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REVIEW OF LITERATURE

Our environmental conditions are not static and human influence has greatly stimulated the flow of environmentally deleterious changes by loading with chemicals to the aquatic system (Dutta and Dalal, 2008). Aquatic ecosystems may become unbalanced by factors due to anthropogenic activities. The most precious and voluminous aquatic ecosystem is being constantly exploited indiscriminately as the most convenient and cheap waste disposal system (Odum, 1971) and it is the only natural resource which gets polluted easily as it serves as a reservoir for agricultural and industrial wastes, domestic sewage and animal excreta and other wastes emanated from anthropogenic alternations of the habitat. The entire ecosystem may be thrown out of gear and may lead towards a severe biological imbalance of the water quality of rivers, streams and lakes get degraded beyond certain limits (Jhingaran, 1983).

Contamination of the aquatic environment by heavy metals has been increasing every year (Majer et al., 2002) and such metals has received special attention due to the fact that they are potentially mutagenic and induce the formation of tumours in the experimental animals and human exposed to them (Garcia-Rodriguez et al., 2001). In recent years, there has been a growing interest in understanding the physiological mechanism associated with the response of fish to environmental stress (Sharma and Gopal, 1994; Roy, 2002). Heavy metals enter into aquatic habitats by a number of routes and cause hazardous effects on their morphology and physiology (Heath, 1995; Veena et al., 1997; Hollis et al., 1999; Lionetto et al., 2000; Vutukuru, 2003; Ciftci-Soydemir et al., 2008; Elango et al., 2011). Heavy metals at high concentration cause hazardous effect to metabolic, physiological, biochemical systems of fishes (Heath, 1987; Coimbra et al., 2000; Yang and Chen, 2003; Atli and Canli, 2007; Dobsikova et al., 2010; Shahsavani et al., 2010 and Patriche et al., 2011).

Indiscriminate exposure to heavy metals may pose serious threat to fish. Fish are widely used to evaluate the health of aquatic ecosystems because pollutants build up in the food chain and are responsible for adverse effects in the aquatic systems (Yousuf and El-Shahawi, 1999; Farkas et al., 2002; Srivastava and Verma, 2009) and
hence, fish can largely serve as bio-indicators of environmental pollution (Das and Kaviraj, 1990; Kock et al., 1996; Lopes et al., 2001; Whitefield and Elliott, 2002; Dautremepuis et al., 2004; Shuahimi-Othman et al., 2010; Serezli et al., 2011). The effect of pollutants on fish is evaluated by acute and chronic toxicity tests (Sprague, 1973; Rand and Petrocelli, 1985; Svobodova et al., 1994; Nussey et al., 1996; Hadjispyrou et al., 2001; Krumschnabel and Nawaz, 2004).

Chromium is very toxic (Van der Putte et al., 1981) and is a common aquatic contaminant. Hexavalent chromium compounds readily penetrate cell membranes, cause cellular damage by inducing oxidative stress (Begum et al. 2006). The hexavalent form is found to be mutagenic in most studies performed, while the trivalent one, until recently, was considered inactive, but it was demonstrated that this form can be reduced to Cr (II) and produce free radicals through the redox cycle (Sala et al., 1995; Stosh et al., 1995). Chromium compounds inside the cell are reduced to its lower oxidation states by low molecular weight molecules, enzymatic and non enzymatic reductant (Shi et al., 1999). This reactive chromium intermediate is capable of generating a whole spectrum of reactive oxygen species (ROS), which are important characteristics of Cr (VI) metabolism (O’Brien et al. 2003).

Excessive quantity of reactive oxygen species generated by these reactions can cause injury to cellular proteins, lipids, and DNA leading to a state known as oxidative stress (Halliwell and Gutteridge, 1990; Stohs and Bagchi, 1995; Nordberg and Arner, 2001). Continuous production of reactive oxygen species induces oxidative stress in the metabolically important organs and causes severe histopathological alterations, results in damage to cell membranes inactivation of enzymes and damage to cell components and metabolically important organs and genetic materials. Further, some diseases are associated with oxidative stress (Bomzon and Ljubuncic, 2001). Although the hexavalent chromium itself doesn’t directly generate free radicals, it indirectly generate various radicals such as superoxide, nitrogen species like peroxy nitrite, nitric oxide and hydroxyl causing damage consistent with oxidative stress (Pritchard et al. 2000).

The increasing awareness of aquatic pollution permits toxicity tests to assess in providing rational limits for pollution control. Acute toxicity studies can rapidly
and inexpensively provide environmentally relevant and useful information (Velma et al., 2009). The genotoxic and carcinogenic effects of hexavalent chromium have been evaluated (Leonard et al., 1980; IARC, 1990; De Flora, 2000; De Lemos et al., 2001; Tagliari et al., 2004; Teles et al., 2005 and Goodale et al., 2008). Very few researchers reviewed the toxicity of chromium compounds to aquatic organism (Becker and Thatcher, 1973; IARC, 1990; Goodale et al., 2008; Domingues et al., 2010 and Hun-Je Jo et al., 2010).

The 96 h LC$_{50}$ trials on fish were conducted to measure the susceptibility of surviving potential of fish to particular toxic substances (Isaac et al., 2000; Gulfrax et al., 2001; Jaffri et al., 2003; Diagomosanolin et al., 2004; Naskar et al., 2006; Madoni and Marina, 2006 and Zhi-Hua Li et al., 2011). The LC$_{50}$ value for hexavalent chromium was reported by many researchers; Cyprinus carpio (Vykusova and svobodova, 1990 and Tayyabah et al., 2005); Oreochromis sp. (Abbas and Ali, 2007); Daphnia magna (Hun Je-Jo et al., 2010). The variation in LC$_{50}$ depends on size, species, source of the toxicants and physical conditions etc. (Jaffri et al., 2003; Ahamed, 2005; Mishra and Mohanti, 2009). The LC$_{50}$ values of fish vary from species to species and from metal to metal (Das and Banerjee 1980; Smet and Blust, 2001 and Kesherwani et al., 2009). Variations in the values may be due to various factors such as temperature, pH, dissolved oxygen and synergism in addition to different fish species (Al-Akel, 1996).

Voluminous literatures were available on the acute and chronic toxicity of various metals on fish; Salvalinus fontinalis to lead (Holcombe et al., 1976); Barbus conchonius to mercury (Gill and Pant, 1985); Oncorhynchus mykiss to cadmium and mercury (Iliopoulou-Georgudaki and Kotsanis, 2001); Cyprinus carpio to cadmium (Smet and Blust, 2001); Tinca tinca to mercury, cadmium and lead (Shah and Altindag, 2005); Clarias gariepinus to lead nitrate (Adeyoma et al., 2008) and Clarias batrachus to chromium and mercury (Rani et al., 2011).

An important negative characteristic of metals is their ability to accumulate in metabolically active organs, especially in the liver, spleen, gills, kidneys and gonads (Yilmaz, 2006; Oguzie and Izevbige, 2009; Kaoud and El-Dahshan, 2010) resulting in hepatic and renal dysfunction with growth retardation and it could induce
alterations in haematological and serum biochemical parameters (Gill et al., 1991) and degenerative changes like oxidative stress in the body (Livingstone, 2001; Filipovic and Raspov, 2003; Abou EL-Naga et al., 2005; Lushchak et al., 2007). The accumulation of heavy metals in the tissues of organisms can result in chronic illness (Holcombe et al., 1976; Barlas, 1999; Hadjispyrou et al., 2001; Scott et al., 2004; Verma and Srivastava, 2008b; Barno et al., 2010 and Redondo-Gomez et al., 2011).

Cr (VI) bioaccumulation is largely attributed to differences in uptake and depuration period for various metals in different fish species (Vincent and Ambrose, 1994; Tawari-Fufeyin and Ekaye, 2007). Cr tends to accumulate in tissues of fish through the gill surfaces and gut tract wall, at higher concentrations than those found in the environment (Knoll and Fromm, 1960; Chevreuil, 1995). It is believed that chromium inflicts most damage during reduction of chromium VI to chromium III, a process considered to be initiated in the cell by glutathione (Bose et al., 1992; Stearns and Wetterhahn, 1994 and Moghaddas et al., 1995). Related studies have demonstrated that exposure to chromium induces acute renal failure in human and other aquatic animals (Piacuda et al., 1991; Micheal et al., 1991 and Pedraza-Chaveri et al., 1995). Chromium (VI) induced structural changes in metabolically important organs (Ahmad et al., 2006; Ashish and Banalata, 2008; Pedro and Alicia, 2008; Lushchak et al., 2008 and Sannadurgappa and Aladakatti, 2010).

Heavy metals cannot be destroyed through biological degradation. When aquatic animals exposed to higher concentrations, organs of aquatic animals may accumulate heavy metals (Pelgrom et al., 1995; Grosell et al., 1996; Kalay et al., 1999; Mazon et al., 2002 and Ashraf, 2005). Numbers of researcher have studied heavy metal accumulation in tissues of various freshwater fish (Kumada et al., 1980; Ay et al., 1999; Tayal et al., 2000; Wepner et al., 2001; Ptashynski and Klaiverkemp, 2002; Yagit and Altindag, 2002; Aleya et al., 2005; Zirong and Shijun, 2007; Cai et al., 2010 and Noor et al., 2011). The distribution of metals in tissues varies from species to species, tissues to tissues of fish (Kamble and Muley, 2000; Bervotes et al., 2001; Mansour and Sidky, 2002; Spurný et al., 2002; Alquezar et al., 2005; Staniskiene et al., 2006 and Rauf et al., 2008).
Liver is the main metabolic center where detoxification and drug metabolism take place which makes it greatly vulnerable to damage by toxic substances (Reddrop et al., 1983). The liver is the principal site involved in the storage of heavy metals and accumulation of various metals in the liver in different species were reported by many researchers; catfish to chromium- (Lakshman, 2001); Cyprinus carpio to copper (Peyghan et al., 2003); Channa punctatus to copper (Karuppasamy et al., 2008); Butter fish to Copper (Jiraungkoorskul et al., 2007); Cyprinus carpio to Cr,Ni,Pb (Vinodhini and Narayanan, 2008); Orechromis niloticus to Cu,Pb,Cd, Hg (Kaoud and El-Dahshan, 2010).

Accumulation of heavy metal in gill tissues can manifest its toxic action internally as well as on the gill surface (Knoll and Fromm, 1960; Zatta, 1985; Wu et al., 1986). Accumulation of various metals in gills were reported in different species; teleost fish to copper, zinc, cadmium and chromium (Van Hoof et al., 1981); Onchorhyncus mykiss to zinc (Camusso et al., 1995); Tilapia sapermanii to copper, iron and zinc (Wepner et al., 2001); Cirrhina mrigala to cadmium (Singh et al., 2008); Odontesthes bonariensis to chromium (Pedro and Alicia, 2008) and Oreochromis niloticus to chromium (Ciftci et al., 2010).

Kidney is the main target organ for chromium accumulation, more sensitive to the toxic effects of metals than other tissues. Number of literatures are available on accumulation of heavy metals in kidney of various species; Channa punctatus to zinc (Gupta and Srivastava, 2006); Labeo rohita, Catla catla, Cirrhinus mrigala to cadmium and chromium (Rauf et al., 2008); Catla catla to cadmium (Singh et al., 2008); Cyprinus carpio to Cr,Ni,Pb (Vinodhini and Narayanan, 2008); Oreochromis niloticus to chromium (Ciftci et al., 2010) and Oreochromis niloticus to Cu,Pb,Cd, Hg (Kaoud and El-Dahshan, 2010).

Physio-morphological changes in blood parameters indicate the changes in the quality of the environment and therefore blood parameters are important in diagnosing the functional status of the fish exposed to toxicants (Casillas and Smith, 1977; Heath, 1987; Seith and Saxena, 2003;Witeska, 2005; Tyagi and Srivastava, 2005; Adhikari et al., 2006; Ciftci et al., 2008; Vinodhini and Narayanan, 2009; Sahaheen, 2009; Kori-Siakepere and Oboh, 2011) and used as an indicator of metal
pollution in the aquatic environment (Shah and Altindag, 2004a; Kori-Siakpere et al., 2006; Mastan et al., 2009).

Haematological parameters can provide satisfactory information on the physiological responses of fish to environmental stressors for two reasons, namely, the close association of the circulatory system with external environment and the ease availability of fish blood (Houston, 1997; Lohner et al., 2001; Cazenave et al., 2005). Early diagnosis is also possible when evaluating haematological data, particularly blood parameters (Blaxhall, 1972; Golovina, 1996; Vosyliene, 1999; Martinez et al., 2004; Reite, 2005 and Oshode et al., 2008). Haematological values are widely used to determine the systemic relationship and physiological adaptations (Vosyliene, 1999). The harmful effects caused by heavy metals include haematological, biochemical and physiological alteration in several aquatic species (Chandravathi and Reddy, 1996; Rainza-Paiva et al., 2000; Rehulka et al., 2002b; Guijaro et al., 2003; Shah 2006 and Ololade and Oginni, 2010).

Hexavalent chromium has an adverse effects on haematological parameters of freshwater fish. Cr (VI) causes alterations in the blood and biochemical changes (Gautam and Gupta, 1989; Edward et al., 2001; Vosyliene, 2002; Teles et al., 2005; Frombi et al., 2007; Prabakaran et al., 2007 and Vinodhini and Narayanan, 2009). Red blood corpuscles are a major and reliable indicator of various sources of stress (Rainza-Paiva et al., 2000). A number of authors reported the increase and decrease of RBC count in various fish exposed to different toxicants; Oreochromis mossambicus to cadmium (Ruparella et al., 1990); Catla catla to cadmium and chromium (Vincent et al., 1996); Saccobranchus fossilis to chromium (Khangarot et al., 1999); Heteroclarias sp. to zinc (Kori-Siakpere et al., 2006); Onchorynchus mykiss to metal mixture (Vosyliene and Jankite, 2006); Tilapia zilli to lead (Zaki et al., 2010) and Salmo coruhensis to copper and lead (Serezli et al., 2011).

White blood cells play a major role in the defense mechanism of the fish and consist of granulocytes, monocytes, lymphocytes and thrombocytes. Granulocytes and monocytes function as phagocytes to salvage debris from injured tissue and lymphocytes produce antibodies (Wedemeyer and Mcleay, 1981). Alterations in the total WBC count were reported by number of investigators; Tilapia spermanii to
chromium (Wepner et al., 1992a); Cyprinus carpio to chromium (Svobodova et al., 1994); Clarias batrachus to mercuric chloride (Joshi et al., 2002); Tinca tinca to mercury (Shah and Alttindag, 2005); Hoplias malabaricus to methyl mercury (Oliveira Ribeiro et al., 2006); Channa punctatus to Cadmium (Ates et al., 2008); Cyprinus carpio to Cd, Ni, Cr (Vinodhini and Narayanan, 2009) and Salmo coruhensis to copper and lead (Serezli et al., 2011).

The haemoglobin content of fish is known to be a useful index of health (Murugesan and Haniffa, 1985). Haemoglobin reflects the supply of an organism with oxygen and the organism itself tries to maintain them as much as stable as possible. Changes in the haemoglobin levels were reported by many researchers in various fish; Anguilla anguilla to cadmium (Larsson, 1975); Salmo gairdneri to lead (Johanson-Sjobeck and Larsson, 1979); Tilapia sperrmani to chromium (Wepner et al., 1992); Oreochromis mossambicus to copper (Gaill Naussey et al., 1995); Saccobranchus fossilis to chromium (Khangarot et al., 1999); Channa punctatus to chromium (Tyagi and Srivastava, 2005); Cyprinus carpio to chromium (Shaheen, 2009); Clarias batrachus to lead (Mastan et al., 2010); Oreochromis niloticus to cadmium sulphate (Zaki et al., 2010) and Salmo coruhensis to copper and lead (Serezli et al., 2011).

Hematocrit values are valuable in determining the effect of stressors on the health of fish and are also used to determine the oxygen carrying capacity of blood. Several authors reported decrease and increase in the hematocrit values in different fish exposed to various heavy metals; Scyliorhinus canicula to cadmium (Tort and Torres, 1988); Catla catla to cadmium and chromium (Vincent et al., 1996); Oreochromis niloticus exposed to heavy metals (Shalaby, 2001); Common carp to heavy metal (Witeska, 2005); Heteroclarias sp. to zinc (Siakpere et al., 2006); Anguilla anguilla to lead (Ciftci et al., 2008) and Tilapia zilli to lead (Zaki et al., 2009).

Biochemical and physiological methods of diagnosis constitutes a promising approach to the problem detecting the toxic chemicals at the earliest possible stage (Larsson et al., 1985). Measurement of serum biochemical parameters can be used as a diagnostic tool in fish toxicology to identify their general health and the target
organisms affected by the pollutants (Zikic et al., 2001; Mc Donald and Groell, 2006). Biochemical profiles in fish and other aquatic organisms under heavy metal stress serves as an important bio-indicators in monitoring of aquatic environment (Hellemans and Bailliene, 1990; Abbas and Mahmoud, 2004; Shalaby et al., 2005; Carvalho and Fernandes, 2006; Abbas et al., 2007; Arnaudova et al., 2008 and Patriche et al., 2011).

Any alterations in physiological and biochemical parameters of chromium treated fish has recently emerged as an important tool for the water quality assessment in pathological studies of fish in the field of environmental toxicology (Racicot et al., 1975; Wieser and Hinterleitner, 1980; Sharma and Gopal, 1994; Kulshrestha et al., 1995; Roy, 2002; Danabas et al., 2010; Eissa et al., 2011). Several authors reported the effects of hexavalent chromium on biochemical constituents of fish (Strick et al., 1975; Gill and Pant, 1981; Vander putt et al., 1982; Sridevi and Reddy, 2000; Abbas and Ali, 2007; Velma et al., 2010 and Zhi-Hua Li et al., 2011). Biochemical and physiological biomarkers are frequently used for detecting lethal and sublethal effects of fish exposed to different toxic substances (Theodorakis et al., 1992; Al-Attar, 2005; Ogueji and Auta, 2007; Kori-Siakpere and Ubogu, 2008; Mousa et al. 2008; Shalaby, 2009 and Selcuk et al., 2010). Serum biochemical parameters helps to differentiate the normal physiological condition of the animal from heavy metal stress (Asadi et al., 2006ab; Bahmani et al., 2010; Kataria et al., 2010 and Munoz et al., 2010).

Plasma glucose responses have been used as indicators of metal stress in fish (Ferrando and Andreu, 1991). Many literatures are available on the effect of heavy metals on plasma glucose level in the fish; Channa punctatus to chromium (Sastry and Sunita, 1983); Colisa fasciatus to chromium (Nath and Kumar, 1988); Cyprinus carpio to chromium (Morsy and Protasowicki, 1990); Cyprinus carpio to chromium (Al-Akel and Shamsi, 1996); Oreochromis niloticus to cadmium (Al-Attar, 2005); Labeo rohita to arsenic (Palaniappan and Vijayasundaram, 2008); Cyprinus carpio to copper (Cicik and Engin, 2005); Oreochromis niloticus to metals Ag, Cd, Cr, Zn (Oner et al., 2009); Cyprinus carpio to Cr, Ni, Pb (Vinodhini and Narayanan, 2009) and Tilapia zilli to lead (Zaki et al., 2010).
The protein concentration in serum has been used as an indicator of their general state of health (Alexander and Ingram 1980). Protein are the most fundamental and abundant biochemical constituent present in the animal body and protein is a main source of energy (Agrahari and Gopal, 2009) and hence, the estimation of protein is considered to be an important tool (Ravichandran et al.1994). Few reports were available on the changes caused by chromium on protein contents in various fishes (Arillo et al., 1982; Jana and Bandyopadhyay, 1987; El-Demerdash et al., 2006; Satyaparameshwar et al., 2006). Voluminous literatures are available on the effect of various metals on protein content of the fish; Catla catla to chromium (Vincent et al., 1995); Cyprinus carpio to chromium (Canli, 1996); Mugil seheli to cadmium and copper (El-Nagar et al., 2001); Channa punctatus to nickel (Sekhar and Balaram, 2002); Labeo rohita to chromium (Vutukuru, 2003); Oreochromis mossambicus to cadmium (Hameed and Kumaravel, 2006); Oreochromis sp. to chromium (Abbas and Ali, 2007); Heteroclarias sp. to zinc (Kori-Siakpere et al., 2008); Clarias batrachus (Linn.) to lead nitrate (Mastan et al., 2009); Oreochromis niloticus to Ag, Cd, Cr, Zn (Oner et al., 2009) and Salmo coruhensis to copper and lead (Serezli et al., 2011).

Cholesterol is the most abundant animal sterol and widely distributed in all cells and major components of cell membranes and lipoproteins. Few literatures were available on the effect of heavy metals on the changes in the cholesterol levels in various fish; Channa punctatus to sodium fluoride (Chitra and Rao, 1981); Anabas testudineus to nickel (Jha and Jha, 1994); Cyprinus carpio to mercury, chromium, nickel (Canli, 1995); Oreochromis niloticus exposed to cadmium (Al-Attar, 2005); Anguilla anguilla to lead (Ciftci et al., 2008); Tilapia zillii to aluminium (Hadi et al. 2009); Cyprinus carpio to combined metal (Vinodhini and Narayanan, 2009) and Tilapia zillii to lead (Zaki et al., 2010).

The rate of lactate production is considered as an index of physiological stress in the biological system (Green et al., 1983). Alterations in the lactic acid concentration is due to metal intoxification in fresh water teleosts have been reported by many researchers; Salmo gairdneri to chromium (Vander putt et al. 1982); Channa punctatus to chromium (Sastry and Sunita Tyagi, 1982); Salmo gairdner to methyl mercury and chlorobenzenes (Lowe- Jinde and Niimi, 1984); Tilapia mossambicus
to ammonia (Surya Prakash, 1988); Oreochromis mossambicus to ammonia (Santhi, 1991); Colisa fasciatus to nickel (Chaudhry et al., 2002). This study aimed to provide additional toxicity data for chromium on selected biochemical parameters like plasma glucose, plasma protein, plasma cholesterol and lactic acid.

Assay of enzyme activities can serve as a valuable bio-monitor of heavy metal pollution in various fishes; Rainbow trout to chromium (Bose et al., 1992); Channa punctatus to zinc (Rana et al., 1995); Labeo rohita to cadmium (Shaffi et al., 1999); Oreochromis niloticus to cadmium (Al-Attar, 2005); Labeo rohita to arsenic (Humtsoe et al., 2007); Clarias gariepinus to lead nitrite (Osman et al., 2007); Channa punctatus to zinc (Verma and Srivastava. 2010) and Labeo rohita to chromium (Zodape, 2010). Many reports were concerning the influence of heavy metal ions upon the enzymes in fish (Kuz’mina et al., 2002; Golovonova, 2004; Golovonova and Komov 2005; Nemova, 2005; Saraswathy and Usharani, 2007 and Zaki et al., 2010). Changes in concentrations and enzyme activities are often directly reflect the cell and organ damage has been reported by number of authors (Casillas et al., 1983; Burtis and Ashwood, 1996; O’Neill et al. 1998; Jacobson- Kram, 2001; Congleton et al., 2001; Roy, 2002 and Atli and Canli, 2007). The magnitude of severity of cell damage and the variation in enzyme activities depends on the degree of increase in the activity of cellular enzymes in serum (Kristoffersson et al., 1974; Nemcsok and Boross, 1982; Sojbeck et al., 1984; Radhakrishnaiah et al., 1992; Szegletes et al., 1995; Thaker et al., 1996; De Smet et al., 2001; Shukla et al., 2007; Vutukuru et al., 2007 and Zaki et al., 2010).

Activities of GOT and GPT can vary greatly among different tissues within the same organisms and among the different species (Christensen et al., 1972; Sastry et al., 1997; Shakoori, 1997; Dang, 2000; Al-Attar, 2005; Atli and Canli, 2007; Humtsoe et al., 2007 and Zaki et al., 2010). Various heavy metals alters the level of serum GOT and GPT enzymes in the various fish; Salvelinus fontinalis exposed to copper (McKim et al., 1970); Heteropneustes fossilis to copper sulphate (Nemcsok and Hughes, 1988); Cyprinus carpio to copper sulphate (Asztalos et al., 1990); Orechromis sp. and Catfish to metals (El-Shehawi et al., 2007); Tilapia zillii to lead (Zaki et al., 2010) and Labeo rohita to hexavalent chromium (Kumari et al., 2011).
Lactate dehydrogenase (LDH) has been used for demonstrating damage in fish for a long time (Nemcsok & Boross, 1982). They are involved in the energy release by the biological oxidation of food stuffs inside of mitochondria and also in the production of reduced potential (NADPH) required in the biosynthetic and detoxification mechanisms as stated by Gupta (1987). The degree of alterations in the activity of such a cellular enzyme depends primarily on the magnitude of severity of cell damage (Asztalos and Nemcsok, 1985). LDH activity in fish occurs at greater concentration in muscle that in other tissues, making total serum LDH level is potential biomarker of muscle damage (Oikari et al., 1983). A significant changes in LDH activity was reported by many authors in various fish; Channa punctatus to chromium (Sastry and Sunita Tyagi, 1982); Anabas scandens to lead nitrate (Mary Chandraivothy and Reddy, 1995); Anabas scandens exposed to Selenium (Anuradha and Raju, 1996); Labeo rohita to HCH (Shaffi, 2001); Carcinus maenas to chromium (Elumalai et al. 2002); Clarias gariepinus to lead (Osman et al., 2007); Cyprinus carpio to Cr, Ni, Pb (Vinodhini and Narayanan, 2008) and Tilapia zilli to lead (Zaki et al., 2010).

Antioxidants are frequently used as a marker of oxidative stress and both anti-oxidants and non-enzymatic anti-oxidants have also been employed in aquatic studies (Haspieler et al., 1994; Filho et al., 1996). Exposure of heavy metals caused a time and dose dependent increase or decrease of GSH concentrations in various fish species (Syed et al., 2003; Ali et al., 2004). The antioxidant role of GSH in cells relies on its concentrations, rates of turn over and rates of synthesis (Potter and Tran, 1993). Effect of chromium on antioxidant enzyme activities was analyzed (Pattolla et al., 2007).

Various authors reviewed the alterations in the level of glutathione (GSH) caused by metals in fish and other aquatic animals; Pagrus major to Cd (Kuros enlarged, 1995); Channa punctatus to mercury (Rana et al., 1995); Onocorhynchus mykiss to Cd (Lange et al., 2002); Parasesarma erythodactyla to metals (Mac Farlane et al. 2006); Clarias gariepinus to metal mixture (Frombi et al., 2007); Gambusia affinis to cadmium (Mohamed et al., 2008); Oreochromis niloticus to metal mixture (Firat et al., 2009); Oreochromis niloticus to cadmium, zinc and copper (Atli and Canli, 2008); Carassius auratus to chromium (Lushchak et al., 2008); Cyprinus carpio to Cr, Ni,
Pb (Vinodhini and Narayanan, 2009). Thus, the present study aimed to find out the effect chromium on the enzyme activities like GOT, GPT, LDH and GSH in the freshwater fish Cyprinus carpio.

Histopathological investigations have been proved to be a sensitive tool to detect effects of chemical compounds within the target organ of fish in laboratory experiments. The exposure of fish to toxic agents such as heavy metals induces histological alterations in several components of the kidney (Kendall, 1975; Kirubagaran and Joy, 1988; Ortiz et al. 2003 and Velmurugan et al. 2007). Heavy metals undergo metabolic activation that provokes cellular changes as well as pathological changes in most of the organs (Ghalab, 1997; Randi et al., 1996; Alazemi et al., 2000; Thophon et al., 2003; Koca et al., 2005; Nero et al., 2006; Gurcu et al., 2010 and Khoshnood et al., 2011). The tissue lesions and apoptosis arise from bioaccumulation, infections, diseases and parasites stimulate necrotic alterations in the fish with an inflammatory defensive reaction (Sorenson 1988; Ramberg et al. 1991; Dutta, 1996; Short and Meyers, 2001; Varanka et al., 2001; Roganovic-Zafirova et al., 2003; Monteiro et al., 2005 and Sindhe et al., 2006).

Liver, gill, kidney and brain are the most vulnerable organs of a fish exposed to medium containing any type of toxicants (Jana and Bandhpathyaya, 1987). Histological alterations in fresh water fish were reported by many researchers (Kirubagaran and Joy, 1988; Randi et al. 1996; Mourad and Wahby, 1999; Thophon et al., 2003; Olojo et al., 2005; Athikesavan et al., 2006; Figueiredo-Fernandes et al., 2007; Farombi et al., 2007; Abdel-Moneim and Abdel-Mohsen, 2010 and Elango et al., 2011). The chromium mediated toxic effects on histopathology of various fish were reported by number of investigators (Murthy et al., 1991; Travacio et al., 2001; Aruldhas et al., 2005; Oliveira et al., 2006; Acharya et al., 2006; Subramanian et al., 2006; Mohamed, 2009 and Soudani et al. 2010). Cr (VI) strongly bound with sulfhydryl group of protein and readily intrudes in fish gills, liver, kidney and gonads with acute necrosis and severe apoptosis (Sridevi and Reddy, 2000; Riba et al., 2004; Ahmed et al., 2006; Ashish et al., 2008; Vinodhini and Narayanan, 2009; Mohanta et al., 2010 and Sahasheen and Akhtar, 2011).
The liver is a detoxification organ and essential for both the metabolism and excretion. Exposure to toxicants may cause histological changes in the liver, which in turn could be used as a biomarker to indicate prior exposure (Hinton and Lauren, 1990; Brusle and Gonzalez I Anadon, 1996). Few authors reviewed the effect of metals in various fish; Clarias gariepinus to lead (Oloja et al., 2005); Oreochromis niloticus to copper (Figueiredo-Fernandes et al., 2007); Cirrhinus mrigala to fenvalerate (Velmurugan et al., 2007); Channa punctatus to chromium (Mishra and Mohanty, 2008) and Oreochromis niloticus to Cu, Hg, Cd, Pb (Kaoud and El-Dahshan, 2010).

Gills are one of the first tissues which come into direct contact with external medium and changes in the fish gill are among the most commonly recognized responses to environmental pollutants (Au, 2004; Rao et al., 2006). Changes in the fish gill are the most commonly recognized responses to environmental pollutants (Mallatt 1985; Perry and Laurent, 1991; Au, 2004). Gills are the principle site for concentrating trace metals and it has different binding affinity for metals (Yilmaz et al., 2010; Noor et al., 2011). Gill tissues participate in many important functions in the fish, remain in close contact with the external environment and particularly sensitive to changes in the quality of water are considered the primary target of the contaminants (Fernandes and Mazon, 2003; Camargo and Martinez, 2007). Several reports were available on the alterations of histomorphology of gill tissues in various fish; Salmo gairdneri to chromium (Strick et al. 1975); Salmo gairdneri to chromium (Putte et al., 1981 b); Colisa fasciatus to chromium (Nath et al., 1997); Prochilodus scrofa to copper (Mazon et al., 2002); Clarias gariepinus to lead (Olojo et al., 2005); Gumbussia affinis to chromium (Begum et al., 2006); Oreochromis niloticus to copper (Figueiredo-Fernandes et al., 2007); Oreochromis sp. to chromium (Abbas and Ali, 2007); Oreochromis niloticus to nickel ( Al-Attar, 2007); Clarias gariepinus to glyphosate (Ayoola, 2008) and Cyprinus carpio to Cr, Ni, Pb (Vinodhini and Narayanan, 2009).

Kidney generally removes much of absorbed metal ions. However the absorbed metal ions in circulation probably was in much greater amount which may be due to the structural damage of the gills caused a dose as well as duration dependent destructions in kidney. The exposure of fish to toxic agents induces
histological alterations in several components of the trunk kidney (Kendall, 1975; Kirubagaran and Joy, 1988; Oritz et al., 2003; Velmurugan et al., 2007; Mohanta et al., 2010). Number of literatures are available on the histopathology of kidney to various pollutants; Cyprinus carpio to pesticides (Csepai, 1978); Notopterus notopterus to phenolic compounds (Gupta and Dalela, 1987); Cyprinus carpio to nitrite (Iqbal et al., 2004); Channa punctatus to chromium (Mishra and Mohanty, 2008); Cirrhinus mrigala to metals (Palaniappan and Karthikeyan, 2009); Oreochromis mossambicus to chromium (Elango et al., 2011) and Cyprinus carpio to chromium (Shaheen and Akhtar, 2011).