DISSCUSION

DISCUSSION

The discharge of industrial effluents through run off from the drainages into ponds, lakes and rivers are causing damage to our aquatic habitats due to variety of hazardous chemicals involved in the industrial processes. Considering the impact of these effluents on aquatic fauna, particularly fishes, effluents from textile mill, electroplating and tannery industries were collected and analysed for physico-chemical parameters. Aquatic animals are in constant danger of being exposed to several pollutants, as well as drastic changes occuring in the quality of water (Doudoroff and Katz, 1953).

The atmospheric temperature generally varies, between 10^0C to 35^0C in a year. In present study, the temperature of the effluents ranged from 23^0 to 36^0C, the average temperature for textile mill effluent was 29.9^0C, for electroplating effluent it was 25.9^0C and for tannery effluent 28.06^0C. The maximum temperature for all the three effluents was recorded in the month of September. There is relationship between temperature of water and chemicals present in the effluents chemicals exert their antagonistic influence on the feeding rates of fish at high temperature, by acting as enzymatic or metabolic depressors, that are responsible for suppression of feeding rate of fish (Sarkar, 1997). The toxicity of the toxicant increases along with the increased temperature (Chauhan and

Saxena, 1992; Sarkar, 1995). The effluents with high temperature may cause thermal pollution in the receiving water body.

The colour of the industrial effluents depends on various dyes, used for different processes in textile mill and tannery effluents. In electroplating effluents the colour is imparted due to different colours of metal salts. The colour of effluent may also be imparted due to various colour marks used to distinguish different lots of yarn and both, synthetic as well as natural colours are easily dispersed in water (Trotman and Trotman, 1984 and Crook, 1964). The colours of the effluents under study differed from effluent to effluent.

Turbidity in natural waters is caused by suspended matter like clay, silt organic matter, phytoplankton and other microscopic organisms. Turbidity because of suspended particles from the industrial effluent restricts the light penetration. The range of the turbidity of the textile mill, electroplating and tannery effluents was from 2 to 960 NTU. The average turbidity was 10.9, 44.43 and 275.1 NTU for textile mill, electroplating and tannery effluents respectively. It was observed that, the tannery effluent was more turbid than textile mill and electroplating effluent. The turbidity s maximum in tannery effluent because of the chemicals and dyes used (Khanna, 1991). Highly turbid water with chemicals may interfere in the respiratory disfunction. It may interfere the transparency of the receiving water body (Mishra and Saksena, 1989).

Total solids are found in the form of salts dissolved in water. The common salts are carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates of calcium, magnesium, sodium, potassium, iron and manganese etc. Govindan and Sundaralingam (1979) found that, composite waste water from a typical textile mill contain total solids, suspended solids and dissolved solids upto 7238.0 mg/l, 165.0 mg/l and 7073.0 mg/l respectively. While, Badrinath et.al. (1983) determined the parameter as 2042.0 mg/l, 1416.0 mg/l and 626.0 mg/l respectively in composite coloured wastewater from a textile mill. Verma, et.al. (1984) found 6160.0 mg/l, 3960.0 mg/l and 1990.0 g/l as mean total solids, suspended solids and dissolved solids respectively in the effluents from Modi industrial complex, Modinagar. Madhav-Nagar Cotton Mills, Sangli had total solids, dissolved solid and suspended solids as 4629.6 mg/l, 4477.0 mg/l and 593.0 mg/l respectively in its mixed effluents (Trivedy, et.al. 1986).

Total solids in textile mill effluent in present study approximately coincides with those found by Badrinath, et.al. (1983). They may be in the form of cotton and synthetic fibres. the values for total solids in other two effluents are higher and exceeds ICMR standard values of 500 mg/l. Total solids were maximum in tannery effluents due to presence of scrapped, body muscles underlying the raw skin, which are removed during beam house processing. They were minimum in electroplating effluents because, the jobs to be plated are just washed under tap water. Mishra and Saksena (1989) pointed out that total solids when present in excess create disturbance in aquatic life by causing osmotic imbalance and suffocation even in the presence of high dissolved oxygen and may prove deleterious.

pH-hydrogen ion concentration is expressed as negative logarithm of hydrogen ion concentration. pH 7 indicates neutral water, pH 7-14 is alkaline and pH below 7 is acidic. The pH of natural waters varies at around 7 generally over 7 (i.e. alkaline). High pH is unfavourable to aquatic organism (Das, 1978). Munshi and Singh (1980) reported effect of low pH on the gills of *Channa punctatus* suggesting that, low pH medium interfere in gaseous exchange, structure of gill and its respiratory function. Peterson, et.al. (1980) reported that, there was inhibition in hatching of the eggs of Atlantic Salmon, *Salmo salar* at low pH (4.0 - 5.5), hatching subsequently could be induced by returning eggs to normal pH levels (6.6 – 6.8). The observed effects on hatching were probably due to inhibition of hatching enzyme, chorionase.

The pH of the effluents under study ranged between 3-10.1. The average pH was 8.5, 4.3 and 8.7 for textile mill, electroplating and tannery effluents respectively. The textile mill effluent and tannery effluent are alkaline with high pH, while that of electroplating effluent is acidic with low pH. Low pH of electroplating effluent is due to the washing of jobs in baths, containing metal salts and acids directly under tap water. The pH values are similar to those reported by Mishra and Saksena (1989) and Pandey, et.al. (1993). The range of pH observed in the wastewaters under present study may be harmless and is suitable for the growth of biota except electroplating wastewater. Toxicity of heavy metals like Al, Cd and Fe on hatching of eggs and survival of larvae of the Zebra fish *Brachydonio revio*, was studied at different pH (4-9) by Dave and Goran (1985) and found that, aluminium and cadmium were more toxic at high pH level, while iron was more toxic at low pH. The hatching was stimulated when pH was lowered from 7 to 6 but further lowering of pH retarded hatching.

Dissolved oxygen (D.O.) is very important parameter to assess the water quality and is an index of physical and biological processes going on in water. The source of oxygen in water is mainly by two ways, either from air or from photosynthetic activities.

In present study, the dissolved oxygen for textile mill effluent fluctuated between 1.62 – 4.86 mg/l with an average of 3.10 mg/l, for electroplating effluent between 3.1 – 5.1 mg/l with an average of 4.3 mg/l and for tannery effluent it ranged between 0.810 to 5.10 mg/l with an average of 3.33 mg/l. Comparatively, the average dissolved oxygen level in textile mill and tannery effluent was low, this may be due to rise in temperature during the process. The minimum dissolved oxygen was 1.62 and 0.810 mg/l for textile mill and tannery effluents respectively, in the month of May and April, as the temperature of textile mill was 27.8^{0}C in May and 29.3^{0}C of tannery effluent in April. The maximum dissolved oxygen in electroplating was 5.1 mg/l in the month of December and May, while it was minimum in July and August. Comparatively high dissolved oxygen was observed in the electroplating effluent because of the chemical reaction, which may release nascent oxygen or may be because of the jobs to be plated are directly washed under tap water. Maximum D.O. in effluent was observed in the winter season due to low temperature.

The dissolved oxygen in industrial effluent remains too less (Kumar, et.al. 1974); Ramaswamy et.al. 1982; and Trivedy et.al., 1986). Many substances are more toxic when dissolved oxygen of the water is reduced (Carins et.al. 1975). Mishra and Saksena (1989) noticed that, the dissolved oxygen from textile mill effluent was 1-0-4.0 mg/l, which was low. Similar observations were recorded by Subramanian, et.al, 1988; Pandey, et.al., 1993; Chauhan, et.al., 1993, Jesudass and Akila, 1995 and Thorat and Wagh, 1998). Dissolved oxygen and organic matter have shown a negative relationship which might be due to the utilisation of oxygen for oxidation of organic matter (Paka and Rao, 1997). The release of biodegradable pollutants from domestic and industrial sources stimulate the growth of micro-organisms which consumes the dissolved oxygen of water (Bath and Kaur, 1999).

The values of the dissolved oxygen in the effluents under present study are in good agreement with the values recorded by above workers.

Carbondioxide accumulates in the water due to microbial activity and respiration of organisms. The free carbondioxide in the effluents under present study ranged from 1.76 to 20.24 mg/l. The concentration of free CO_2 was maximum in tannery effluent (20.24 mg/l) followed by electroplating effluent (17.8 mg/l) and textile mill effluent (9.02 mg/l). The average values for tannery effluent for electroplating effluent and for textile mill effluent was 10.97 mg/l, 6.70 mg/l and 3.87 3.87 mg/l respectively. It was noticed that free carbondioxide in effluent may be present or absent (Ramaswamy, et.al., 1982 and Trivedy, et.al., 1986). Considering this observation of above workers, in present study also free carbondioxide was absent in textile mill effluent in September, October and December. Free carbondioxide in the industrial effluent (textile mill) at Birla Nagar, Gwalior ranged from 1.7 – 5.4 mg/l with an average of 2.99 mg/l, with highest values in the month of September and December 1986 (Mishra and Saksena, 1989). Comparatively the values for CO_2 in textile mill effluent under present study are low rather than the electroplating and tannery effluents. This finding is similar to that of Mishra and Saksena

(1989). The CO_2 content in the water of power channel lake, which receives water after passage through turbines from the power house within Burla (Orissa) municipality, ranged between 8.5 to 16 mg/l. This power channel receives municipal waste. The values are high due to passage of water through the turbines and high turbulence in the power channel whereby more gases are dissolved. Carbondioxide gas dissolves more than on account of its higher solubility (Pramod, et.al. 1989). Thus the CO_2 of the tannery effluent under present study is high, may be due to pickling and chrome tanning process, in which the leather is soaked in chromium sulphate and rotated in the drum for 6 hrs. According to Kumar and Sharma (1999) maximum CO_2 in river Sengar (Etawah, U.P.) was due to influx of industrial and agricultural waste.

Hardness of water is due to major cations of calcium and magnesium. The anions responsible for hardness are bicarbonates, carbonates, sulphates and chlorides. Hardness of water prevents lather formation with soap therefore, hardwater is not suitable for bathing and washing. The hardness of the effluents under study ranged between 72-580 mg/l. The average values of hardness was 217 mg/l for textile mill effluent, 341.91 mg/l for electroplating effluent and 310.66 mg/l for tannery effluent. The maximum hardness for electroplating effluent (580 mg/l) and for tannery effluent (534 mg/l) was recorded in February. Mishra and Saksena (1989) recorded the range of hardness of industrial effluent at Birla

Nagar (Gwalior) to be 28.5 – 1158 mg/l, Pandey, et.al. (1993) recorded the hardness between 250-335 mg/l of Hussain Sagar, an industrially polluted lake (Hyderabad).

In present study, the average values of hardness for electroplating and tannery effluent exceeds that of ICMR standard (300.0 mg/l).

Toxicity of the pollutant depends on the hardness of the water medium. Hardness interferes with the toxicity under the influence of pH and temperature (Mount, 1966, Waiwood and Beamish, 1978). Miller and Mackay (1980) recorded the hardness, alkalinity and pH of test water, plays significant role in the toxicity of copper to rainbow trout *Salmo gairdneri*. At low water hardness incipient lethal concentration (ILC) of Cu was not affected. The ILC for copper increased as hardness increased regardless of alkalinity. Bradley and Sprague (1985) reported that the intrinsic toxicity was similar in rainbow trout. *Salmo gairdneri*, that were exposed to zinc in acid or neutral water (pH 5.5 or 7.0) and in hard or soft water (total hardness 390 or 30 mg/l). Kallanagaudar and Patil (1997) reported the influence of water hardness on copper, zinc and nickel toxicity to *Gambasia affinis*. The result shows that copper was found to be more toxic to male, female and fries than nickel and zinc in all the hardness of water. The males were slightly more tolerant than female, and fries were highly sensitive to all the metals. Toxicity of the metals was reduced with increase in the hardness.

As the hardness of the effluents under study exceeds the ICMR standard, the heavy metals present in the effluents, may cause damage to the aquatic organism.

Chlorides in natural waters are very low in concentration. High concentration of chlorides are considered to be an indicator of pollution due to organic water. Industrial effluents may increase the chloride content in natural waters through runoffs. Mishra and Saksena (1989) reported that, the chlorides ranged between 539 to 102.2 mg/l in industrial effluent of Birlanagar (Gwalior), Pandey, et.al. (1993) recorded the chloride range between 231-338 mg/l. in industrially polluted Hussain Sagar lake (Hyderabad).

In present study, the chloride content ranged from 90.88-362, 34.08 – 1775.0 and 176.08 – 3380.6 mg/l for textile mill, electroplating and tannery effluents respectively. The average values were 168.66, 320.70 and 992.21 mg/l for these effluents respectively. Chlorides in textile mill effluent found to vary from 128.0 to 960 mg/l. (Govindan and Sundarlingam, 1979, Verma et.al. 1984). The chloride content of Buddha-Nallah (Ludhiana, Punjab), industrially polluted area ranged between 300-1220 mg/l (Bath and Kaur, 1999). In present study, the average values of chloride for electroplating and tannery effluents exceeds the ICMR standard of 250 mg/l. This may be because of different salts used during processing. Similar results were obtained by Chauhan, et.al. (1993) and Thorat and Wagh (1998) in tannery effluents.

A number of bases such as carbonates, bicarbonates, hydroxides, phosphates, nitrates, silicates, borates etc. contribute to the alkalinity. In natural waters alkalinity is caused due to CO_2. Alkalinity of water is its capacity to neutralize a strong acid and is characterised by the presence of hydroxyl (OH^-) ions capable of combining with (H^+) ions.

Total alkalinity of the effluents under present study ranges from 80.0 to 905 mg/l. The average values were 446.62, 166.58 and 215.8 mg/l for textile mill, electroplating and tannery effluents respectively. The values of alkalinity for these effluents exceeds ICMR standard (120.0 mg/l) which correlates with the findings of Mishra and Saksena (1989); Pandey, et.al. (1993) and Jesudass and Akila (1995).

Alkalinity plays an important role in toxicity of the pollutant Miller and Mackay (1980) reported the effect of hardness, alkalinity and pH of test water on toxicity of copper to rainbow trout (*Salmo gairdneri*) and stated that, incipient lethal concentration increased due to increase in alkalinity. Bhaskar and Govindappa (1986) reported that, the white muscle showed depleted glycogen content with increased glycolysis in an alkaline medium. This leads to one adaptive compensatory mechanism providing increased resistance capacity to the fish, *Tilapia mossambica* during acclimation. Thus the effluents under study when entered into the water bodies may affect the water quality and the aquatic organisms.

Acidity of the water is its qualitative capacity to neutralize a strong base. It is the capacity of a liquid to donate H^+ ions. Mineral oxides, weak and strong acids from the industrial wastewater contribute to acidity of water bodies, there was direct impact of environmental acidification on a rainbow trout (*Salmo gairdneri*) (Neville, 1979). Bhaskar and Govindappa (1986) reported that, white muscles showed an elevated glycogen content with suppressed glycolysis on acclimation of *Tilapia mossambica* to more acidic water. Vijayalakshmi et.al. (1990) acclimated the fish. *Cyprinus carpio* to sub lethal acidic medium and non acclimated fish were exposed to lethal acidic medium (pH 4.5). The non acclimated group recorded mortality while, acclimated group had no mortality. The muscles of acclimated group of fish developed alkali reserves for effective neutralisation of acidity, which might have provided survival in environmental acidification. Toxicity of heavy metals is influenced by acidity of the medium. Abbasi, et.al. (1995) exposed the teleost *Nuria denricus* to different levels of chromium and pH. It was recorded that chromium was found to be more toxic at pH, 3, 5 and 11 compared to 7 and 9.

Acidity of the effluents under present study varied between 90-737.2 mg/l. The average values were 149.79, 356.80 and 205.41 mg/l for textile mill, electroplating and tannery effluents. The acidity of the electroplating effluent was maximum due to the use of strong acids in the processing.

Inorganic phosphorus is one of the most important nutrients, limiting growth of autotroph and thus biological productivity of the system. The enrichment of phosphorous lead to the process of eutrophication. Domestic sewage, industrial effluents, detergents are main sources of phosphates in water. The values of phosphate for textile mill effluent ranged from 1.28 to 23.0 mg/l (Verma, et.al. 1984, Ajmal, et.al. 1985 and Trivedy, et.al. 1986).

In present study, the phosphate content ranged between 0.044 to 1.136 mg/l for all the three effluents. The average values were 0.319, 0.337 and 0.202 for textile mill, electroplating and tannery effluents respectively. The phosphate content in these effluents exceeds the ICMR standard. These effluents after reaching the receiving water body may lead to significant undesirable growth of the plankton's and other weed species leading to organic pollution of the water body.

Nitrates are the highest oxidised form of nitrogen and in water its important source is biological oxidation of nitrogenous organic matter. Metabolic waste of aquatic community and dead organism add the autochthonous nitrogenous organic matter while domestic sewage, industrial wastewater and agricultural runoff are chief sources of allochthonous nitrogenous organic matter. The high concentration of nitrate in water is indication of pollution.

Mishra and Saxena (1989) reported the nitrate content in textile mill effluent ranged between 0.001- 0.056 mg/l. Janiyani, et.al. (1993) reported low nitrate content in oil sludges from various sources of refinery. Nitrate content of the Sagar factory effluent showed marked difference in treated and untreated effluent (Jesudass, et.al. 1995). Bath and Kaur (1999) reported that nitrates content ranged between 3.0 – 15.0 mg/l in the water sample collected from industrially polluted, Buddha-Nallah (Ludhiana, Punjab).

In present study, the nitrate content for all the three effluents ranged between 0.213 to 3.332 mg/l. The average values were 1.222, 1.250 and 1.204 mg/l for textile mill, electroplating and tannery effluents respectively. These values are well within the ICMR limits (20.0 mg/l) as far as water pollution is concerned. The values of nitrate contents of the effluents under study are higher than those found by Mishra and Saxena (1989) and lower than those found by Bath and Kaur (1999).

The benefits of industrialisation are shared by a few, but the impact of environmental pollution is inevitably thrust on the populace of the region. The presence of many metals at the trace or ultratrace levels in the human environment has received increased global attention (WHO, 1977, IRPTC, 1984). Higher concentration of Cd, Cu, Hg, Zn and Pb might kill organism or cause other adverse effect that change the aquatic community structure (Martin and Holdrich, 1986). Salts of Ni and Co have been shown to have carcinogenic potential (Ray, 1986). Pb contamination in soil has been identified as a contributing environmental source of childhood lead poisoning (CDC 1982). Cd is a non essential heavy metal inhibiting numerous enzymes with functional sulfhydryl groups (Valle and Ulmer, 1972) and produces congenital malformation, developmental retardation and death in amphibians (Perez, et.al. 1986).

Dharwadkar and Deshpande (1990) have detected heavy metals such as Zn, Cd, Hg, Pb, Fe, Al and Cu from industrial and domestic sewage sludge and reported higher values of Zn and Pb than permissible limits for human consumption. Suresh and Wanganeo (1996) detected the heavy metals such as Cd, Cu, Cr, Fe, Ni, Pb, Mn, Mu, Zn etc. from municipal sewage sludge. The values were 9.20, 339.13, 59.27, 32300.00, 28.35, 92.97, 99.10, 23.80, 488.78 ppm respectively. Zn is present in higher amount compared to Cu, Pb, Cr and Ni. Presence of Zn, Cu and Ni to some extent have been considered to be toxic either singly or more likely in combination.

Shrivastava (1996) detected the heavy metals from industrial wastewater on sludge from Dandesara, GIDC area of Surat (Gujarat). The concentration of heavy metals like Cu, Cd, Ni, Pb, Zn, Hg, Fe was determined and few metal ions level was found beyond the ISI permissible limits.

In present study the heavy metals like Cu, Ni, Cd, Zn, lead Cr and Al were detected from the textile mill, electroplating and tannery effluents. The average values for copper nickel, zinc and alluminium were 0.028, 0.273, 0.075 and 0.034 mg/l respectively in textile mill effluent. Comparatively concentration of Ni was more, while Cd, Pb and Cr was absent. In electroplating effluent the average values were 2.892, 0.069, 2.687, 0.075, 0.067, 234.95 and 2.122 mg/l for Cu, Ni, Cd, Zn, Pb, Cr and Al respectively. The concentration of Cr was high because of more demand for chromium plating. In tannery effluent the average concentration values were 1.737, 3.048, 1.730, 2.200, 0.055, 5.912 and 0.243 ppm for Cu, Ni, Cd, Zn, Pb, Cr and Al respectively. The concentration of Cr seems to be high as compared to other metals because the salt, chromium sulphate used during chrome tanning process in tannery.

Acute toxicity test of industrial effluents have been conducted in India and abroad by many workers on variety of non target organisms. Subramanian and Varadraj (1993) reported that, freshwater prawn, *Macrobrachium idella* when exposed to sub lethal concentrations of tannery effluent for 15 days, there was significant reduction in the biochemical constituents of the haemolymph. There was progressive decline starting from protein, free amino acids and free sugars. It was evident that decrease in the biochemical constituents of the haemolymph was more as the concentration of the effluent increased. Viswaranjan and Muthukishnana (1982) reported the toxicity of tannery effluent to the mosquito *Culex pipiens quinquefasciatus*. Fraser and Clark

(1984) reported that hatching success of washed embryos was similar in all concentrations of the effluent but unwashed embryos were significantly affected by the effluent treatment because of spnaerolitus growth. Nikam (1986) reported the toxicity of distillery effluent (spent wash) on two freshwater fishes *Tilapia mossambica* and *Rasbora daniconius*.

Tana and Nikunen (1986) exposed rainbow trout to pulp and paper mill effluent at different concentrations for 10 days in cages to determine haematological parameters. Changes were detected even at the caging site, 8 Km from the discharge. They observed decrease in the plasma Mg^{++} and increase in the plasma K^+ concentration. Dutta and Zutshi (1988) observed the effect of sewage effluent on the eggs of *Cyprinus carpio* (Linn.) and reported the effect on incubation time, hatching, mortality and abnormality of hatching. Patra, et.al. (1990) exposed spawn of *Labeo rohita* to 10%, 25% and 50% of paper mill effluent and it was observed that exposure to low concentration of effluents has reduced the time of hatching by 200 to 300 minutes and the rate of hatching upto 90%, whereas the mortality rate of hatching was 80%. Toxic heavy metals in industrial effluent discharge to Thane Creek being resistant to biodegradation get accumulated in the water and sediments this affects the water quality and aquatic life (Mahapatra, 1987). Haniffa and Selvan (1991) performed the acute toxicity of bleaching, dyeing and mixed textile mill effluent to fresh water fish

Cyprinus carpio and showed that the dyeing effluent was found to be more toxic than bleaching effluent. The 96h LC_{50} values were 5.19% for dyeing 5.19% for mixed, and 6.12% for bleaching effluents. Ghosh and Konar (1992) reported that the growth and fecundity of fish was greatly reduced due to effect of sugar mill complex effluent treatment to fish. Varadraj, et.al. (1994) reported that 96 h LC_{50} value of tannery effluent for fresh water snail *Pila globossa* was 70%.

Singh, et.al. (1996) reported that the wastewater of electroplating industry contain Ni and Cr (III and VI), of these Cr (VI) wass more toxic. When Zebra fish, *Brachydanio rerio* was exposed, it was unable to survive in 10% concentration of the effluents. When fish *Cyprinus carpio* was exposed to dairy effluents no mortality was observed at 10% within 96h, 100% mortality was observed in 35% concentration and 25% concentration was found to be median lethal concentration at 96 h (Amudha and Mahalingam, 1996).

Thus, from the acute toxicity studies it was observed that, the LC_0 and LC_{50} concentrations for tannery effluent were 15% and 20%, for electroplating effluent they were 3% and 6% and for textile mill effluent they were 18% and 20% respectively. It was observed that, the sublethal and lethal concentrations of the effluents varied from effluent to effluent, may be because of different chemicals used in the process, raw materials and volume of water utilised during the processing. The sublethal and lethal concentration obtained by many workers for the same effluents also differed, may be because of the different organism exposed to toxicants and different methods used in processing units. In present study the electroplating effluent seems to be more toxic due to use of more strong acid during the process, such as surface cleaning, pickling or stripping and plating. Tannery and textile mill effluents have near about similar range of toxicity, may be because of the use of less acids and more alkaline salts during the processing, as the pH of these effluents ranged between 8.1 to 10.1 and 8.5 to 9.6 respectively. The pH of the electroplating effluent ranged between 3 to 5.6 which is beyond the tolerance limits of the aquatic fauna in general and fish species in particular.

Behaviour is usually a very complicated phenomenon through which the animal is capable of adjusting its various functions to a constant or changing environment. If normal behaviour is known, then changes in behaviour can be effectively used to identify change in the environment. Behavioural studies have been carried out by number of workers, as this is the easiest method to identify presence of abnormal constituents, of effluents, pesticides, agriculture runoff etc. without sacrificing the fish. Many workers have reported abnormal behavioural pattern of variety of fishes exposed to different chemicals, effluents, influenced by physico-chemical parameter.

Alis and Shamsi (1988) reported the behaviour responses imputed by contamination of water with zinc sulphate and mercuric chloride and observed that, fish showed loss of balance, tilting of body dorsoventrally, wagging of caudal fins, jerky movements and aggressiveness. Joseph (1992) worked on the behavioural alterations induced by nickel and chromium on common carp, *Cyprinus carpio* and observed loss of equilibrium, loss of schooling behaviour, increased cough rate, spasm, curvature of spine, darkened area on skin and increased mucous secretion. Eggs, fry and fingerlings of *Catla catla* and *Labeo rohita* when exposed to nitrogen and phosphorus fertilizers at variable temperature, showed erratic motion, jumping out of test solution, abnormal movements, opening and closing of mouth, sluggishness, top swimming, bottom swimming, side-lying and mortality at different temperature at the end of 96 h (Sarkar, 1995). Amudha et.al. (1997) studied the behaviour of *Cyprinus carpio* exposed to various concentrations of dairy effluent (5% - 50%) and observed surfacing activity and opercular beating as indicators of stress. Both these activities registered notable increase under stress condition. Beyond a concentration of 35% effluent, the opercular beating was very high and erratic. Similarly surfacing activity increased with the increase in concentration of the effluent upto 25% and decreased thereafter.

In present study, abnormal behavioural changes were observed in lethal as well as sublethal concentration of the three effluents as compared to control. The changes at sublethal concentration were backward movements, tendency to escape from the container by jumping, sudden forward rushes, chasing other fish, loss of balance etc. In the later stages, increased opercular movements, increased defecation and surfacing to gulp air was noticed. In lethal groups, along with the above mentioned behavioural abnormalities mortality was observed. Prior to death, fishes showed loss of balance, erratic swimming, loss of escape response, swimming belly upward, stricking the containers, erratic movements of eyeball, wide opening of mouth, stiffening of caudal end, discolouration and excess secretion of mucus. These changes in the behaviour might be due to combination of disturbances in physiological, biochemical, enzymological and hormonal aspects in fishes.

Biochemical constituents such as glycogen, protein and lipids act as source of energy in fish. Many workers have reported changes in these, due to industrial effluent stress. These changes in biochemical constituents do not follow a definite pattern and vary according to utilization for counteracting the toxic stress.

Glycogen is the prime source of energy and changes in glycogen content was observed by many workers. Shaffi (1980) reported depletion in the glycogen level in muscle followed by liver, kidney and brain of nine fish species when exposed to industrial effluent. Decrease in glycogen content in liver and muscles of *Channa punctatus* exposed to mercury was observed by Sharma (1984). Bhaskar and Govindappa (1985) reported that in acidic media the glycogenolysis was elevated in the tissue and glycolysis was suppressed. In contrast, in alkaline medium the tissue glycolytic pathway was accelerated with accumulation of organic acids. Adams (1985) reported significant changes in glycogen in *Salmo gairdneri* to varying duration of acidification stress. Bengeri and Patil (1986) reported that, the amount of liver glycogen was reduced as the concentration of Zn increased. Kumar, et.al. (1986) observed that, there was decrease in glycogen content in *Cyprinus carpio* exposed to dinitrobenzen plant effluent. Muscle glycogen in a fish *Sarotherodon mossambicus* was found to be depleted which was dose dependent, but that was not the case with liver glycogen when the fish was exposed to tannery effluent (Natrajan, 1989). There was decrease in liver and muscle glycogen in *Labeo rohita* exposed to lethal and sublethal concentrations of copper (Radhakrishnaiah, et.al. (1992). Rajan (1990) observed depletion in carbohydrate content in muscle, liver and intestine of *Cyprinus carpio* exposed to sublethal concentration of textile mill effluent. Somnath (1991) reported decrease in carbohydrates of different tissues except gill of *Labeo rohita* when exposed to tannic acid. Jha (1999) observed depletion in total carbohydrate and protein content in intestine, liver, testis and ovary of *Clarias batrachus* (Linn.) when exposed to the household detergents like surf and key.

In present study, there was depletion in glycogen in lethal and sublethal concentration of tannery, electroplating and textile mill effluents. The finding can be correlated with the similar effects due to different effluents by Balaji and Chokalingam (1989), Amudha and Mahalingam (1999), Maruthi and Rao (2000). This decrease in tissue glycogen may be due to increased glycolysis for production of energy to overcome toxic effect of the effluents. Decrease in glycogenesis has also been suggested by Shaffi (1994) to explain depletion in glycogen. Similar depletion in glycogen content in this study may be attributed to its utilization to meet the high demand created by stress of the effluents. This could have happened by rapid glycogenolysis and inhibition of glycogenesis through activation of glycogen phosphorylase and depression of glycogen transferase (Jha and Pandey, 1989; Jha and Jha,1995 a and b).

Proteins are important constituents which have structural as well as functional importance. Protein plays vital role in spawning, movements and other metabolic activities. Alteration in protein contents have been reported by many workers. Tort, et.al. (1984) reported that, the levels of all the metabolites in the gill tissue of dog fish *Scyliorchinus canicula* varied, only protein content was significantly lowered after subacute treatment of zinc. Tort, et.al. (1987) observed that protein, glycogen and lipid levels in liver of dog fish *Scyllorhinus canicula* was not affected by any concentration of copper. Significant differences was noticed for the mean protein content in all tissues except liver and muscle of *Cyprinus carpio* exposed to nickel. (Joseph et.al. 1992).

Increase in protein and free amino acid levels in brain, liver, muscle and gill tissues of *Sarotherodon mossambicus* was noticed by Chitra (1983) under ambient urea stress. Jana, et.al. (1986) reported increase in protein content in the liver, kidney, stomach, intestine, testis and ovary while, decrease in muscle of the freshwater fish *Clarias batrachus* L. as compared to control, when exposed to heavy metals.

In present study, there was decrease in the protein content of all organs in sublethal concentration, (LC_0) while, decrease in lethal concentration, (LC_{50}) except gill for tannery effluent. For electroplating effluent there was decrease in protein content of all organs in sublethal concentration, and in lethal concentration there was decrease in gill, liver and muscle except kidney and brain. For textile mill effluent there was decrease in protein content in gill, muscle and brain except liver and kidney in sublethal concentration and decrease in all the organs in lethal concentrations.

Significant decrease in total protein content indicates that, stress due to effluent treatment induces proteolysis. Stress have been reported to accelerate protein catabolism in man and animals (Nichol and Rosen, 1963). Protein decrease may also be due to stress and fish, is likely to undergo hydrolysis and oxidation though TCA cycle to meet the increased demand for energy caused by the stress (Somnath, 1991). Increase in liver protein may be due to increase in synthesis of detoxification enzymes as suggested by Chitra (1983). The alteration in the tissue protein, in the present study suggest disturbance in the physiological activity.

Lipids constitute a reserve depot of energy, from which the energy is taken when needed. Changes in lipid contents have been reported due to industrial effluent stress. Bhaskar, et.al. (1986) reported depletion in the level of lipid content in freshwater fish *Cyprinus carpio* when acclimated to acidic medium. Rajan (1990) reported decrease in lipid content in the tissues like muscle, liver and intestine of fish *Cyprinus carpio* when exposed to the sublethal concentration of textile mill effluent. There was significant decrease in cholesterol level in both, liver and ovary of a hill stream teleost *Garra mullya* (Skyes) exposed to sublethal concentration of cadmium (Khan, et.al. 1992). Ambrose, et.al. (1994) observed decrease in lipid content in *Cyprinus carpio* under the toxic stress of sublethal concentrations of composite tannery effluent. Jha (1999) also observed depletion in total lipid in the fish *Clarias batrachus* exposed to household detergents.

In present study, there was decrease in lipid content of all the organs in sublethal and lethal concentrations due to tannery effluents. For electroplating effluent, there was decrease in the lipid content in all the organ in sublethal concentration. In lethal concentration depletion of lipid ciontent was observed in all the organs except liver, it showed non significant increase.

The depletion in the hepatic total lipid could be due to their active mobilization towards the blood and/ or tissue metabolism (Murthy, et.al. 1994). The decrease might be due to the utilization of lipid to meet the additional energy requirement under stress (Roe and Rao, 1981; Rao et.al 1985). The toxic substances might have accumulated in the brain of fish, causing disintegration of nerve cells, clotting of blood and reduction in transport of oxygen to brain (Panigrahi and Mishra, 1980). Loss of lipids noticed in this study may be due to inhibited lipid synthesis and mobilizing the stored lipids, either through β oxidation or through a gradual unsaturation of lipid molecules as suggested by Jha (1991), Jha and Jha (1995).