed fresh water fishes. Aruldoss *et al.* (2004) also reported decline in RBC count and Hb content and simultaneous increase in WBC count in lead exposed tree frog. Increase in TLC and decrease in TEC were also recorded by Dhanapakiam and Ramasamy (2001) in fish *Cyprinus*
carpio treated with copper and zinc mixture; Tyagi and Srivastava (2005) reported decrease in erythrocyte count and Hb percentage in *Channa punctatus* to chronic zinc exposure.

Alteration of DLC due to metal toxicity was reported by Larsson *et al.* (1980). He noted depletion in the number of lymphocytes in fish. Lymphocytopenia was also recorded by Joshi *et al.* (2002) in *C. batrachus* exposed to cadmium chloride. Srivastava and Mishra (1979) noticed no significant difference in lymphocyte number in *Colisa fasciatus* after exposure to sub lethal concentration of lead. Increase in the number of monocytes and eosinophil and decrease in neutrophil and basophil number were reported by Mishra and Behera (1992) in mercuric chloride exposed *C. punctatus*. Increment of TLC with the increase in the number of neutrophil and lymphocyte in response to polluted environment in fish was documented by Nayak and Madhaystha (1977), Jinde and Nimi (1986), Thakur and Pandey (1990), Thakur and Sahani (1993); Rao and Hymavathi (2000), Devi *et al.* (2004) and recently by Suresh (2007).

Environmental pollutants such as industrial effluents, pesticides and heavy metals may cause cytological alterations and induce histopathological changes in different organisms. There are reports in relation to histological effects of various pollutants on gill, liver and kidney in many animals including fish. Aquatic pollutants cause severe histopathological abnormalities in the gills. Anitha Kumari and Kumar (1997) reported histopathological changes in some vital tissues including gill of the fresh water teleost *Channa punctatus* inhabiting in polluted water of Hussainsagar lake (AP) containing industrial effluent. Dhanapakiam *et al.* (1998) detected histopathological deformities in the gill of fish *Channa punctatus* treated with Cauvery river water carrying industrial effluents.

There are reports of heavy metals causing severe histopathological abnormalities in the gills. Ahmed *et al.* (1989) reported cytological breakdown of heavy metal exposed
gill. Mathiessen and Brafield (1973) reported gill changes like appearance of vacuoles in gill epithelium of fish on exposure to sub lethal concentration of zinc. Van Hoff and Van San (1981) conducted a series of sub acute toxicity test in fish pertaining to zinc, copper and chromium exposure which caused damages in gills, kidney and liver. Khangarot (1982) observed degenerative gill epithelium of *Puntius sophore* after zinc exposure. Sharma and Sharma (1991) observed hypertrophy of anterior and posterior gill lamellae accompanied by pyknotic and karyorrhetic stages in the epithelial nuclei of the gills of *Cyprinus carpio* and histological changes like complete disruption of epithelial cells and pillar cells, accumulation of degenerated blood cells and cellular debris in middle of gill lamellae in zinc exposed *Lebistes reticulatus*.

Kumada *et al.* (1973) and Gupta and Rajbanshi (1995) reported that gills are the primary sites for accumulation of heavy metals. Oedema with lifting of lamellar epithelium was observed in the gills of rainbow trout when exposed to zinc sulphate by Skidmore and Tovell (1972). Dhanapakiam *et al.* (1998, 2004) reported some degenerative changes like fusion of lamellae and atrophy of the lamellae in gills of the fishes exposed to aquatic pollutants and metals.

Various workers noticed toxic effect of mercury on the gills of fishes. Jagadessan (1999) observed damage in the respiratory epithelium surface, appearance of vacuoles and damages in secondary gill lamellae when fish was exposed to different concentrations of mercury. Gupta and Dua (2002) observed lifting of epithelium, increase in the number of mucus gland openings, sloughing of the epithelium, total damage of the gill raker and distortion in the pattern of microridges on the epithelial surface in mercury induced gill of *Channa punctatus*. Palaniappan *et al.* (2003a) studied the histopathological effect of nickel on fingerlings of *Cirrhinus mrigala* and found that metallic salt was capable of producing severe damage and changes in the cellular level of gills leading to the death of fish. Kalita (2007) reported alteration in gill structure including clumping of gill lamellae, partial loss of tissue and disorganization of lamellae structure in fish *H. fossilis* exposed to waste water containing industrial effluents.
The toxic effects of different pollutants on various aspects of liver of fishes have been reported by several authors. Nanda et al. (2004) reported severe histopathological abnormalities in the liver of fresh water fish *Anabas testudineus* exposed to paper mill effluent. Reports are available on the lethality of various heavy metals on the histology of liver of different animals. Wong et al (1977) reported histological changes in the liver of *Cyprinus carpio* and *Ctenophryngodon idella* when treated with zinc and copper salt. They found that presence of particles in liver caused internal injury which was an important reaction of toxicants. Martoja et al. (1984) reported appearance of granulomatous nodules and cirrhosis of liver in flounder, shad and trouts following exposure to iron. Alterations of hepatocytes in liver of *Poecilia reticulata* exposed to water borne iron were noted by Segner and Storch (1985). Dudley et al. (1985) reported that repeated exposure of rats to low, daily doses of cadmium for six months resulted in liver injury prior to the onset of renal injury.

Sharma and Sharma (1991) noted vacuoles in hepatic cells, pyknotic nuclei in the livers of zinc exposed *L. reticulatus* and *Cyprinus carpio*. Sharma and Sharma (1995) observed various histopathological alterations in the liver of fish *Lebistes reticulatus* exposed to zinc and cadmium. Banerjee and Bhattacharya (1994) reported vacuolation and pyknosis of the hepatocytes, necrosis and degeneration of the sinusoids in the liver of *Channa punctatus* exposed to heavy metal and ammonia.

Gubrelay et al. (2004) reported debris filled central vein, centriolobular disturbances and liquefaction in few areas, karyopyknotic nuclei, leucocyte infiltration, widening of sinusoidal spaces, karyolysis and disturbed cord arrangement in the liver of cadmium exposed rats. Enlarged cells, cellular necrosis, extensive vacuolization and shifting of nuclei to the periphery of some cells in the liver of chromium exposed tadpole were observed by Anusuya et al. (2005).

Exposure to environmental pollutants also causes toxic stress on the kidney which is actively engaged with the elimination of the toxicants from the body. Thurston et al. (1984) reported mild nephrosis and extensive hyaline droplet degeneration in kidney tubules of rainbow trout after exposure to ammonia. Meade and Herman (1986)
noted kidney damage in Lake trout which was reared for 8 weeks in a water reuse system. Gupta and Dalela (1987) noted kidney damage in *Notopterus notoperus* following exposure to phenolic compounds. Bucher and Hoffer (1990) also observed necrosis of kidney tubules in *Salmo trutta* after exposure to ammonia. Rana and Raizada (2000) studied histopathological changes along with marked alteration in renal interstitium and tubules in the kidney of *Labeo rohita* exposed to tannery and textile dying effluents. Kumar (2000) reported vacuolization of the tubular epithelium, hydropoic degeneration of the tubular epithelium, shrinkage of the cytoplasm along with pyknotic nuclei and marked shrinkage in glomerular capillary network resulting in widening of the malpighian capsular cavity in ammonia exposed *Channa punctatus*.

There are reports on the effect of metals on the histopathology of kidneys. Pandey *et al.* (1997) recorded an initial hypertrophy followed by degenerative changes like vacuolation, pyknosis, karyorrhexis and karyolysis in the renal epithelial lining cells of estuarine mullet, *Liza parsia* exposed to sublethal concentration of lead. They also reported excessive shrinkage of glomeruli, edema and hyperemia with increase in exposure period. Gubrelay *et al.* (2004) reported leucocyte infiltration, degenerated glomeruli, hypertrophied glomeruli, vacuolated nuclei and focal degeneration in the medullary region of cadmium exposed rats.

of leucocytes in the kidney tubules, damaged glomeruli, enlarged kidney tubules and pyknotic nuclei in *Tilapia mossambica* exposed to cadmium chloride.

Aquatic pollutants have remarkable influences on various biochemical processes such as protein, carbohydrate and lipid metabolism in fishes and other aquatic organisms. Pollution induced biochemical changes particularly on protein content was reported by Palanichamy *et al.* (1989), Rao and Niraja (1990), Somnath (1991), Vijayram *et al.* (1991), Anusha *et al.* (1996), Gangotri and Matkar (2004), Lomte *et al.* (2000) and Baruah *et al.* (2004).

Rajan (1990) noted significant decrease in muscle protein content of *Cyprinus carpio* on exposure to sub lethal concentration of textile mill effluent. Ambrose *et al.* (1994) also observed decline in protein contents in various tissues of *Cyprinus carpio* under the toxic stress of sub lethal concentration of tannery effluent. Maruthi and Subha Rao (2000) recorded significant decrease in total muscle protein content of *Channa punctatus* exposed to distillery effluent. Revathi *et al.* (2005) noted significant decline in protein content in different tissues of *Gambusia affinis* exposed to tannery effluent. Muley *et al.* (2007) reported decline in muscle protein content of fish *Labeo rohita* exposed to tannery effluent. Such significant decrease in soluble protein content due to pollution stress was also reported by Melay and Brown (1974), Sherekar and Kulkarni (1989), Varadaraj and Subramaniam (1991) and Kalita *et al.* (2003a).

Syversen (1981) reported that heavy metals in general interfered with protein synthesis. Ram and Sathyanesan (1984) noted that mercury chloride reduced the protein content in various tissues of *Channa punctatus*. Janà and Bandyopadhay (1981) stated a significant fall in total protein content of various tissues of *Channa punctatus* when exposed to Hg, Pb, Cu, Cd and Cr. Radhakrishnaiah *et al.* (1991) observed influence of zinc in protein profiles of tissues of fresh water fish and found decline in protein content. Jha and Jha (1995) observed protein depletion in various tissues of *Anabas testudineus* under the stress of nickel chloride. James *et al.* (1995) observed
effect of copper and mercury, which caused growth reduction and altered food conversion efficiency leading to change in gross biochemical constitution of fish body. Decline in protein content of fish after exposure to copper and nickel was reported by Indra and Ramalingam (1996) and Desai et al., (2002) respectively.

Appreciable decrease in protein level in muscle was noticed in fish when exposed to copper by Geetha et al. (1996); in *Channa punctatus* exposed to arsenic by Hota (1996); in *Channa striatus* exposed to mercury, chromium and lead by Palanichamy and Bhaskaran (1995); in *Cirrhina mrigala* exposed to lead acetate by Ramalingam et al. (2000) and in *Labeo rohita* exposed to arsenic by Pazhanisamy and Indra (2007).

Depletion in carbohydrate content on exposure to various pollutants in different animals was reported by several authors like Balaji and Chokalingam (1990) in tadpoles exposed to dairy factory effluent, Sivakami et al. (1994) in *Mystus vittatus* exposed to different industrial effluents, Maruthanayagam et al. (1997) in detergent exposed *Macrobrachium lamarrie* and Maruthanayagam et al. (2000) in detergent exposed *Channa punctatus*.

Revathi et al. (2005) recorded drastic decrease in the carbohydrate content of all the tissues of fresh water fish *Gambusia affinis* on exposure to tannery effluent. Recently Muley et al. (2007) reported depletion in glycogen in lethal and sub lethal concentration of tannery, electroplating and textile mill effluent. Much information is there on the effect of metals on carbohydrate metabolism. Shaffi (1978) recorded marked decrease of glycogen content of fresh water fish due to copper intoxication. Sastry and Gupta (1978) pointed out the fluctuation in glycogen level in *Channa punctatus* when exposed to different concentrations of mercuric chloride. Gill and Pant (1981) observed the effect of nickel intoxication on carbohydrate metabolism. Decreased level of carbohydrate in tissues was reported by Nath and Nishith (1987) in *Colisa fasciatus* on exposure to manganese.
Sreenivasan (1988) noted decline in carbohydrate content in *Penaeus indicus* exposed to copper. Vijayram *et al.* (1989) found decrease of muscle glycogen level in cadmium exposed fresh water fish. Sivakami *et al.* (1994) reported that there was a significant decrease in carbohydrate content in fresh water fish *Mystus vittatus* exposed to chromium. A significant decrease in the level of glycogen content in muscle was observed by Jagadessan (1994) in mercuric chloride exposed *Labeo rohita*; James *et al.* (1995) in fish exposed to media containing copper and mercury and Sheela *et al.* (1995) in various tissues of fresh water fish exposed to zinc. Continuous decline in glycogen content of various tissues of fresh water fish exposed to lead nitrate throughout the exposure period was noted by Chandravathy and Reddy (1996) and Shobha *et al.* (2000) in *Tilapia mossambica* exposed to arsenic toxicity.

Various reports are available on the effect of number of toxic materials on lipid content of different tissues in animals. Rajan (1990) and Ambrose *et al.* (1994) recorded decrease in lipid content of *Cyprinus carpio* on exposure to textile mill and tannery mill effluents. Maruthi and Subha Rao (2000) recorded significant decrease in total lipid content in both liver and muscle tissues of *Channa punctatus* with an increase in the concentration of distillery effluent. Kaur and Saxena (2002) reported decline in total lipid content in fresh water fish exposed to polluted water of river Satluj. Revathi *et al.* (2005) noted drop in lipid level of muscle in fish *Gambusia affinis* exposed to tannery effluent. They found that the decline was lesser in comparison to the decline in carbohydrate and protein levels. Muley *et al.* (2007) observed depletion in lipid content in muscle, kidney, liver and gill of tannery effluent exposed *Labeo rohita*.

Various studies indicated that heavy metals were involved in impairment of lipid metabolism. Ansari (1983) noted depletion in muscle lipid level in *C. punctatus* on exposure to copper. Ram and Sathyanesan (1984) reported significant fall in lipid levels in various tissues of *C. punctatus* on exposure to mercuric chloride. Similar results were obtained by Weis *et al.* (1986) in *Fundulus heteroclitus* on exposure to copper. Dwindling of lipid content in muscle and liver of *Tilapia mossambica* exposed to sub lethal concentration of zinc was noted by Amudhavalli *et al.* (1988). Sreenivasan
(1988) observed decline in lipid content in *Pinaeus indicus* exposed to copper. Decline in lipid content was observed in *H. fossilis* exposed to 75% concentration of nickel-chrome electroplating effluent for 120 days (Gupta, 1991) and that of *C. carpio* exposed to 0.5, 1.0 and 2.5% of zinc electroplating effluent for 90 days (Kaur 1992). A marked decline in lipid content of freshwater cat fish, *Mystus vittatus* exposed to chromium was observed by Sivakami *et al.* (1994). Sheela *et al.* (1995) documented decline in lipid content in tissues of *Oreochomis mossambicus* exposed to zinc. Veena *et al.* (1997) noted marked decline in lipid contents of muscle and liver of an estuarine teleost treated with metals like Cu, Se and Hg. Virk and Sharma (1999) stated significant decrease in the lipid content of liver of nickel and chromium exposed *Cyprinus carpio*.

The fishes are generally recognized as one of the most sensitive indicators of changes in water quality (Mathis and Kevem, 1975). There are several studies on the response of fish exposed to metal contaminations. Many investigators reported the accumulation of heavy metals in fish species under polluted conditions. Al-Mohanna (1994) studied accumulation of metals in liver and muscle of fish. Lakshmi *et al.* (2000) noted bioaccumulation of copper in textile dying effluent exposed fish *Labeo rohita*. Singh *et al.* (2004) documented accumulation of heavy metals copper, chromium and iron in liver, heart and muscle of *Labeo rohita*. Sivakumar *et al.* (1989) studied the accumulation of metals in different tissues of fishes and stated that accumulation of metals in muscle is less in comparison to other tissues. High levels of cadmium accumulation were reported in liver and kidney of trout, *Salvelinus foatalis* by Benoit *et al.* (1976). Swapna (2006) noted deposition of heavy metals in the muscle of fish *Cyprinus carpio* treated with bleaching effluent.

Das *et al.* (2005) studied the heavy metal pollution in the estuary of river Ganga and recorded the accumulation pattern of heavy metals in members of benthic and pelagic communities and they confirmed that accumulation of metal in different species was a function of the membrane permeability and enzyme system. The
accumulation of heavy metal copper in the muscle of *Labeo rohita* exposed to industrial effluent was reported by Lakshmi *et al.* (2000). Maiti and Banerjee (2002) studied zinc accumulation in muscle, liver and kidney of fresh water fish *Oreochromis nilotica* and concluded that this metal accumulate in different organs only after chronic exposure.

Various workers had related bioaccumulation process with the pH of the aquatic environment. Studies of Dey (2002) established a link between pH of water and deposition of certain heavy metals like chromium, zinc, lead and copper in the muscle of the fresh water fish *Channa punctatus*. Bhagwant (2003) observed bioaccumulation of Pb, Zn, and Cu in different organs including muscle tissues of edible fishes of different species in Tombeau Bay associated with domestic, industrial and shipping activities related to pollution.

Earlier reports are there on the higher rate of bioaccumulation of zinc in fish. Pandey (1984) studied the effect of zinc on fresh water fish *H. fossilis* and detected zinc accumulation in the gills after 20 days. Rao and Patnaik (1999) studied the bioaccumulation of zinc, lead and cadmium in the cat fish *Mystus vittatus* exposed to Mehadrigedda stream and detected highest accumulation in zinc. Sinha *et al.* (2002) studied bioaccumulation of heavy metals in some edible fishes of Kharkai River. They also confirmed that zinc accumulation was highest in all the studied fishes. Coetzee (1996); Wepener (1997) and Thangam and Shivkumar (2004) confirmed the least bioaccumulation of chromium in muscle of fish from their studies. Yousafzai (2000) also noted that in fish muscle, zinc was the most concentrated metal and chromium was the least.

The above cited literatures have showered light on some facts on aquatic pollution induced by a variety of industrial effluents, pesticides, chemicals and metals present in the aquatic environment. But very limited literatures are available on the characteristics of galvanizing industry effluent and its effect on living organisms, especially on aquatic animals. Therefore, the present investigation has been designed in an
integrated manner to assess the possible impact of galvanizing industry effluent on the aquatic model fish in histological, physiological and biochemical level.

It is expected that the findings will help in exploring the factors responsible for intensity of pollution induced by galvanizing industry effluent and its effect on fish health since large volume of effluent is released to the surrounding aquatic ecosystem by galvanizing industry units. Besides, the study will provide adequate information to find out ways and means to control the pollution menace caused by industrial establishments in general and galvanizing industry in particular.