SUMMARY
&
CONCLUSIONS

SUMMARY AND CONCLUSION

In the present investigation an attempt has been made to evaluate the impact of industrial effluents on economically important estuarine cat fish *Mystus gulio* (Ham.). The physico - chemical parameters of water samples viz. pH, temperature, dissolved oxygen, free carbon dioxide, salinity, nitrates and phosphates were studied along with heavy metal contents of water and sediments.

The investigation clearly indicated that the temperature of estuarine water was in the range of 26 ^{0}C to 30 ^{0}C and tended to be warmer during summer season at all the selected stations. Slight increase in the temperature at station A was due to release of heavy load of industrial effluents.

The acidic nature of waters at all the stations, particularly at station A, might be due to release of industrial effluents. In the present investigation pH values ranged from 5.15 to 7.90.

The salinity of water samples was fluctuated between 0.04 to 6.00 ppt at all stations. Elevated level of salinity during March to May might be due to high degree of evaporation of surface water, but less salinities during June to November might be due to run-off rain water from catchment area and release of huge quantity of fresh water from hydro- power projects of Pophali and Kolkewadi.

In the present study, the minimum concentration of free carbon dioxide (3.00 mg / l) was recorded at Damandevi (Station C) in the month of March 2008 and maximum (76.15 mg / l) at Kotawali (Station A) in the month of July 2008.

Maximum dissolved oxygen content of 10.72 mg / l was recorded in the month of August at Dhamandevi (Station C); while minimum of 4.48 mg / l in the month of February at Kotawali (Station A).

The phosphate content of water samples ranged from BDL (Below Detectable Level) to 12.50 mg / l at all stations. The phosphate content was maximum (12.50 mg / l) in the months of December, 2007 and September, 2008, at Kotawali (Station A).

The values of nitrates were ranged between BDL (Below Detectable Level) to 47.50 mg / l. The maximum nitrate content at Kotawali (Station A) was 47.50 mg / l in the month of June 2008; while at Station B, in the month of April, it was BDL (Below Detectable Level) and at Station C, it was BDL (Below Detectable Level) in the months of December, 2007, January, 2008, April, 2008 and May, 2008. The average nitrate content at Station A was high, which may probably be due to organic flow from industries. The values of nitrate concentration at Station C were within the permissible limit.

In the present investigations, the contents of heavy metals viz. Cu, Fe, Zn, Cd, Ni, Co and Mn of water samples were high at Kotawali (Station A) as compare to other stations. Maximum Copper content of water sample was 0.046 ppm, Iron content was 0.830 ppm, Zinc content was 0.37 ppm, Nickel content was maximum 0.40 ppm, Cobalt content was 0.14 ppm, Mn content was 40.00 ppm. Cadmium contents were BDL (Below Detectable Level), during entire study period except in the month of May, 2008 which was 0.007 ppm.

In the present investigations, the contents of heavy metals viz. Cu, Fe, Zn, Cd, Ni. Co and Mn in the sediment samples from all the stations were reported. The concentration of Ni was BDL (Below Detectable Level) at Songaon (Station B) and Dhamandevi (Station C) from April, 2008 to November, 2008.

The maximum and minimum contents of Copper (Cu) at Kotawali (Station A) were 20.93 ppm and 1.96 ppm, respectively. At Songaon (Station B) they were 5.02 ppm, and 1.10 ppm, and at Dhamandevi (Station C) 5.12 ppm and 0.32 ppm, respectively.

The maximum and minimum contents of Iron (Fe) at Kotawali (Station A) were 37.21 ppm and 4.15 ppm, respectively. At Songaon (Station B) they were 69.84 ppm and 6.82 ppm and at Dhamandevi (Station C), 70.46 ppm and 6.52 ppm, respectively.

The maximum and minimum Zinc (Zn) content from sediment samples at Kotawali (Station A) were 28.49 ppm and 12.43 ppm respectively. At Songaon (Station B) they were 25.10 ppm and BDL (Below Detectable Level) in months of May, 2008 and July, 2008. At Dhamandevi (Station C), were 0.46 ppm and BDL (Below Detectable Level) in months of December 2007, and through May, 2008 to November, 2008, respectively.

The maximum and minimum contents of Cadmium (Cd) at Kotawali (Station A) were 0.82 ppm and 0.03 ppm, respectively. At Songaon (Station B) they were 0.67 ppm and 0.02 ppm, and at Dhamandevi (Station C) 0.65 ppm and BDL (Below Detectable Level) respectively for several months.

The maximum and minimum content of Nickel (Ni) at Kotawali (Station A) were BDL (Below Detectable Level) and 0.520 ppm, at Songaon (Station B), BDL (Below Detectable Level) and 0.46 ppm and at Dhamandevi (Station C) BDL (Below Detectable Level) and 0.18 respectively. The Nickel (Ni) contents of sediments were BDL (Below Detectable Level) during the months of December, 2007, May, 2008, to July, 2008, and October, 2008, at Kotawali (Station A),during December, 2007, and May, 2008 to November, 2008, at Songaon (Station B) and during May, 2008 to November, 2008 at Dhamandevi (Station C).

The maximum and minimum contents of Cobalt (Co) at Kotawali (Station A) were 0.71 ppm and 0.004 ppm respectively, while at Songaon (Station B) they were 0.42 ppm 0.027 ppm and at Dhamandevi (Station C) 0.95 ppm and BDL (Below Detectable Level) in the months of December, 2007, September 2008, October, 2008 and November, 2008.

The maximum and minimum contents Manganese (Mn) at Kotawali (Station A) were 112.65 ppm and 12.80 ppm, respectively. At Songaon (Station B) they were 113.20 ppm and 4.48 ppm and at Dhamandevi (Station C) 53.12 ppm and 4.38 ppm, respectively.

In the present study, the test fish were chronically exposed to1/10th of LC 50 value (18 ppm) of the industrial effluents for 30 days and heavy metals such as, Cu, Fe, Zn, Cd, Ni, Co and Mn were detected from the test organs of catfish, *Mystus gulio* (Ham.).

During investigation, maximum concentration of Cu was detected in the liver (0.35 ppm), followed by the kidney (0.22 ppm), gill (0.027ppm), and minimum was detected in the muscle (0.011ppm).The bioaccumulation of Cu was below the prescribed permissible limit.

Observed Iron (Fe) content of kidney was maximum (1.12 ppm) followed by gill (0.091 ppm), muscle (0.055 ppm) and liver (0.053 ppm).

The maximum concentration of Zn was detected in kidney (1.47 ppm) followed by liver (0.25 ppm), gill (0.14 ppm) and muscle (0.06 ppm). The high level of Zn in the liver may possibly reflect storage and also due to fact that liver being the center and target for metabolism may concentrate heavy metals. In the present study, accumulation of Zn in the gill may be due to the fact that they serves as respiratory organs through which metal icns are absorbed.

The Cadmium (Cd) content was below detection level in all the organs except liver (0.002 ppm), while Nickel (Ni) content was BDL (Below Detectable Level) in all the organs.

The concentration of Cobalt (Co) was high in the muscle (0.002 ppm) and low (0.001 ppm) in gill, liver and kidney.

The Manganese (Mn) concentration was BDL (Below Detectable Level) in all the organs of fish.

The concentrations of all the heavy metals were more in liver followed by kidney, gill and muscle. Liver, known to have high metabolic activities, has boon widely recognized as valuable indicator of pollution.

The study indicated that, the concentration of Cu, Fe, Zn, Cd, Ni, Co and Mn were within the permissible limits laid down by international standards.

In the present investigation, test fish were chronically exposed to $1/10^{th}$ (18 ppm) and $1/20^{th}$ (9 ppm) of LC_{50} of industrial effluent for 30 days and alterations in glycogen, protein and lipid contents of various organs were, observed in catfish *Mystus gulio* (Ham.).

For control group the glycogen content was recorded in the order of order of liver (7.69 mg ± 0.41/ 100 mg) > muscle (6.98 mg ± 0.30/ 100 mg) > gill (4.58 mg ± 0.39/ 100 mg) and kidney (4.54 ± 0.86/ 100 mg / 100 mg) wet tissue.

Under the toxic influence of industrial effluent at $1/10^{th}$ of LC_{50}, the glycogen was significantly decreased in all the organs. The maximum depletion of (69.22 %) was recorded in the gill (1.41 ± 0.18 mg / 100 mg, $P < 0.01$), followed by liver (55.66 %) (3.41 ± 0.25 mg / 100 mg, $P < 0.01$), muscle (52.15 %) (3.34 ± 0.48 mg / 100mg, $P < 0.01$) and kidrey (39.21 %) (2.76 ± 0.27 mg / 100 mg, $P < 0.01$).

The glycogen content also decreased significantly at the$1/20^{th}$ of LC_{50} in the different body organs. The maximum depletion of (52.50 %) in glycogen content was recorded from gill (2.13 ± 0.11 mg / 100 mg, $P < 0.01$); followed by muscle (42.13 %)

(4.04 ± 0.91 mg / 100 mg, $P < 0.01$); liver (34.34 %) (5.05 ± 0.49 mg / 100 mg, $P < 0.001$), and kidney (33.04 %) (3.04 ± 0.07 mg / 100 mg, $P < 0.01$). Decline in the glycogen contents of test organs of fish might be due to its use as the principal and immediate energy precursor in fish under stress condition.

For control group the protein content was recorded in the order of muscle (26.98 ± 0.47 mg / 100 mg) > liver (15.06 ± 0.13 mg / 100 mg) > kidney (12.35 ± 0.32 mg / 100 mg) > gill (10.50 ± 0.51 mg / 100 mg) wet tissue.

The protein content was decreased significantly in all the selected tissues of the test fishes exposed to the 1/10th of LC_{50} of the industrial effluent. The maximum depletion of (77.43 %) in protein content was recorded in the liver (3.40 ± 0.29 mg / 100 mg, $P < 0.001$); followed by kidney (58.78 %) (5.10 ± 0.36 mg / 100 mg, $P < 0.001$); muscle (50.26 %) (13.42 ± 0.54 mg / 100 mg, $P < 0.001$); and gill (15.53 %) (8.87 ± 0.26 mg / 100 mg, $P < 0.01$).

Significant decline in the protein content of selected tissues of the experimental fishes were recorded after their exposure to 1/20th of LC_{50} concentration of industrial effluent. The maximum depletion of protein content was recorded in the liver (63.74 %) (5.46 ± 0.59 mg / 100 mg, $P < 0.001$); followed by muscle (40.06 %) (16.17 = 0.32 mg / 100 mg, $P < 0.001$); kidney (38.73 %) (7.58 ± 0.13 mg / 100 mg, $P < 0.001$); and gill (9.53 %) (9.50 ± 0.11 mg / 100 mg, $P < 0.05$).

For the control group, maximum lipid content was recorded in the liver (16.59± 0.53 mg / 100 mg); followed by gill (11.19 ± 0.33 mg / 100 mg); kidney (10.69 ± 0.67 mg / 100 mg); muscle (3.54 ± 0.30 mg / 100 mg) wet tissue..

The present study indicated that, when compared to control group the lipid content was considerably depleted in all body tissues of fishes exposed to industrial effluent at 1/10th of LC_{50} concentration. The maximum depletion of lipid content was recorded in gill (76.14 %) (2.67 ± 0.30 mg / 100 mg, $P < 0.001$); followed by liver (74.87 %) (4.17 ± 0.97 mg / 100 mg, NS); kidney 73.91 %(2.79 ± 0.80 mg / 100 mg, $P < 0.05$); and muscle (69.21 %) (1.09 ± 0.41 mg / 100 mg, NS).

The lipid content of target tissues gets influenced by toxic nature of industrial effluent at 1/20th of LC_{50} concentration. Compared to control, lipid was significantly decreased in all the organs. The maximum depletion of lipid content was recorded in gill of (62.02 %) (4.25 ± 0.25 mg / 100 mg, $P < 0.001$); followed by liver (61.67 %) (6.36 ± 1.17 mg / 100 mg, $P < 0.01$); kidney (51.74 %) (5.16 ± 0.74 mg / 100 mg, $P < 0.01$); and muscle (44.64 %) (1.93 ± 0.21 mg / 100 mg, $P < 0.01$).

Conclusion:

The present study showed that:

1. Heavy metal content from sediment was more than that of water from the selected study area.
2. The industrial effluent affects aquatic biota.
3. The bioaccumulation of heavy metals was seen in various body tissues of catfish, *Mystus gulio* exposed to industrial effluent.
4. The biochemical component showed significant decrease from various tissues of *Mystus gulio* exposed to industrial effluent.