RESULTS

PHYSICO-CHEMICAL PARAMETERS OF WATER

Temperature (ºC):

The three year data on temperature at four selected sites of the Satluj river is shown in the Table 1. Statistical data comprising minimum and maximum values of temperature along with mean values and standard deviation for three seasons at selected sites over a period of three year is summarized in the Table 2. Over the period of three years, water temperature ranged from 19.7 ºC to 34.9 ºC in the river water.

At site-I, temperature values ranged from 19.7 ºC to 29.5 ºC with maximum temperature recorded during summer’ 07 and minimum during winter’ 05. During winter season, mean temperature was found to be 19.8±0.115 ºC in 2005, 20.0±0.115 ºC in 2006 and 21.9±0.1 ºC in 2007. During summer season, mean temperature was found to be 28.1±0.173 ºC in 2005, 29.0±0.057 ºC in 2006 and 29.4±0.115 ºC in 2007. During post monsoon season, mean temperature was found to be 23.0±0.057 ºC in 2005, 23.7±0.173 ºC in 2006 and 24.2±0.057 ºC in 2007 (Table 1 & Figure 7). Over the period of three years, values ranged from 19.70 ºC to 21.90 ºC with mean 20.56±1.159 during winter, 28.00 ºC to 29.50 ºC with mean 28.83±0.665 during summer and 23.00 ºC to 24.30 ºC with mean 23.63±0.602 during post monsoon period (Table 2).

At site-II, temperature values ranged from 21.2 ºC to 31.7 ºC with maximum during summer’ 07 and minimum during winter’ 06. During winter, mean temperature was found to be 21.8±0.115 ºC in 2005, 21.2±0.057 ºC in 2006 and 22.9±0.115 ºC in 2007. During summer, mean temperature was found to be 30.0±0.115 ºC in 2005, 31.2±0.115 ºC in 2006 and 31.5±0.115 ºC in 2007. During post monsoon, mean
temperature was found to be 23.6±0.115 °C in 2005, 24.0±0.057 °C in 2006 and 25.5±0.230 °C in 2007 (Table 1 & Figure 7). Over the period of three years, values ranged from 21.20 °C to 23.00 °C with mean 21.96±0.862 during winter, 30.00 °C to 31.70 °C with mean 30.90±0.793 during summer and 23.60 °C to 25.70 °C with mean 24.36±1.001 during post monsoon period (Table 2).

At site-III, temperature values ranged from 22.7 °C to 34.9 °C over the period of three years with maximum during summer’06 and minimum during winter’05. During winter, mean temperature was found to be 22.9±0.305 °C in 2005, 23.2±0.115 °C in 2006 and 24.7±0.208 °C in 2007. During summer, mean temperature was found to be 32.1±0.115 °C in 2005, 34.6±0.305 °C in 2006 and 32.2±0.057 °C in 2007. During post monsoon, mean temperature was found to be 25.1±0.152 °C in 2005, 26.1±0.057 °C in 2006 and 27.7±0.173 °C in 2007 (Table 1 & Figure 7). Over the period of three years, values ranged from 22.70 °C to 24.90 °C with mean 23.60±0.964 during winter, 32.00 °C to 34.90 °C with mean 32.96±1.415 during summer and 25.00 °C to 27.90 °C with mean 26.30±1.311 during post monsoon period (Table 2).

At site-IV, temperature values ranged from 21.8 °C to 30.9 °C over the period of study with the highest recorded during summer’05 and the lowest during winter’05. During winter, mean temperature was found to be 21.8±0.057 °C in 2005, 22.2±0.020 °C in 2006 and 23.0±0.1 °C in 2007. During summer, mean temperature was found to be 30.8±0.115 °C in 2005, 30.2±0.057 °C in 2006 and 29.9±0.115 °C in 2007. During post monsoon, mean temperature was found to be 23.7±0.173 °C in 2005, 24.6±0.230 °C in 2006 and 24.3±0.115 °C in 2007 (Table 1 & Figure 7). Over the period of three years, values ranged from 21.80 °C to 23.10 °C with mean 22.33±0.611 during
winter, 29.90 °C to 30.90 °C with mean 30.30±0.458 during summer and 23.60 °C to 24.80 °C with mean 24.23±0.472 during post monsoon period (Table 2).

**pH:**

pH of a solution at a given temperature refers to its hydrogen ion activity. It is expressed as a negative reciprocal of hydrogen ion activity in moles per litre (APHA, 1989). The three years data on pH at selected sites of the Satluj river is shown in the Table 3. The data comprising minimum values, maximum values, mean and standard deviation for pH at the selected sites for three seasons over a period of three years is summarized in the Table 4. The pH ranged from 6.8 to 8.2 in the river water during the entire period of study.

At site-I, pH values ranged from 6.8 to 7.6. The maximum pH value was recorded during summer’ 05 and 07 and the lowest value was noticed during post monsoon’ 07. During winter, mean pH was found to be 7.3±0.115 in 2005, 7.3±0.115 in 2006 and 7.4±0.1 in 2007. During summer, mean pH was found to be 7.5±0.577 in 2005, 7.4±0.057 in 2006 and 7.4±0.115 in 2007. During post monsoon, mean pH was found to be 7.1±0.1 in 2005, 6.9±0.115 in 2006 and 6.8±0.057 in 2007 (Table 3 & Figure 8). Over the period of three years, average pH values were 7.33±0.057 (7.2 - 7.5) during winter, 7.43±0.057 (7.4 - 7.6) during summer and 6.93±0.152 (6.8 - 7.2) during post monsoon period (Table 4).

At site-II, pH values varied from 6.8 to 7.9. The maximum pH value was observed during summer’ 05 and minimum pH value was recorded during post monsoon’ 07. During winter season, mean pH was found to be 7.6±0.057 in 2005, 7.5±0.057 in 2006 and 7.4±0.057 in 2007. During summer, mean pH was found to be 7.7±0.115 in 2005, 7.7±0.115 in 2006 and 7.6±0.057 in 2007. During post monsoon, mean pH was found to be 7.3±0.115 in 2005, 7.2±0.057 in 2006 and 6.9±0.230 in
2007 (Table 3 & Figure 8). Over the period of study, average pH values were 7.50±0.1 (7.4 - 7.7) during winter, 7.66±0.057 (7.6 - 7.9) during summer and 7.13±0.208 (6.8 - 7.4) during post monsoon period (Table 4).

At site-III, pH values were ranged between 6.5 and 8.2. The maximum pH value was observed during winter’ 06 and summer’ 07 and minimum pH value was recorded during post monsoon’07. During winter, mean pH was found to be 8.0±0.1 in 2005, 7.9±0.208 in 2006 and 7.9±0.115 in 2007. During summer, mean pH was found to be 7.9±0.115 in 2005, 7.9±0.1 in 2006 and 8.1±0.057 in 2007. During post monsoon, mean pH was found to be 7.1±0.115 in 2005, 7.0±0.152 in 2006 and 6.7±0.230 in 2007 (Table 3 & Figure 8). Over the period of study, average values were found to be 7.93±0.057 (7.8 - 8.2) during winter, 7.96±0.115 (7.8 - 8.2) during summer and 6.93±0.208 (6.5 - 7.2) during post monsoon period (Table 4).

At site-IV, pH values ranged from 6.9 to 7.8. The minimum pH value was observed during post monsoon’ 06 and 07 and the maximum pH value was recorded during summer’ 07. During winter, mean pH was found to be 7.5±0.115 in 2005, 7.4±0.115 in 2006 and 7.4±0.057 in 2007. During summer, mean pH was found to be 7.6±0.173 in 2005, 7.6±0.057 in 2006 and 7.6±0.115 in 2007. During post monsoon, mean pH was found to be 7.0±0.057 in 2005, 7.1±0.173 in 2006 and 7.0±0.152 in 2007 (Table 3 & Figure 8). Over the period of study, average pH values were 7.43±0.057 (7.4 - 7.7) during winter, 7.60±1.087 (7.4 - 7.8) during summer and 7.03±0.057 (6.9 - 7.2) during post monsoon period (Table 4).

**Dissolved Oxygen:**

Table 5 shows values of dissolved oxygen contents at the four selected sites and Table 6 shows statistical summary comprising minimum values, maximum values,
mean and standard deviation during the entire study period i.e. from January, 2005 to December, 2007.

At site-I, dissolved oxygen contents ranged from 5.5 mg/L to 7.1 mg/L with maximum during winter’ 05 and minimum during summer’ 07. During winter, mean dissolved oxygen value was found to be 7.0±0.057 mg/L in 2005, 6.0±0.057 mg/L in 2006 and 6.1±0.115 mg/L in 2007. During summer, mean dissolved oxygen value was found to be 6.3±0.115 mg/L in 2005, 5.9±0.115 mg/L in 2006 and 5.5±0.057 mg/L in 2007. During post monsoon, mean dissolved oxygen value was found to be 6.8±0.115 mg/L in 2005, 6.1±0.1 mg/L in 2006 and 5.8±0.057 mg/L in 2007 (Table 5 & Figure 9). Over the period of three years, mean dissolved oxygen values were found 6.36±0.550 (6.0 - 7.1 mg/L) during winter, 5.90±0.40 (5.5 - 6.4 mg/L) during summer and 6.23±0.513 (5.8 - 6.9 mg/L) during post monsoon period (Table 6).

At site-II, dissolved oxygen values ranged from 5.4 mg/L to 6.4 mg/L with the highest during winter’ 05 and the lowest during summer’ 07. During winter, mean dissolved oxygen value was found to be 6.3±0.115 mg/L in 2005, 6.1±0.057 mg/L in 2006 and 6.0±0.057 mg/L in 2007. During summer, mean dissolved oxygen value was found to be 6.0±0.057 mg/L in 2005, 5.9±0.057 mg/L in 2006 and 5.4±0.057 mg/L in 2007. During post monsoon, mean dissolved oxygen value was found to be 6.2±0.057 mg/L in 2005, 5.9±0.115 mg/L in 2006 and 5.6±0.115 mg/L in 2007 (Table 5 & Figure 9). Over the period of three years, mean values were 6.13±0.152 (6.0 - 6.4 mg/L) during winter, 5.76±0.321 (5.4 - 6.1 mg/L) during summer and 6.23±0.351 (5.6 - 6.3 mg/L) during post monsoon period (Table 6).

At site-III, dissolved oxygen levels ranged between 2.2 mg/L and 5.1 mg/L with minimum during summer’ 07 and maximum during winter season’ 05. During winter, mean dissolved oxygen value was found to be 5.0±0.057 mg/L in 2005,
4.8±0.057 mg/L in 2006 and 4.7±0.2 mg/L in 2007. During summer, mean dissolved oxygen value was found to be 3.9±0.230 mg/L in 2005, 3.7±0.173 mg/L in 2006 and 2.4±0.305 mg/L in 2007. During post monsoon, mean dissolved oxygen value was found to be 4.8±0.057 mg/L in 2005, 4.5±0.057 mg/L in 2006 and 4.4±0.057 mg/L in 2007 (Table 5 & Figure 9). Over the period of three years, mean dissolved oxygen values were 4.83±0.152 (4.5 - 5.1 mg/L) during winter, 3.33±1.814 (2.2 - 4.2 mg/L) during summer and 4.56±0.208 (4.4 - 4.9 mg/L) during post monsoon period (Table 6).

At site-IV, dissolved oxygen levels ranged from 5.5 mg/L to 6.3 mg/L with minimum during summer’ 05 and 07 and maximum during winter’ 06. During winter, mean dissolved oxygen value was found to be 6.1±0.115 mg/L in 2005, 6.2±0.057 mg/L in 2006 and 6.0±0.057 mg/L in 2007. During summer, mean dissolved oxygen value was found to be 5.6±0.115 mg/L in 2005, 5.7±0.115 mg/L in 2006 and 5.6±0.1 mg/L in 2007. During post monsoon, mean dissolved oxygen value was found to be 6.0±0.115 mg/L in 2005, 6.0±0.057 mg/L in 2006 and 5.8±0.115 mg/L in 2007 (Table 5 & Figure 9). Over the period of three years, mean dissolved oxygen values were 6.10±0.1 (6.0 - 6.3 mg/L) during winter, 5.63±0.057 (5.5 - 5.7 mg/L) during summer and 5.93±0.115 (5.7 - 6.1 mg/L) during post monsoon period (Table 6).

**Total Hardness:**

Table 7 shows total hardness contents at selected sites and Table 8 shows statistical summary of total hardness comprising maximum values, minimum values, mean and standard deviation at selected sites during the entire study period.

At site-I, total hardness values ranged from 106 mg/L to 129 mg/L during the study period with the highest value was recorded during winter’ 07 and the lowest value during post monsoon’ 05. During winter, mean total hardness value was found
to be 118±1.732 mg/L in 2005, 119±2.00 mg/L in 2006 and 127.3±2.081 mg/L in 2007. During summer, mean total hardness value was found to be 110±0.577 mg/L in 2005, 112.3±0.577 mg/L in 2006 and 115±1.154 mg/L in 2007. During post monsoon, mean total hardness value was found to be 106.3±0.577 mg/L in 2005, 110±0.577 mg/L in 2006 and 112±3.00 mg/L in 2007 (Table 7 & Figure 10). Over the period of three years, mean total hardness values were found to be 121.43±5.105 (117 – 129) mg/L during winter, 112.83±2.542 (110-117) mg/L during summer and 109.50±2.926 (106 -115) mg/L during post monsoon period (Table 8).

At site-II, total hardness levels ranged from 111 mg/L to 149 mg/L during the study period with minimum during post monsoon’ 05 and maximum during winter, 07. During winter, mean total hardness value was found to be 130±3.511 mg/L in 2005, 143±1.527 mg/L in 2006 and 147.3±2.081 mg/L in 2007. During summer, mean total hardness value was found to be 125.6±0.577 mg/L in 2005, 133.6±1.154 mg/L in 2006 and 141±1.732 mg/L in 2007. During post monsoon, mean total hardness value was found to be 112.3±1.154 mg/L in 2005, 123.3±0.577 mg/L in 2006 and 130±1.00 mg/L in 2007 (Table 7 & Figure 10). Over the period of three years, mean total hardness values were found 140.50±8.770 (127 – 149) mg/L during winter, 133.40±7.701 (125 – 143) mg/L during summer and 121.86±8.936 (111 - 131) mg/L during post monsoon period (Table 8).

At site-III, total hardness values ranged from 167 mg/L to 289 mg/L during the study period with minimum during post monsoon’ 05 and maximum during winter, 07. During winter, mean total hardness value was found to be 220.3±1.527 mg/L in 2005, 239±1.00 mg/L in 2006 and 286.3±3.785 mg/L in 2007. During summer, mean total hardness value was found to be 209.3±0.577 mg/L in 2005, 227.3±0.057 mg/L in 2006 and 237±1.732 mg/L in 2007. During post monsoon, mean total hardness value
was found to be 167.6±1.154 mg/L in 2005, 189.6±3.055 mg/L in 2006 and 194.6±2.081 mg/L in 2007 (Table 7 & Figure 10). Over the period of three years, mean total hardness values were 248.53±34.017 (219 - 289) mg/L during winter, 224.53±14.055 (209 - 238) mg/L during summer and 183.93±14.364 (167 - 194) mg/L during post monsoon period (Table 8).

At site-IV, total hardness values ranged from 117 mg/L to 141 mg/L during over the period of three years with minimum during post monsoon season’ 05 and 06 and maximum during winter’ 07. During winter, mean total hardness value was found to be 128.3±1.527 mg/L in 2005, 134.3±1.154 mg/L in 2006 and 140.3±0.057 mg/L in 2007. During summer, mean total hardness value was found to be 120.3±1.154 mg/L in 2005, 127.3±1.154 mg/L in 2006 and 130.6±0.577 mg/L in 2007. During post monsoon, mean total hardness value was found to be 117.6±1.154 mg/L in 2005, 118.6±2.081 mg/L in 2006 and 123.6±1.154 mg/L in 2007 (Table 7 & Figure 10). Over the period of three years, mean total hardness values were found to be 134.30±6 (127 - 141) mg/L during winter, 126.60±5.259 (119 - 131) mg/L during summer and 119.93±3.214 (117 - 125) mg/L during post monsoon period (Table 8).

METALS IN WATER

Cadmium:

Cadmium level shows fluctuations in cadmium concentration during the period of study with maximum (0.021 mg/L) at site-III in winter’ 07 and minimum (0.004 mg/L) at site-I and site-IV in post monsoon’ 05 (Table 13). Table 14 shows four member statistical summary comprising minimum and maximum values, mean and standard deviation at selected sites of river during the entire period of study.

At site-I, Cadmium contents ranged from 0.004 mg/L to 0.010 mg/L with the highest level recorded during winter’ 07 and the lowest level during post monsoon’
During winter, mean concentration was found to be 0.007±0 mg/L in 2005, 0.008±0 mg/L in 2006 and 0.009±0 mg/L in 2007. During summer, mean concentration was found to be 0.005±0 mg/L in 2005, 0.006±0.001 mg/L in 2006 and 0.008±0 mg/L in 2007. During post monsoon, mean concentration was found to be 0.004±0 mg/L in 2005, 0.005±8.231 mg/L in 2006 and 0.006±0 mg/L in 2007 (Table 13 & Figure 11). Over the period of three years, average values ranged from 0.007 mg/L to 0.010 mg/L (0.008±0.001) during winter, 0.005 mg/L to 0.009 (0.006±0.001) during summer and 0.004 mg/L to 0.007 mg/L (0.005±0.001) during post monsoon period (Table 14).

At site-II, Cadmium contents ranged from 0.006 mg/L to 0.016 mg/L with the highest level recorded during winter’ 07 and the lowest level during summer’ 05. During winter, mean concentration was found to be 0.009±0.001 mg/L in 2005, 0.011±0.001 mg/L in 2006 and 0.015±0 mg/L in 2007. During summer, mean concentration was found to be 0.006±0 mg/L in 2005, 0.009±0 mg/L in 2006 and 0.010±0 mg/L in 2007. During post monsoon, mean concentration was found to be 0.007±0 mg/L in 2005, 0.010±0.001 mg/L in 2006 and 0.011±0 mg/L in 2007 (Table 13 & Figure 12). Over the period of three years, average values ranged from 0.008 mg/L to 0.016 mg/L (0.011±0.003) during winter, 0.006 mg/L to 0.011 (0.008±0.002) in summer and 0.007 mg/L to 0.012 mg/L (0.009±0.002) during post monsoon period (Table 14).

At site-III, Cadmium contents ranged from 0.007 mg/L to 0.021 mg/L with the highest level recorded during winter’ 07 and the lowest level during summer’ 05. During winter, mean concentration was found to be 0.013±0.001 mg/L in 2005, 0.014±0.001 mg/L in 2006 and 0.020±0 mg/L in 2007. During summer, mean concentration was found to be 0.008±0.001 mg/L in 2005, 0.011±0.001 mg/L in 2006
and 0.013±0 mg/L in 2007. During post monsoon, mean concentration was found to be 0.009±0 mg/L in 2005, 0.012±0.002 mg/L in 2006 and 0.014±0 mg/L in 2007 (Table 13 & Figure 13). Over the period of three years, average values ranged from 0.012 mg/L to 0.021 mg/L (0.015±0.003) during winter, 0.007 mg/L to 0.014 (0.010±0.002) in summer and 0.005 mg/L to 0.012 mg/L (0.011±0.002) during post monsoon period (Table 14).

At site-IV, Cadmium contents ranged from 0.004 mg/L to 0.015 mg/L with the highest level recorded during post monsoon’ 07 and the lowest level during post monsoon’ 05. During winter, mean concentration was found to be 0.007±0 mg/L in 2005, 0.009±0.001 mg/L in 2006 and 0.013±0 mg/L in 2007. During summer, mean concentration was found to be 0.006±0.001 mg/L in 2005, 0.009±0 mg/L in 2006 and 0.011±0.001 mg/L in 2007. During post monsoon, mean concentration was found to be 0.004±0 mg/L in 2005, 0.008±0.001 mg/L in 2006 and 0.013±0.001 mg/L in 2007 (Table 13 & Figure 14). Over the period of three years, average values ranged from 0.007 mg/L to 0.014 mg/L (0.009±0.003) during winter, 0.005 mg/L to 0.012 (0.008±0.002) in summer and 0.004 mg/L to 0.015 mg/L (0.008±0.004) during post monsoon period (Table 10).

**Chromium:**

Table 15 shows fluctuations in chromium concentrations during the entire period of study with maximum (0.063 mg/L) at site-III during winter’ 07 and minimum (0.044 mg/L) at site-I during summer’ 05. Table 16 shows four member statistical summary comprising minimum and maximum values, mean and standard deviation at selected sites of river during the entire period of study. At site-I, chromium contents ranged from 0.043 mg/L to 0.053 mg/L with the highest level recorded during winter’ 05 and 07 and the lowest level during summer’
During winter, mean concentration was found to be 0.050±0.003 mg/L in 2005, 0.050±0 mg/L in 2006 and 0.052±0 mg/L in 2007. During summer, mean concentration was found to be 0.044±0.002 mg/L in 2005, 0.047±0 mg/L in 2006 and 0.050±0 mg/L in 2007. During post monsoon, mean concentration was found to be 0.047±0.001 mg/L in 2005, 0.049±0 mg/L in 2006 and 0.050±0.001 mg/L in 2007 (Table 15 & Figure 11). Over the period of three years, average values ranged from 0.047 mg/L to 0.053 mg/L (0.050±0.001) during winter, 0.043 mg/L to 0.051 (0.047±0.003) during summer and 0.047 mg/L to 0.052 mg/L (0.048±0.001) during post monsoon period (Table 16).

At site-II, chromium contents ranged from 0.049 mg/L to 0.055 mg/L with the highest level recorded during post monsoon’ 06 and winter’ 07 and the lowest level during summer’ 05 and 06. During winter, mean concentration was found to be 0.052±0.003 mg/L in 2005, 0.053±0.001 mg/L in 2006 and 0.054±0 mg/L in 2007. During summer, mean concentration was found to be 0.049±0 mg/L in 2005, 0.050±0.001 mg/L in 2006 and 0.050±0 mg/L in 2007. During post monsoon, mean concentration was found to be 0.052±0 mg/L in 2005, 0.052±0.002 mg/L in 2006 and 0.053±0.002 mg/L in 2007 (Table 15 & Figure 12). Over the period of three years, average values ranged from 0.050 mg/L to 0.056 mg/L (0.053±0.001) during winter, 0.049 mg/L to 0.052 (0.049±0.00) in summer and 0.050 mg/L to 0.053 mg/L (0.052±0.00) during post monsoon period (Table 16).

At site-III, chromium contents ranged from 0.052 mg/L to 0.068 mg/L with the highest level recorded during winter’ 07 and the lowest level during summer’ 06. During winter, mean concentration was found to be 0.055±0.002 mg/L in 2005, 0.057±0.002 mg/L in 2006 and 0.063±0.003 mg/L in 2007. During summer, mean concentration was found to be 0.053±0.003 mg/L in 2005, 0.053±0.003 mg/L in 2006
and 0.058±0 mg/L in 2007. During post monsoon, mean concentration was found to be 0.052±0.002 mg/L in 2005, 0.053±0.001 mg/L in 2006 and 0.060±0.001 mg/L in 2007 (Table 15 & Figure 13). Over the period of three years, average values ranged from 0.054 mg/L to 0.068 mg/L (0.058±0.004) during winter, 0.050 mg/L to 0.059 (0.054±0.002) in summer and 0.050 mg/L to 0.061 mg/L (0.055±0.004) during post monsoon period (Table 16).

At site-IV, chromium contents ranged from 0.044 mg/L to 0.056 mg/L with the highest level recorded during winter’ 07 and the lowest level during summer’ 05. During winter, mean concentration was found to be 0.047±0.001 mg/L in 2005, 0.051±0.002 mg/L in 2006 and 0.054±0.001 mg/L in 2007. During summer, mean concentration was found to be 0.045±0.002 mg/L in 2005, 0.049±0.002 mg/L in 2006 and 0.052±0.001 mg/L in 2007. During post monsoon, mean concentration was found to be 0.047±0.002 mg/L in 2005, 0.050±0.002 mg/L in 2006 and 0.052±0 mg/L in 2007 (Table 15 & Figure 14). Over the period of three years, average values ranged from 0.047 mg/L to 0.056 mg/L (0.050±0.003) during winter, 0.044 mg/L to 0.054 (0.048±0.003) in summer and 0.045 mg/L to 0.054 mg/L (0.049±0.002) during post monsoon period (Table 16).

Nickel:

Table 17 shows variations in nickel concentrations during the period of study with maximum (0.031 mg/L) at site-III in winter’ 05 and minimum (0.011 mg/L) at site-IV in summer’ 05. Table 18 shows four member statistical summary comprising minimum and maximum values, mean and standard deviation at selected sites of river during the entire period of study.

At site-I, nickel contents ranged from 0.012 mg/L to 0.027 mg/L with the highest level recorded during winter’ 07 and the lowest level during winter’ 05. During
winter, mean concentration was found to be 0.016±0.003 mg/L in 2005, 0.022±0.001 mg/L in 2006 and 0.025±0.001 mg/L in 2007. During summer, mean concentration was found to be 0.012±0.001 mg/L in 2005, 0.020±0.001 mg/L in 2006 and 0.022±0.00 mg/L in 2007. During post monsoon, mean concentration was found to be 0.015±0 mg/L in 2005, 0.022±0 mg/L in 2006 and 0.024±0.001 mg/L in 2007 (Table 17 & Figure 11). Over the period of three years, average values ranged from 0.012 mg/L to 0.027 mg/L (0.021±0.004) during winter, 0.011 mg/L to 0.024 (0.018±0.005) during summer and 0.015 mg/L to 0.026 mg/L (0.020±0.004) during post monsoon period (Table 18).

At site-II, nickel contents ranged from 0.021 mg/L to 0.031 mg/L with the highest level recorded during winter and post monsoon’ 07 and the lowest level during post monsoon’ 05. During winter, mean concentration was found to be 0.023±0.002 mg/L in 2005, 0.025±0.002 mg/L in 2006 and 0.030±0.001 mg/L in 2007. During summer, mean concentration was found to be 0.021±0.001 mg/L in 2005, 0.023±0.002 mg/L in 2006 and 0.027±0 mg/L in 2007. During post monsoon, mean concentration was found to be 0.024±0.003 mg/L in 2005, 0.025±0.001 mg/L in 2006 and 0.030±0 mg/L in 2007 (Table 17 & Figure 12). Over the period of three years, average values ranged from 0.022 mg/L to 0.031 mg/L (0.026±0.003) during winter, 0.020 mg/L to 0.029 (0.023±0.003) during summer and 0.021 mg/L to 0.031 mg/L (0.026±0.006) during post monsoon period (Table 18).

At site-III, nickel contents ranged from 0.024 mg/L to 0.033 mg/L with the highest level recorded during winter’ 05 and the lowest level during summer’ 05. During winter, mean concentration was found to be 0.031±0.001 mg/L in 2005, 0.028±0.002 mg/L in 2006 and 0.030±0 mg/L in 2007. During summer, mean concentration was found to be 0.024±0.001 mg/L in 2005, 0.027±0.002 mg/L in 2006
and 0.026±0.001 mg/L in 2007. During post monsoon, mean concentration was found to be 0.027±0.001 mg/L in 2005, 0.028±0.001 mg/L in 2006 and 0.027±0.002 mg/L in 2007 (Table 17 & Figure 13). Over the period of three years, average values ranged from 0.026 mg/L to 0.033 mg/L (0.029±0.001) during winter, 0.024 mg/L to 0.030 (0.025±0.001) during summer and 0.025 mg/L to 0.030 mg/L (0.027±0.00) during post monsoon period (Table 18).

At site-IV, nickel contents ranged from 0.011 mg/L to 0.025 mg/L with the highest level recorded during winter’ 06 and the lowest level during summer’ 05. During winter, mean concentration was found to be 0.013±0.001 mg/L in 2005, 0.021±0.003 mg/L in 2006 and 0.023±0 mg/L in 2007. During summer, mean concentration was found to be 0.011±0.001 mg/L in 2005, 0.014±0.001 mg/L in 2006 and 0.020±0.001 mg/L in 2007. During post monsoon, mean concentration was found to be 0.012±0.001 mg/L in 2005, 0.017±0 mg/L in 2006 and 0.022±0.001 mg/L in 2007 (Table 17 & Figure 14). Over the period of three years, average values ranged from 0.012 mg/L to 0.025 mg/L (0.019±0.005) during winter, 0.010 mg/L to 0.022 (0.015±0.004) during summer and 0.012 mg/L to 0.023 mg/L (0.017±0.005) during post monsoon period (Table 18).

**Lead:**

Table 19 shows fluctuations in nickel concentration during the period of study with maximum (0.065 mg/L) at site-III in winter’ 07 and minimum (0.036 mg/L) at site-IV in post monsoon’ 05. Table 20 shows four member statistical summary comprising minimum and maximum values, mean and standard deviation at selected sites of river during the entire period of study.

At site-I, lead contents ranged from 0.038 mg/L to 0.064 mg/L with the highest level recorded during winter’ 07 and the lowest level during post monsoon’ 05.
During winter, mean concentration was found to be 0.040±0.001 mg/L in 2005, 0.046±0.002 mg/L in 2006 and 0.060±0.003 mg/L in 2007. During summer, mean concentration was found to be 0.040±0.001 mg/L in 2005, 0.043±0.001 mg/L in 2006 and 0.055±0.001 mg/L in 2007. During post monsoon, mean concentration was found to be 0.040±0.002 mg/L in 2005, 0.046±0.001 mg/L in 2006 and 0.059±0.001 mg/L in 2007 (Table 19 & Figure 11). Over the period of three years, average values ranged from 0.039 mg/L to 0.064 mg/L (0.048±0.010) during winter, 0.039 mg/L to 0.057 mg/L (0.046±0.007) during summer and 0.038 mg/L to 0.061 mg/L (0.048±0.009) during post monsoon period (Table 20).

At site-II, lead contents ranged from 0.047 mg/L to 0.064 mg/L with the highest level recorded during winter’ 07 and the lowest level during summer’ 05. During winter, mean concentration was found to be 0.050±0.001 mg/L in 2005, 0.061±0.002 mg/L in 2006 and 0.062±0.002 mg/L in 2007. During summer, mean concentration was found to be 0.048±0.001 mg/L in 2005, 0.053±0.003 mg/L in 2006 and 0.052±0.002 mg/L in 2007. During post monsoon, mean concentration was found to be 0.050±0.001 mg/L in 2005, 0.052±0.001 mg/L in 2006 and 0.055±0 mg/L in 2007 (Table 19 & Figure 12). Over the period of three years, average values ranged from 0.049 mg/L to 0.064 mg/L (0.057±0.006) during winter, 0.047 mg/L to 0.057 mg/L (0.051±0.002) in summer and 0.048 mg/L to 0.056 mg/L (0.052±0.002) during post monsoon period (Table 20).

At site-III, lead contents ranged from 0.057 mg/L to 0.065 mg/L with the highest level recorded during winter’ 07 and the lowest level during summer’ 05. During winter, mean concentration was found to be 0.061±0.002 mg/L in 2005, 0.062±0.001 mg/L in 2006 and 0.063±0.001 mg/L in 2007. During summer, mean concentration was found to be 0.059±0.002 mg/L in 2005, 0.060±0.001 mg/L in 2006 and
0.059±0.001 mg/L in 2007. During post monsoon, mean concentration was found to be 0.060±0.001 mg/L in 2005, 0.061±0.002 mg/L in 2006 and 0.061±0.001 mg/L in 2007 (Table 19 & Figure 13). Over the period of three years, average values ranged from 0.059 mg/L to 0.065 mg/L (0.062±0.001) during winter, 0.057 mg/L to 0.062 (0.059±0.00) in summer and 0.059 mg/L to 0.064 mg/L (0.060±0.00) during post monsoon period (Table 20).

At site-IV, lead values ranged from 0.036 mg/L to 0.055 mg/L with maximum level recorded during winter’ 07 and the lowest level during post monsoon’ 05. During winter, mean concentration was found to be 0.040±0.002 mg/L in 2005, 0.043±0.001 mg/L in 2006 and 0.054±0.001 mg/L in 2007. During summer, mean concentration was found to be 0.039±0.001 mg/L in 2005, 0.040±0.001 mg/L in 2006 and 0.050±0.002 mg/L in 2007. During post monsoon, mean concentration was found to be 0.039±0.003 mg/L in 2005, 0.039±0.002 mg/L in 2006 and 0.050±0.001 mg/L in 2007 (Table 19 & Figure 14). Over the period of three years, average values ranged from 0.039 mg/L to 0.055 mg/L (0.045±0.007) during winter, 0.038 mg/L to 0.053 (0.043±0.006) in summer and 0.036 mg/L to 0.051 mg/L (0.042±0.006) during post monsoon period (Table 20).

**METALS IN SEDIMENT**

Results of heavy metal analysis of river sediments from Nangal, Ropar, Ludhiana and Harike are presented in Table 21-28. Heavy metals concentrations in the river sediments displayed a range of (in mg kg⁻¹): 0.12-0.47 for cadmium (Table 21); 0.56-3.96 for chromium (Table 23); 0.69-5.05 for nickel (Table 25) and 0.88-5.03 for lead (Table 27).

**Cadmium:**
Cadmium concentration show variations during the whole period of study with minimum (0.12 mg/k) at site-I during post monsoon’ 05 and maximum (0.47 mg/k) at site-III during winter’ 06 (Table 21). Table 22 shows four member statistical summary comprising minimum and maximum values, mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, cadmium levels ranged from 0.12 mg/k to 0.38 mg/k with the highest concentration observed during winter’ 07 and the lowest concentration during post monsoon’ 05. During winter, mean concentration was found to be 0.26±0.017 mg/k in 2005, 0.32±0.011 mg/k in 2006 and 0.38±0.015 mg/k in 2007. During summer, mean concentration was found to be 0.20±0.115 mg/k in 2005, 0.28±0.011 mg/k in 2006 and 0.34±0.020 mg/k in 2007. During post monsoon, mean concentration was found to be 0.12±0.011 mg/k in 2005, 0.25±0.026 mg/k in 2006 and 0.30±0.010 mg/k in 2007 (Table 21 & Figure 15). Over the period of three years, the cadmium concentration ranged from 0.25 mg/k to 0.40 mg/k (0.32±0.06) during winter, 0.19 mg/k to 0.36 (0.27±0.070) during summer and 0.11 mg/k to 0.31 mg/k (0.22±0.092) during post monsoon period (Table 22).

At site-II, cadmium contents ranged from 0.26 mg/k to 0.43 mg/k with the highest value recorded during winter’ 07 and the lowest value during post monsoon’ 05. During winter, mean concentration was found to be 0.32±0.020 mg/k in 2005, 0.35±0.017 mg/k in 2006 and 0.043±0.011 mg/k in 2007. During summer, mean concentration was found to be 0.27±0.026 mg/k in 2005, 0.31±0.015 mg/k in 2006 and 0.35±0.026 mg/k in 2007. During post monsoon, mean concentration was found to be 0.26±0.040 mg/k in 2005, 0.31±0.026 mg/k in 2006 and 0.39±0.015 mg/k in 2007 (Table 21 & Figure 16). Over the period of three years, average values ranged from 0.30 mg/k to 0.44 mg/k (0.36±0.056) during winter, 0.24 mg/k to 0.37 mg/k
(0.31±0.04) in summer and 0.22 mg/k to 0.41 mg/k (0.32±0.065) during post monsoon period (Table 22).

At site-III, cadmium values ranged from 0.39 mg/k to 0.47 mg/k with the highest level recorded during winter’ 06 and the lowest level during post monsoon’ 05. During winter, mean concentration was found to be 0.44±0.036 mg/k in 2005, 0.47±0.020 mg/k in 2006 and 0.46±0.025 mg/k in 2007. During summer, mean concentration was found to be 0.40±0.015 mg/k in 2005, 0.44±0.012 mg/k in 2006 and 0.42±0.025 mg/k in 2007. During post monsoon, mean concentration was found to be 0.39±0.036 mg/k in 2005, 0.47±0.020 mg/k in 2006 and 0.46±0.025 mg/k in 2007. Over the period of three years, average values ranged from 0.41 mg/k to 0.50 mg/k (0.45±0.015) during winter, 0.39 mg/k to 0.46 (0.42±0.02) in summer and 0.38 mg/k to 0.43 mg/k (0.39±0.005) during post monsoon period (Table 21 & Figure 17).

At site-IV, cadmium contents ranged from 0.23 mg/k to 0.41 mg/k with the highest value observed during winter’ 07 and the lowest value during post monsoon’ 05. During winter, mean concentration was found to be 0.30±0.005 mg/k in 2005, 0.36±0.020 mg/k in 2006 and 0.41±0.020 mg/k in 2007. During summer, mean concentration was found to be 0.25±0.0.020 mg/k in 2005, 0.33±0.015 mg/k in 2006 and 0.39±0.025 mg/k in 2007. During post monsoon, mean concentration was found to be 0.23±0.0.023 mg/k in 2005, 0.30±0.010 mg/k in 2006 and 0.37±0.020 mg/k in 2007 (Table 21 & Figure 18). Over the period of three years, average values ranged from 0.30 mg/k to 0.44 mg/k (0.35±0.055) during winter, 0.23 mg/k to 0.42 (0.32±0.070) in summer and 0.22 mg/k to 0.40 mg/k (0.30±0.07) during post monsoon period (Table 22).

**Chromium:**
Table 23 shows variations in chromium concentration during the course of study with minimum (0.56 mg/k) at site-I during summer’ 05 and maximum (3.96 mg/k) at site-III during winter’ 07. Table 24 shows four member statistical summary comprising minimum and maximum values, mean and standard deviation at selected sites of river during the entire period of study.

At site-I, chromium concentrations ranged from 0.56 mg/k to 1.37 mg/k with the highest concentration recorded during winter’ 07 and the lowest concentration during summer’ 05. During winter, mean concentration was found to be 0.58±0.032 mg/k in 2005, 0.62±0.037 mg/k in 2006 and 1.37±0.052 mg/k in 2007. During summer, mean concentration was found to be 0.56±0.026 mg/k in 2005, 0.61±0.025 mg/k in 2006 and 1.25±0.165 mg/k in 2007. During post monsoon, mean concentration was found to be 0.57±0.045 mg/k in 2005, 0.62±0.025 mg/k in 2006 and 1.31±0.060 mg/k in 2007 (Table 23 & Figure 15). Over the period of three years, average values ranged from 0.56 mg/k to 1.41 mg/k (0.85±0.445) during winter, 0.54 mg/k to 1.42 (0.80±0.384) during summer and 0.52 mg/k to 1.39 mg/k (0.83±0.413) during post monsoon period (Table 24).

At site-II, chromium levels varied between 1.60 mg/k and 1.75 mg/k with the highest level recorded during winter’ 07 and the lowest level during post monsoon’ 05. During winter, mean concentration was found to be 1.63±0.025 mg/k in 2005, 1.74±0.061 mg/k in 2006 and 1.75±0.049 mg/k in 2007. During summer, mean concentration was found to be 1.61±0.020 mg/k in 2005, 1.69±0.020 mg/k in 2006 and 1.66±0.032 mg/k in 2007. During post monsoon, mean concentration was found to be 1.60±0.034 mg/k in 2005, 1.66±0.030 mg/k in 2006 and 1.67±0.065 mg/k in 2007 (Table 23 & Figure 16). Over the period of three years, average values ranged from 1.61 mg/k to 1.81 mg/k (1.70±0.066) during winter, 1.59 to 1.71 mg/k
(1.65±0.040) in summer and 1.58 mg/k to 1.74 mg/k (1.64±1.037) during post monsoon period (Table 24).

At site-III, chromium contents ranged from 1.89 mg/k to 3.96 mg/k with the highest value recorded during winter’ 07 and the lowest value during post monsoon’ 05. During winter, mean concentration was found to be 2.28±0.284 mg/k in 2005, 3.25±0.231 mg/k in 2006 and 3.96±0.130 mg/k in 2007. During summer, mean concentration was found to be 2.17±0.345 mg/k in 2005, 3.04±0.265 mg/k in 2006 and 3.94±0.620 mg/k in 2007. During post monsoon, mean concentration was found to be 1.89±0.823 mg/k in 2005, 3.20±0.270 mg/k in 2006 and 3.76±0.499 mg/k in 2007 (Table 23 & Figure 17). Over the period of three years, average values ranged from 1.97 to 4.09 mg/k (3.16±0.84) during winter, 1.89 to 4.01 mg/k (3.05±0.885) in summer and 1.01 mg/k to 4.31 mg/k (2.95±0.959) during post monsoon period (Table 24).

At site-IV, chromium contents ranged from 1.17 mg/k to 1.85 mg/k with the highest value recorded during post monsoon’ 07 and the lowest value during summer’ 05. During winter, mean concentration was found to be 1.45±0.147 mg/k in 2005, 1.58±0.036 mg/k in 2006 and 1.65±0.492 mg/k in 2007. During summer, mean concentration was found to be 1.17±0.247 mg/k in 2005, 1.57±0.060 mg/k in 2006 and 1.64±0.258 mg/k in 2007. During post monsoon, mean concentration was found to be 1.49±0.529 mg/k in 2005, 1.54±0.402 mg/k in 2006 and 1.85±1.136 mg/k in 2007 (Table 23 & Figure 18). Over the period of three years, average values ranged from 1.11 mg/k to 2.07 mg/k (1.56±0.101) during winter, 0.98 mg/k to 1.87 (1.46±0.253) in summer and 0.88 mg/k to 2.01 mg/k (1.62±0.195) during post monsoon period (Table 24).

Nickel:
Table 25 shows variations in nickel concentration during the period of study with maximum (5.05 mg/k) at site-III in winter’ 07 and minimum (0.69 mg/k) at site-I in summer’ 05. Table 26 shows four member statistical summary comprising minimum and maximum values, mean and standard deviation at selected sites of river during the entire period of study.

At site-I, nickel contents varied between 0.69 mg/k and 1.24 mg/k with the highest level recorded during winter’ 07 and the lowest level during summer’ 05. During winter, mean concentration was found to be 0.78±0.210 mg/k in 2005, 0.88±0.159 mg/k in 2006 and 1.24±0.141 mg/k in 2007. During summer, mean concentration was found to be 0.69±0.076 mg/k in 2005, 1.11±0.135 mg/k in 2006 and 1.05±0.060 mg/k in 2007. During post monsoon, mean concentration was found to be 0.76±0.041 mg/k in 2005, 0.89±0.115 mg/k in 2006 and 1.07±0.166 mg/k in 2007 (Table 25 & Figure 15). Over the period of three years, average values ranged from 0.63 mg/k to 1.35 mg/k (0.96±0.241) during winter, 0.61 mg/k to 1.25 (0.95±0.227) during summer and 0.73 mg/k to 1.21 mg/k (0.90±0.155) during post monsoon period (Table 26).

At site-II, nickel contents varied between 0.87 mg/k and 1.68 mg/k with the highest level recorded during post monsoon’ 07 and the lowest level during summer’ 06. During winter, mean concentration was found to be 1.05±0.270 mg/k in 2005, 1.28±0.075 mg/k in 2006 and 1.59±0.184 mg/k in 2007. During summer, mean concentration was found to be 0.87±0.119 mg/k in 2005, 1.41±0.315 mg/k in 2006 and 1.59±0.110 mg/k in 2007. During post monsoon, mean concentration was found to be 0.94±0.035 mg/k in 2005, 1.54±0.171 mg/k in 2006 and 1.68±0.353 mg/k in 2007 (Table 25 & Figure 16). Over the period of three years, average values ranged from 0.86 mg/k to 1.75 mg/k (1.30±0.270) during winter, 0.79 mg/k to 1.72
(1.29±0.374) in summer and 0.91 mg/k to 2.01 mg/k (1.38±0.393) during post monsoon period (Table 26).

At site-III, nickel contents varied between 2.71 mg/k and 5.05 mg/k with the highest level recorded during winter' 07 and the lowest level during post monsoon’ 05. During winter, mean concentration was found to be 3.21±0.185 mg/k in 2005, 4.13±0.170 mg/k in 2006 and 5.05±0.126 mg/k in 2007. During summer, mean concentration was found to be 3.08±0.316 mg/k in 2005, 3.79±0.197 mg/k in 2006 and 4.52±0.367 mg/k in 2007. During post monsoon, mean concentration was found to be 2.71±0.141 mg/k in 2005, 3.41±0.625 mg/k in 2006 and 4.70±0.367 mg/k in 2007 (Table 25 & Figure 17). Over the period of three years, average values ranged from 3.01 mg/k to 5.24 mg/k (4.13±0.92) during winter, 2.78 mg/k to 4.78 (3.79±0.720) in summer and 2.59 mg/k to 5.00 mg/k (3.60±1.009) during post monsoon period (Table 26).

At site-IV, nickel contents varied between 0.98 mg/k and 2.00 mg/k with the highest level recorded during post monsoon’ 06 and the lowest level during summer' 05. During winter, mean concentration was found to be 1.23±0.230 mg/k in 2005, 1.92±0.119 mg/k in 2006 and 1.47±0.209 mg/k in 2007. During summer, mean concentration was found to be 0.98±0.110 mg/k in 2005, 1.86±0.113 mg/k in 2006 and 1.31±0.205 mg/k in 2007. During post monsoon, mean concentration was found to be 1.12±0.219 mg/k in 2005, 2.00±0.125 mg/k in 2006 and 1.41±0.195 mg/k in 2007 (Table 25 & Figure 18). Over the period of three years, average values ranged from 0.98 mg/k to 2.01 mg/k (1.54±0.350) during winter, 0.87 mg/k to 1.99 (1.38±0.444) in summer and 0.87 mg/k to 2.14 mg/k (1.51±0.448) during post monsoon period (Table 26).

**Lead:**
Table 27 shows variations in lead concentration during the course of study with maximum (5.03 mg/k) at site-III in winter’07 and minimum (0.88 mg/k) at site-I in summer’05 (figure 13). Table 28 shows four member statistical summary comprising minimum and maximum values, mean and standard deviation at selected sites of river during the entire period of study.

At site-I, lead levels ranged from 0.88 mg/k to 1.06 mg/k with the highest value observed during winter’06 and the lowest value during summer’05. During winter, mean concentration was found to be 0.97±0.076 mg/k in 2005, 1.06±0.126 mg/k in 2006 and 0.98±0.095 mg/k in 2007. During summer, mean concentration was found to be 0.88±0.105 mg/k in 2005, 0.92±0.327 mg/k in 2006 and 0.91±0.211 mg/k in 2007. During post monsoon, mean concentration was found to be 0.93±0.045 mg/k in 2005, 0.95±0.100 mg/k in 2006 and 0.92±0.153 mg/k in 2007 (Table 27 & Figure 15). Over the period of three years, average values ranged from 0.88 mg/k to 1.21 mg/k (1.00±0.049) during winter, 0.69 mg/k to 1.30 mg/k (0.90±0.020) during summer and 0.79 mg/k to 1.09 mg/k (0.93±0.015) during post monsoon period (Table 28).

At site-II, lead levels ranged from 1.12 mg/k to 2.36 mg/k with the highest value recorded during winter’06 and the lowest value during summer and post monsoon’05. During winter, mean concentration was found to be 1.36±0.117 mg/k in 2005, 2.36±0.407 mg/k in 2006 and 1.76±0.480 mg/k in 2007. During summer, mean concentration was found to be 1.12±0.079 mg/k in 2005, 2.11±0.110 mg/k in 2006 and 1.71±0.638 mg/k in 2007. During post monsoon, mean concentration was found to be 1.12±0.115 mg/k in 2005, 1.88±0.115 mg/k in 2006 and 1.43±0.424 mg/k in 2007 (Table 27 & Figure 16). Over the period of three years, average values ranged from 1.21 mg/k to 2.79 mg/k (1.82±0.503) during winter, 1.01 mg/k to 2.26 mg/k
(1.64±0.498) in summer and 1.01 mg/k to 1.91 mg/k (1.47±0.382) during post monsoon period (Table 28).

At site-III, lead levels ranged from 3.47 mg/k to 5.03 mg/k with maximum value recorded during winter’ 07 and minimum value during summer’ 05. During winter, mean concentration was found to be 4.04±0.308 mg/k in 2005, 4.77±0.285 mg/k in 2006 and 5.03±0.070 mg/k in 2007. During summer, mean concentration was found to be 3.47±0.216 mg/k in 2005, 4.08±0.105 mg/k in 2006 and 4.59±0.190 mg/k in 2007. During post monsoon, mean concentration was found to be 3.53±0.477 mg/k in 2005, 3.85±0.160 mg/k in 2006 and 4.24±0.258 mg/k in 2007 (Table 27 & Figure 17). Over the period of three years, average values ranged from 3.71 mg/k to 5.11 mg/k (4.61±0.513) during winter, 3.29 mg/k to 4.71 (4.04±0.560) in summer and 2.99 mg/k to 4.52 mg/k (3.87±0.355) during post monsoon period (Table 28).

At site-IV, lead levels ranged from 1.28 mg/k to 2.14 mg/k with maximum value observed during winter’ 06 and minimum value during post monsoon’ 05. During winter, mean concentration was found to be 1.46±0.234 mg/k in 2005, 2.14±0.083 mg/k in 2006 and 1.71±0.636 mg/k in 2007. During summer, mean concentration was found to be 1.33±0.070 mg/k in 2005, 2.06±0.056 mg/k in 2006 and 1.88±0.105 mg/k in 2007. During post monsoon, mean concentration was found to be 1.28±0.080 mg/k in 2005, 2.06±0.110 mg/k in 2006 and 1.81±0.110 mg/k in 2007 (Table 27 & Figure 18). Over the period of three years, average values ranged from 1.10 mg/k to 2.37 mg/k (1.77±0.343) during winter, 1.27 mg/k to 2.11 (1.75±0.380) in summer and 1.20 mg/k to 2.19 mg/k (1.71±0.398) during post monsoon period (Table 28).

**Metal Enrichment Factor:**

Metal EF for the river sediment at various sites have been calculated and are presented in Table 29-32.
Enrichment Factor for cadmium varied from 0.66 to 1.26 at site-I, 0.86 to 1.43 at site-II, 1.30 to 1.56 at site-III and 0.76 to 1.36 at site-IV. EF values for chromium varied from 0.006 to 0.10 at site-I, 0.01 at site-II, 0.02 to 0.04 at site-III and 0.01 to 0.02 at site-IV. EF values for nickel varied from 0.01 at site-I, 0.01 to 0.02 at site-II, 0.03 to 0.07 at site-III and 0.01 to 0.02 at site-IV. EF values for lead varied from 0.04 to 0.05 at site-I, 0.05 to 0.11 at site-II, 0.17 to 0.25 at site-III and 0.06 to 0.10 at site-IV (Table 25-28).

Maximum cadmium enrichment was at site-III followed in decreasing order by site-II, site-IV and site-I. EF values for chromium, nickel and lead, too, were maximum at site-III. Metal enrichment increased over the period from 2005 to 2007 at all the sites.

**Metal Enrichment of the sediment due to anthropogenic activities in Punjab:**

One of the objectives of the sediment sampling study was to estimate how much sediment chemistry has changed due to man made sources of pollution in Punjab. The metal enrichment due to anthropogenic activities at a location is represented as the ratio of the metal concentration in the sediment at the location to the concentration of the metal at the location that represents the background concentration (Singh et al., 2002). To evaluate the metal enrichment at site-II, site-III and site-IV due to anthropogenic activities, the values at site-I which is the entry point of the river in Punjab, have been used as the background values. To calculate metal enrichment, average values of concentrations of a metal at a site for three years have been used (Table 33). The values of metal enrichment at site-II, III and IV are depicted in the Table 34. % contribution by human activities is depicted in Table 35 & Figure 19-22.
The data shows maximum enrichment at site-III for all the metals. Enrichment at this site is almost 4 times for nickel and lead (anthropogenic contribution: 75.90% and 75.55% respectively), 3 times for chromium (anthropogenic contribution: 66.31%) and 1.6 times for cadmium (anthropogenic contribution: 38.09%). At site-II, lead and chromium enrichment is about 1.7 times (anthropogenic contribution: 41.42%). Cadmium enrichment is comparatively less and site wise variations are not very distinct.

**SEDIMENT QUALITY ASSESSMENT:**

Sediment quality assessment was done by calculating geo-accumulation index and sediment pollution index.

**Geo-accumulation Index ($I_{geo}$):**

The $I_{geo}$ values calculated for the Satluj River Sediments (SRS) at different sites during different seasons are given in Table 36. The $I_{geo}$ value remain below zero in all the samples along the river Satluj for all the heavy metals.

**Sediment Pollution Index (SPI):**

The sediment quality on the basis of collective accumulation of all the metals is assessed by calculating Sediment Pollution Index which classifies sediment into five classes; unpolluted, low polluted, moderately polluted, highly polluted and dangerously polluted sediment (Table 37, Singh et al., 2005). Sediment quality indices at investigated sites along the river were calculated and are represented in the Table 36. The SPI values remain below 2 at all the sites indicating that the sediment comes under class-0 i.e., it is unpolluted with respect to metal concentrations.
METALS IN FISH

1. Cadmium:

1.1 Labeo rohita (Hamilton):

Liver

During the entire study period, cadmium concentration in liver of *Labeo rohita* collected from four selected sites varied from 0.006 mg/kg at site-IV to 0.020 mg/kg at site-III (Table 39). Table 40 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, cadmium concentrations ranged from 0.010 mg/kg to 0.013 mg/kg with maximum during summer’ 05 and minimum during post monsoon seasons of all the three years. During winter, mean concentration was found to be 0.012±0.002 mg/kg in 2005, 0.011±0.002 mg/kg in 2006 and 0.011±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.013±0.002 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.012±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.010±0.002 mg/kg in 2006 and 2007 (Table 39 & Figure 23). Over the period of three years, average values were found to be 0.011±0.00 mg/kg during winter, 0.012±0.001 mg/kg during summer and 0.010±0.00 mg/kg during post monsoon period (Table 40).

At site-II, cadmium concentrations ranged from 0.012 mg/kg to 0.020 mg/kg with maximum during winter’ 06 and minimum during post monsoon seasons’05 and 07. During winter, mean concentration was found to be 0.013±0.004 mg/kg in 2005, 0.020±0.002 mg/kg in 2006 and 0.013±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.014±0.001 mg/kg in 2005, 0.014±0.001 mg/kg in 2006 and 0.015±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.012±0.002 mg/kg in 2005, 0.013±0.002 mg/kg in 2006 and 0.012±0.002
mg/kg in 2007 (Table 39 & Figure 24). Over the period of three years, average values were found to be 0.015±0.004 mg/kg during winter, 0.014±0.00 mg/kg during summer and 0.012±0.00 mg/kg during post monsoon period (Table 40).

At site-III, cadmium contents ranged from 0.012 mg/kg to 0.020 mg/kg with maximum during winter and post monsoon’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.014±0.005 mg/kg in 2005, 0.020±0.003 mg/kg in 2006 and 0.019±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.014±0.004 mg/kg in 2005, 0.016±0.002 mg/kg in 2006 and 0.017±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.012±0.004 mg/kg in 2005, 0.020±0.002 mg/kg in 2006 and 0.014±0.001 mg/kg in 2007 (Table 39 & Figure 25). Over the period of three years, average values were found to be 0.017±0.003 mg/kg during winter, 0.015±0.001 mg/kg during summer and 0.015±0.004 mg/kg during post monsoon period (Table 40).

At site-IV, cadmium levels ranged from 0.006 mg/kg to 0.019 mg/kg with maximum during winter’ 07 and minimum during winter’ 05. During winter, mean concentration was found to be 0.006±0.002 mg/kg in 2005, 0.016±0.001 mg/kg in 2006 and 0.019±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.010±0.002 mg/kg in 2005, 0.011±0.00 mg/kg in 2006 and 0.012±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.013±0.002 mg/kg in 2006 and 0.011±0.00 mg/kg in 2007 (Table 39 & Figure 26). Over the period of three years, average values were found to be 0.013±0.006 mg/kg during winter, 0.011±0.001 mg/kg during summer and 0.011±0.001 mg/kg during post monsoon period (Table 40).

**Trends:** The three years data reveals no definite seasonal trend in cadmium accumulation in the liver of *Labeo rohita*. Cadmium concentration in liver tissue has
been found to be maximum at site-III followed in decreasing order by site-II, site-IV and site-I.

**Muscle**

Cadmium contents varied in muscle during the three year study from BTL at site-I to 0.019 mg/kg at site-III (Table 39). Table 40 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, cadmium concentrations ranged from BTL to 0.013 mg/kg with maximum during winter’ 07 and minimum during winter’ 06. During winter, mean concentration was found to be 0.012±0.003 mg/kg in 2005, BTL in 2006 and 0.013±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.010±0.00 mg/kg in 2005, 0.008±0.001 mg/kg in 2006 and 0.011±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.008±0.001 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.011±0.001 mg/kg in 2007 (Table 39 & Figure 23). Over the period of three years, average values were found to be 0.012±0.001 mg/kg during winter, 0.009±0.001 mg/kg during summer and 0.010±0.001 mg/kg during post monsoon period (Table 40).

At site-II, cadmium concentrations ranged from 0.009 mg/kg to 0.017 mg/kg with maximum during winter’ 06 and 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.015±0.003 mg/kg in 2005, 0.017±0.002 mg/kg in 2006 and 2007. During summer, mean concentration was found to be 0.011±0.001 mg/kg in 2005, 0.010±0.00 mg/kg in 2006 and 0.013±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.012±0.002 mg/kg in 2006 and 0.012±0.00 mg/kg in 2007 (Table 39 & Figure 24). Over the period of three years, average values were found to be
0.016±0.005 mg/kg during winter, 0.011±0.001 mg/kg during summer and post monsoon period (Table 40).

At site-III, cadmium contents ranged from 0.010 mg/kg to 0.019 mg/kg with maximum during winter’ 06, 07 and summer’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.012±0.002 mg/kg in 2005, 0.019±0.001 mg/kg in 2006 and 0.019±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.013±0.001 mg/kg in 2005, 0.012±0.001 mg/kg in 2006 and 0.019±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.010±0.00 mg/kg in 2005, 0.015±0.001 mg/kg in 2006 and 2007 (Table 39 & Figure 25). Over the period of three years, average values were found to be 0.018±0.006 mg/kg during winter, 0.014±0.003 mg/kg during summer and 0.013±0.002 mg/kg during post monsoon period (Table 40).

At site-IV, cadmium levels were between BTL and 0.018 mg/kg with maximum during winter’ 07 and minimum during summer and post monsoon’ 05. During winter, mean concentration was found to be 0.003±0.00 mg/kg in 2005, 0.015±0.002 mg/kg in 2006 and 0.018±0.003 mg/kg in 2007. During summer, mean concentration was found to be BTL in 2005, 0.010±0.001 mg/kg in 2006 and 0.013±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be BTL in 2005, 0.012±0.001 mg/kg in 2006 and 2007 (Table 39 & Figure 26). Over the period of three years, average values were found to be 0.012±0.007 mg/kg during winter, 0.011±0.002 mg/kg during summer and 0.012±0.00 mg/kg during post monsoon period (Table 40).

**Trends:** No seasonal trend of cadmium accumulation in muscle tissue of *Labeo rohita* is depicted. Among sites, the accumulation levels in muscle in muscle decrease in the order:
Kidney

Cadmium concentrations show variations in kidney during the entire period of study with minimum BTL at site-I and maximum 0.019 mg/kg at site-III (Table 39). Table 40 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, cadmium concentrations ranged from BTL to 0.014 mg/kg with maximum during winter’ 07 and minimum during winter’ 06. During inter, mean concentration was found to be 0.011±0.001 mg/kg in 2005, BTL in 2006 and 0.014±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.008±0.001 mg/kg in 2005, 0.008±0.00 mg/kg in 2006 and 0.011±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.006±0.001 mg/kg in 2005, 0.008±0.001 mg/kg in 2006 and 0.006±0.001 mg/kg in 2007 (Table 39 & Figure 23). Over the period of three years, average values were found to be 0.012±0.002 mg/kg during winter, 0.009±0.001 mg/kg during summer and 0.006±0.001 mg/kg during post monsoon period (Table 40).

At site-II, cadmium concentrations ranged from 0.010 mg/kg to 0.018 mg/kg with maximum during winter’ 07 and minimum during winter and summer’ 05. During winter, mean concentration was found to be 0.010±0.001mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.018±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.010±0.00 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.013±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.013±0.001 mg/kg in 2005, 0.012±0.001 mg/kg in 2006 and 0.014±0.001 mg/kg in 2007 (Table 39 and Figure 24). Over the period of three years, average
values were found to be 0.013±0.001 mg/kg during winter, 0.011±0.001 mg/kg during summer and 0.013±0.001 mg/kg during post monsoon period (Table 40).

At site-III, cadmium contents ranged from 0.009 mg/kg to 0.019 mg/kg with maximum during winter’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.012±0.005 mg/kg in 2005, 0.013±0.001 mg/kg in 2006 and 0.019±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.013±0.001 mg/kg in 2005, 0.015±0.001 mg/kg in 2006 and 0.015±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.009±0.00 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.010±0.00 mg/kg in 2007 (Table 39 and Figure 25). Over the period of three years, average values were found to be 0.014±0.003 mg/kg during winter, 0.014±0.001 mg/kg during summer and 0.010±0.001 mg/kg during post monsoon period (Table 40).

At site-IV, cadmium levels were between 0.007 mg/kg and 0.018 mg/kg with maximum during winter’ 07 and minimum during winter’ 06. During winter, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.007±0.006 mg/kg in 2006 and 0.018±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.010±0.001 in 2005, 0.009±0.00 mg/kg in 2006 and 0.013±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.008±0.002 mg/kg in 2005, 0.008±0.001 mg/kg in 2006 and 0.008±0.001 mg/kg in 2007 (Table 39 & Figure 26). Over the period of three years, average values were found to be 0.011±0.005 mg/kg during winter, 0.010±0.002 mg/kg during summer and 0.008±0.00 mg/kg during post monsoon period (Table 40).

**Trends:** The three years data reveals no definite seasonal trend in accumulation of cadmium in kidney of *Labeo rohita*. Among sites, the order is site-III > site-II > site-IV > site-I.
Brain

Cadmium concentrations show variations in brain during the entire period of study with minimum BTL and maximum 0.015 mg/kg at site-III (Table 39). Table 40 shows summary comprising mean and standard deviation at the selected sites of the river during the entire period of study.

At site-I, cadmium levels ranged from BTL to 0.005 mg/kg with maximum during winter’ 07. During winter, mean concentration was found to be BTL in 2005, 2006 and 0.005±0.002 mg/kg in 2007. During summer, mean concentration was found to be BTL in 2005, 2006 and 2007. During post monsoon, mean concentration was found to be BTL in 2005, 0.003±0.00 mg/kg in 2006 and BTL in 2007 (Table 39 & Figure 23). Over the period of three years, average values were found to be 0.005±0.002 mg/kg during winter, BTL during summer and 0.003±0.00 mg/kg during post monsoon period (Table 40).

At site-II, cadmium concentrations ranged from BTL to 0.008 mg/kg with maximum during winter’ 07. During winter, mean concentration was found to be BTL in 2005, 2006 and 0.008±0.001 mg/kg in 2007. During summer, mean concentration was found to be BTL in 2005, 2006 and 2007. During post monsoon, mean concentration was found to be BTL in 2005, 0.005±0.001 in 2006 and BTL in 2007 (Table 39 & Figure 24). Over the period of three years, average values were found to be 0.008±0.001 mg/kg during winter, BTL during summer and 0.005±0.001 mg/kg during post monsoon period (Figure 40).

At site-III, cadmium contents ranged from BTL to 0.015 mg/kg with maximum during summer’ 07. During winter, mean concentration was found to be BTL in 2005, 2006 and 0.011±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.005±0.003 mg/kg in 2005, 0.004±0.001 mg/kg in 2006 and 0.015±0.001
mg/kg in 2007. During post monsoon, mean concentration was found to be BTL in 2005, 0.006±0.001 mg/kg in 2006 and BTL in 2007 (Table 39 & Figure 25). Over the period of three years, average values were found to be 0.011±0.001 mg/kg during winter, 0.008±0.006 mg/kg during summer and 0.006±0.001 mg/kg during post monsoon period (Table 40).

At site-IV, cadmium levels were between BTL and 0.006 mg/kg with maximum during winter’ 07. During winter, mean concentration was found to be BTL in 2005, 2006 and 0.006±0.001 mg/kg in 2007. During summer, mean concentration was found to be BTL in 2005, 2006 and 2007. During post monsoon, mean concentration was found to be BTL in 2005, 0.003±0.001 mg/kg in 2006 and BTL in 2007 (Table 39 & Figure 26). Over the period of three years, average values were found to be 0.006±0.001 mg/kg during winter, BTL during summer and 0.003±0.001 mg/kg during post monsoon period (Table 40).

**Trends:** The three year data shows no seasonal trend in the accumulation of cadmium in the brain. Most of the time, the accumulation levels remained below detection level at site-I, site-II and site-IV. At Site-III, cadmium levels were comparatively higher.

Among various tissues of *Labeo rohita*, cadmium contents were found to be accumulated maximum in liver, minimum in brain and intermediate in muscle and kidney with no clearcut indication of any trend.

1.2 *Cyprinus carpio* Linnaeus:

**Liver**

In *Cyprinus carpio*, cadmium concentrations show variations in liver during the whole period of study with minimum 0.015 mg/kg at site-I and maximum 0.021 mg/kg at site-III (Table 41). Table 42 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.
At site-I, cadmium concentrations ranged from 0.015 mg/kg to 0.017 mg/kg with maximum during summer’ 07 and minimum during winter’ 07 and post monsoon’ 05 and 06. During winter, mean concentration was found to be 0.016±0.002 mg/kg in 2005, 0.016±0.003 mg/kg in 2006 and 0.015±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.016±0.002 mg/kg in 2005, 0.016±0.003 mg/kg in 2006 and 0.017±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.015±0.001 mg/kg in 2005, 0.015±0.002 mg/kg in 2006 and 0.016±0.003 mg/kg in 2007 (Table 4 & Figure 27). Over the period of three years, average values were found to be 0.015±0.00 mg/kg during winter, 0.016±0.00 mg/kg during summer and 0.015±0.00 mg/kg during post monsoon period (Table 4).

At site-II, cadmium concentrations ranged from 0.016 mg/kg to 0.019 mg/kg with maximum during summer’ 05 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.017±0.003 mg/kg in 2005, 0.018±0.003 mg/kg in 2006 and 0.017±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.019±0.004 mg/kg in 2005, 0.018±0.003 mg/kg in 2006 and 0.017±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.017±0.002 mg/kg in 2005, 0.016±0.002 mg/kg in 2006 and 0.018±0.004 mg/kg in 2007 (Table 41 & Figure 28). Over the period of three years, average values were found to be 0.017±0.00 mg/kg during winter, 0.018±0.001 mg/kg during summer and 0.017±0.001 mg/kg during post monsoon period (Table 4).

At site-III, cadmium contents ranged from 0.019 mg/kg to 0.021 mg/kg with maximum during winter’ 06, summer’ 05 and post monsoon’ 05 and minimum during winter’ 05 and post monsoon’ 07. During winter, mean concentration was found to be 0.019±0.003 mg/kg in 2005, 0.021±0.004 mg/kg in 2006 and 0.020±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.021±0.004 mg/kg in
2005, 0.020±0.002 mg/kg in 2006 and 0.020±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.021±0.003 mg/kg in 2005, 0.020±0.003 mg/kg in 2006 and 0.019±0.002 mg/kg in 2007 (Table 41 & Figure 29). Over the period of three years, average values were found to be 0.020±0.001 mg/kg during winter, summer and post monsoon period (Table 42).

At site-IV, cadmium levels ranged from 0.017 mg/kg to 0.020 mg/kg with maximum during winter’ 06 and minimum during winter’05 and post monsoon’ 05 and 06. During winter, mean concentration was found to be 0.017±0.004 mg/kg in 2005, 0.020±0.002 mg/kg in 2006 and 0.019±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.018±0.003 mg/kg in 2005, 0.018±0.002 mg/kg in 2006 and 0.018±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.017±0.002 mg/kg in 2005, 0.017±0.003 mg/kg in 2006 and 0.018±0.002 mg/kg in 2007 (Table 41 & Figure 30). Over the period of three years, average values were found to be 0.018±0.001 mg/kg during winter, 0.018±0.00 mg/kg during summer and 0.017±0.002 mg/kg during post monsoon period (Table 42).

**Trends:** The three years data reveals no definite seasonal trend in accumulation of cadmium in liver of *Cyprinus carpio*. Among sites, the order is site-III > site-IV > site-II > site-I.

**Muscle**

Cadmium contents show variations in muscle during the entire period of study with minimum 0.011 mg/kg at site-I, II and IV and maximum 0.019 mg/kg at site-III (Table 41). Table 42 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, cadmium concentrations ranged from 0.011 mg/kg to 0.015 mg/kg with maximum during post monsoon’ 06 and minimum during summer’ 06. During winter,
mean concentration was found to be 0.012±0.001 mg/kg in 2005, 0.014±0.002 in 2006 and 0.012±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.014±0.002 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.014±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.012±0.001 mg/kg in 2005, 0.015±0.002 mg/kg in 2006 and 0.012±0.001 mg/kg in 2007 (Table 41 & Figure 27). Over the period of three years, average values were found to be 0.012±0.001 mg/kg during winter, 0.013±0.001 mg/kg during summer and post monsoon period (Table 42).

At site-II, cadmium concentrations ranged from 0.011 mg/kg to 0.015 mg/kg with maximum during winter’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.012±0.001 mg/kg in 2005, 0.014±0.001 mg/kg in 2006 and 0.015±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.012±0.002 mg/kg in 2005, 0.012±0.001 mg/kg in 2006 and 0.014±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.011±0.001 mg/kg in 2005, 0.013±0.002 mg/kg in 2006 and 0.012±0.002 mg/kg in 2007 (Table 41 & Figure 28). Over the period of three years, average values were found to be 0.013±0.001 mg/kg during winter, 0.012±0.001 mg/kg during summer and 0.012±0.001 mg/kg during post monsoon period (Table 42).

At site-III, cadmium contents ranged from 0.015 mg/kg to 0.019 mg/kg with maximum during summer’ 06 and minimum during winter’ 05 and post monsoon’ 05 and 06. During winter, mean concentration was found to be 0.015±0.005 mg/kg in 2005, 0.017±0.004 mg/kg in 2006 and 0.016±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.017±0.003 mg/kg in 2005, 0.019±0.003 mg/kg in 2006 and 0.016±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.015±0.002 mg/kg in 2005, 0.015±0.003 mg/kg in 2006 and
0.016±0.001 mg/kg in 2007 (Table 41 & Figure 29). Over the period of three years, average values were found to be 0.016±0.001 mg/kg during winter, 0.017±0.001 mg/kg during summer and 0.015±0.002 mg/kg during post monsoon period (Table 42).

At site-IV, cadmium levels were between 0.011 mg/kg and 0.015 mg/kg with maximum during winter’ 07, summer’ 06 and 07, and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.014±0.002 mg/kg in 2005, 0.012±0.002 mg/kg in 2006 and 0.015±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.014±0.002 in 2005, 0.015±0.001 mg/kg in 2006 and 0.015±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.011±0.001 in 2005, 0.012±0.002 mg/kg in 2006 and 0.012±0.001 mg/kg in 2007 (Table 41 & Figure 30). Over the period of three years, average values were found to be 0.013±0.001 mg/kg during winter, 0.014±0.00 mg/kg during summer and 0.011±0.001 mg/kg during post monsoon period (Table 42).

**Trends:** The three year data shows no definite seasonal trend in cadmium accumulation in muscle of *Cyprinus carpio*. Among sites, cadmium accumulation in muscle is maximum at site-III, minimum at site-I and intermediate at site-II and site-IV.

**Kidney**

Cadmium concentrations show variations in kidney during the entire period of study with minimum 0.012 mg/kg at site-I and IV and maximum 0.019 mg/kg at site-III (Table 41). Table 42 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, cadmium levels ranged from 0.012 mg/kg to 0.015 mg/kg with maximum during winter and summer’ 07 and minimum 0.012 mg/kg during post
monsoon’ 06. During winter, mean concentration was found to be 0.013±0.002 mg/kg in 2005, 0.014±0.003 mg/kg in 2006 and 0.015±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.014±0.003 mg/kg in 2005, 0.014±0.002 mg/kg in 2006 and 0.015±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.014±0.002 mg/kg in 2005, 0.012±0.001 mg/kg in 2006 and 0.013±0.002 mg/kg in 2007 (Table 41 & Figure 27). Over the period of three years, average values were found to be 0.014±0.001 mg/kg during winter, 0.014±0.00 mg/kg during summer and 0.013±0.001 mg/kg during post monsoon period (Table 42).

At site-II, cadmium concentrations ranged from 0.014 mg/kg to 0.017 mg/kg with maximum during summer’ 07 and minimum during winter’ 05 and all post monsoon period. During winter, mean concentration was found to be 0.014±0.003 mg/kg in 2005, 0.015±0.003 mg/kg in 2006 and 0.016±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.016±0.002 mg/kg in 2005, 2006 and 0.017±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.014±0.002 mg/kg in 2005, 2006 and 0.014±0.003 mg/kg in 2007 (Table 41 & Figure 28). Over the period of three years, average values were found to be 0.015±0.001 mg/kg during winter, 0.016±0.001 mg/kg during summer and 0.014±0.001 mg/kg during post monsoon period (Table 42).

At site-III, cadmium contents ranged from 0.016 mg/kg to 0.019 mg/kg with maximum all during summer periods and minimum during winter’ 05 and post monsoon’ 07. During winter, mean concentration was found to be 0.016±0.002 mg/kg in 2005, 0.017±0.003 mg/kg in 2006 and 2007. During summer, mean concentration was found to be 0.019±0.003 mg/kg in 2005, 0.019±0.002 mg/kg in 2006 and 2007. During post monsoon, mean concentration was found to be 0.017±0.002 mg/kg in
2005, 0.017±0.003 mg/kg in 2006 and 0.016±0.004 mg/kg in 2007 (Table 41 & Figure 29). Over the period of three years, average values were found to be 0.016±0.001 mg/kg during winter, 0.019±0.00 mg/kg during summer and 0.016±0.00 mg/kg during post monsoon period (Table 42).

At site-IV, cadmium levels were between 0.012 mg/kg and 0.018 mg/kg with maximum during summer and post monsoon’ 07 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.016±0.002 mg/kg in 2005, 0.015±0.003 mg/kg in 2006 and 0.016±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.014±0.001 in 2005, 0.015±0.002 mg/kg in 2006 and 0.018±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.014±0.003 mg/kg in 2005, 0.012±0.001 mg/kg in 2006 and 0.018±0.002 mg/kg in 2007 (Table 41 & Figure 30). Over the period of three years, average values were found to be 0.015±0.00 mg/kg during winter, 0.015±0.002 mg/kg during summer and 0.014±0.003 mg/kg during post monsoon period (Table 42).

**Trends:** The three year study reveals no seasonal trend in cadmium accumulation in kidney of *Cyprinus carpio*. Cadmium accumulation in kidney is maximum at site-III, followed in decreasing order by site-II, site-IV and site-I.

**Brain**

Cadmium concentrations show variations in brain during the entire period of study with minimum BTL at site-I and maximum 0.009 mg/kg at site- II and III (Table 41). Table 42 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, cadmium levels ranged from BTL to 0.008 mg/kg with maximum during post monsoon’ 06 and minimum during winter’ 06. During winter, mean concentration was found to be 0.007±0.002 in 2005, BTL in 2006 and 0.005±0.002
mg/kg in 2007. During summer, mean concentration was found to be 0.006±0.00 in 2005, 0.006±0.001 in 2006 and 0.005 0.001 in 2007. During post monsoon, mean concentration was found to be 0.007±0.002 in 2005, 0.008±0.00 mg/kg in 2006 and 0.007±0.001 in 2007 (Table 4 & Figure 27). Over the period of three years, average values were found to be 0.006±0.001 mg/kg during winter, 0.005±0.00 during summer and 0.007±0.00 mg/kg during post monsoon period (Table 42).

At site-II, cadmium concentrations ranged from 0.006 mg/kg to 0.009 mg/kg with maximum during winter’ 06, 07 and summer’ 06 and minimum during winter’ 05 and post monsoon’ 07. During winter, mean concentration was found to be 0.006±0.001 in 2005, 0.009±0.001 in 2006 and 0.009±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.007±0.001 in 2005, 0.009±0.002 in 2006 and 0.008±0.001 in 2007. During post monsoon, mean concentration was found to be 0.008±0.001 in 2005, 0.007±0.002 in 2006 and 0.006±0.001 in 2007 (Table 41 & Figure 28). Over the period of three years, average values were found to be 0.008±0.001 mg/kg during winter and summer and 0.007±0.001 mg/kg during post monsoon period (Table 42).

At site-III, cadmium contents ranged from 0.006 mg/kg to 0.009 mg/kg with maximum during summer’ 05 and winter and post monsoon’ 06 and minimum during winter and post monsoon’ 07. During winter, mean concentration was found to be 0.007±0.00 in 2005, 0.009±0.002 in 2006 and 0.006±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.002 mg/kg in 2005, 0.007±0.001 mg/kg in 2006 and 0.007±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.007±0.001 in 2005, 0.009±0.001 mg/kg in 2006 and 0.006±0.001 in 2007 (Table 41 & Figure 29). Over the period of three years,
average values were found to be 0.007±0.001 mg/kg during winter, summer and post monsoon period (Table 42).

At site-IV, cadmium levels were between 0.006 mg/kg and 0.008 mg/kg with maximum during summer’ 05 and post monsoon’ 07 and minimum during post monsoon’ 06 and winter’ 07. During winter, mean concentration was found to be 0.007±0.001 in 2005 and 2006 and 0.006±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.008±0.002 in 2005, 0.007±0.001 in 2006 and 0.007±0.002 in 2007. During post monsoon, mean concentration was found to be 0.007±0.001 in 2005, 0.006±0.001 mg/kg in 2006 and 0.008±0.002 in 2007 (Table 41 & Figure 30). Over the period of three years, average values were found to be 0.006±0.001 mg/kg during winter, 0.007±0.001 during summer and post monsoon period (Table 40).

**Trends:** From the data, no definite seasonal trend is indicated. Cadmium accumulation is higher at site-II and III as compared to site-IV and minimum at site-I.

The three year data on cadmium accumulation in various tissues of *Cyprinus carpio* show maximum concentrations in liver followed in decreasing order by kidney, muscle and brain.

1.3 *Mystus seenghala* (Sykes):

**Liver**

In *Mystus seenghala*, cadmium concentrations show variations in liver during the whole period of study with minimum 0.020 mg/kg at site-I and maximum 0.035 mg/kg at site-III (Table 43). Table 44 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, cadmium concentrations ranged from 0.020 mg/kg to 0.024 mg/kg with maximum during post monsoon’ 05 and minimum during winter’ 05, 07 and post
monsoon’ 07. During winter, mean concentration was found to be 0.020±0.001 mg/kg in 2005, 0.023±0.002 mg/kg in 2006 and 0.020±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.021±0.002 mg/kg in 2005, 0.022±0.001 mg/kg in 2006 and 0.022±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.024±0.001 mg/kg in 2005, 0.021±0.002 mg/kg in 2006 and 0.020±0.001 mg/kg in 2007 (Table 43 & Figure 31). Over the period of three years, average values were found to be 0.021±0.001 mg/kg during winter, summer and 0.021±0.002 mg/kg during post monsoon period (Table 44).

At site-II, cadmium concentrations ranged from 0.022 mg/kg to 0.028 mg/kg with maximum during summer’ 07 and minimum during summer’ 06. During winter, mean concentration was found to be 0.024±0.001 mg/kg in 2005, 0.026±0.002 mg/kg in 2006 and 0.023±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.025±0.002 mg/kg in 2005, 0.022±0.001 mg/kg in 2006 and 0.028±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.027±0.001 mg/kg in 2005, 0.026±0.002 mg/kg in 2006 and 0.024±0.002 mg/kg in 2007 (Table 43 & Figure 32). Over the period of three years, average values were found to be 0.024±0.001 mg/kg during winter, 0.025±0.003 mg/kg during summer and 0.025±0.001 mg/kg during post monsoon period (Table 44).

At site-III, cadmium contents ranged from 0.026 mg/kg to 0.035 mg/kg with maximum during post monsoon’ 06 and minimum during summer’ 05. During winter, mean concentration was found to be 0.028±0.005 mg/kg in 2005, 0.027±0.004 mg/kg in 2006 and 0.030±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.026±0.003 mg/kg in 2005, 0.033±0.003 mg/kg in 2006 and 0.031±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.031±0.003 mg/kg in 2005, 0.035±0.003 mg/kg in 2006 and 0.033±0.001 mg/kg in
2007 (Table 43 & Figure 33). Over the period of three years, average values were found to be 0.028±0.001 mg/kg during winter, 0.030±0.003 mg/kg during summer and 0.033±0.002 mg/kg during post monsoon period (Table 44).

At site-IV, cadmium levels ranged from 0.025 mg/kg to 0.031 mg/kg with maximum during post monsoon’ 07 and minimum during summer’07. During winter, mean concentration was found to be 0.027±0.002 mg/kg in 2005, 0.029±0.002 mg/kg in 2006 and 0.030±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.028±0.002 mg/kg in 2005, 0.027±0.001 mg/kg in 2006 and 0.025±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.028±0.001 mg/kg in 2005, 0.026±0.002 mg/kg in 2006 and 0.031±0.001 mg/kg in 2007 (Table 43 & Figure 34). Over the period of three years, average values were found to be 0.028±0.001 mg/kg during winter, 0.026±0.001 mg/kg during summer and 0.028±0.002 mg/kg during post monsoon period (Table 44).

**Trends:** From the three year data, no seasonal trend in cadmium accumulation in the liver of *Mystus seenghala* is indicated. The cadmium accumulation is maximum at site-III followed in decreasing order by site-IV, site-II and site-I.

**Muscle**

Cadmium contents show variations in muscle during the entire period of study with minimum 0.017 mg/kg at site-IV and maximum 0.029 mg/kg at site-III (Table 43). Table 44 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, cadmium concentrations ranged from 0.018 mg/kg to 0.021 mg/kg with maximum during winter’ 05 and, summer and post monsoon’ 06 and minimum during post monsoon’ 07. During winter, mean concentration was found to be 0.021±0.001 mg/kg in 2005, 0.019±0.002 in 2006 and 0.019±0.001 mg/kg in 2007. During
summer, mean concentration was found to be 0.019±0.001 mg/kg in 2005, 0.021±0.001 mg/kg in 2006 and 0.020±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.019±0.001 mg/kg in 2005, 0.021±0.002 mg/kg in 2006 and 0.018±0.001 mg/kg in 2007 (Table 43 & Figure 31). Over the period of three years, average values were found to be 0.019±0.001 mg/kg during winter, 0.020±0.001 mg/kg during summer and 0.019±0.001 mg/kg during post monsoon period (Table 44).

At site-II, cadmium concentrations ranged from 0.020 mg/kg to 0.028 mg/kg with maximum during post monsoon’ 07 and minimum during winter’ 05 and 07. During winter, mean concentration was found to be 0.020±0.002 mg/kg in 2005, 0.022±0.002 mg/kg in 2006 and 0.020±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.024±0.002 mg/kg in 2005, 0.021±0.001 mg/kg in 2006 and 0.025±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.023±0.002 mg/kg in 2005, 0.026±0.002 mg/kg in 2006 and 0.028±0.001 mg/kg in 2007 (Table 43 & Figure 32). Over the period of three years, average values were found to be 0.020±0.001 mg/kg during winter, 0.023±0.002 mg/kg during summer and 0.025±0.002 mg/kg during post monsoon period (Table 44).

At site-III, cadmium contents ranged from 0.023 mg/kg to 0.029 mg/kg with maximum during summer’ 06 and winter’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.027±0.004 mg/kg in 2005, 0.025±0.003 mg/kg in 2006 and 0.029±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.025±0.003 mg/kg in 2005, 0.029±0.002 mg/kg in 2006 and 0.027±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.023±0.001 mg/kg in 2005, 0.028±0.001 mg/kg in 2006 and 0.026±0.002 mg/kg in 2007 (Table 43 & Figure 33). Over the period of three years, average values
were found to be 0.027±0.002 mg/kg during winter, summer and 0.025±0.002 mg/kg during post monsoon period (Table 44).

At site-IV, cadmium levels ranged from 0.017 mg/kg to 0.021 mg/kg with maximum during post monsoon’ 05 and summer’ 07 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.019±0.001 mg/kg in 2005, 0.018±0.002 mg/kg in 2006 and 0.020±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.018±0.001 in 2005, 0.019±0.003 mg/kg in 2006 and 0.021±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.021±0.002 in 2005, 0.017±0.002 mg/kg in 2006 and 0.020±0.001 mg/kg in 2007 (Table 43 & Figure 34). Over the period of three years, average values were found to be 0.019±0.001 mg/kg during winter, summer and 0.019±0.002 mg/kg during post monsoon period (Table 44).

**Trends:** Any definite seasonal trend in cadmium accumulation of *Mystus seenghala* is not indicated. Cadmium concentration in muscle is maximum at site-III followed in decreasing order by site-II, site-IV and site-I.

**Kidney**

Cadmium concentrations show variations in kidney during the entire period of study with minimum 0.018 mg/kg at site-I, II and IV and maximum 0.029 mg/kg at site-III (Table 43). Table 44 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, cadmium concentrations ranged from 0.018 mg/kg to 0.022 mg/kg with maximum during winter’ 06 and minimum during summer’ 05. During winter, mean concentration was found to be 0.019±0.001 mg/kg in 2005, 0.022±0.002 mg/kg in 2006 and 0.020±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.018±0.002 mg/kg in 2005, 0.021±0.001 mg/kg in 2006 and 0.020±0.001
mg/kg in 2007. During post monsoon, mean concentration was found to be 0.019±0.001 mg/kg in 2005, 0.021±0.002 mg/kg in 2006 and 0.019±0.003 mg/kg in 2007 (Table 43 & Figure 31). Over the period of three years, average values were found to be 0.020±0.001 mg/kg during winter, 0.019±0.001 mg/kg during summer and post monsoon period (Table 44).

At site-II, cadmium concentration ranged from 0.018 mg/kg to 0.022 mg/kg with maximum during post monsoon’ 07 and minimum during winter and post monsoon’ 05. During winter, mean concentration was found to be 0.018±0.002 mg/kg in 2005, 0.019±0.001 mg/kg in 2006 and 0.021±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.019±0.003 mg/kg in 2005, 0.020±0.002 mg/kg in 2006 and 0.020±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.018±0.001 mg/kg in 2005, 0.019±0.002 mg/kg in 2006 and 0.022±0.002 mg/kg in 2007 (Table 43 & Figure 32). Over the period of three years, average values were found to be 0.019±0.001 mg/kg during winter, 0.019±0.00 mg/kg during summer and 0.019±0.002 mg/kg during post monsoon period (Table 44).

At site-III, cadmium contents ranged from 0.024 mg/kg to 0.029 mg/kg with maximum during summer’ 06 and post monsoon, 07 and minimum during post monsoon’ 05 and winter’ 07. During winter, mean concentration was found to be 0.027±0.004 mg/kg in 2005, 0.026±0.003 mg/kg in 2006 and 0.024±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.026±0.002 mg/kg in 2005, 0.029±0.003 mg/kg in 2006 and 0.028±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.024±0.003 mg/kg in 2005, 0.027±0.002 mg/kg in 2006 and 0.029±0.001 mg/kg in 2007 (Table 43 & Figure 33). Over the period of three years, average values were found to be 0.025±0.001 mg/kg.
during winter, 0.027±0.001 mg/kg during summer and 0.026±0.002 mg/kg during post monsoon period (Table 44).

At site-IV, cadmium levels were between 0.018 mg/kg and 0.025 mg/kg with maximum during summer’ 06 and minimum during winter’ 05. During winter, mean concentration was found to be 0.018±0.001 mg/kg in 2005, 0.022±0.002 mg/kg in 2006 and 0.023±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.019±0.002 in 2005, 0.025±0.003 mg/kg in 2006 and 0.022±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.020±0.002 mg/kg in 2005, 0.023±0.001 mg/kg in 2006 and 0.022±0.002 mg/kg in 2007 (Table 43 & Figure 34). Over the period of three years, average values were found to be 0.021±0.002 mg/kg during winter, 0.022±0.003 mg/kg during summer and 0.021±0.001 mg/kg during post monsoon period (Table 44).

**Trends:** The three year data reveals no definite seasonal trend of cadmium accumulation in kidney of *Mystus seenghala*. Among sites, maximum accumulation is seen at site-III followed by site-IV. At site-I and site-II, cadmium accumulation is more or less similar.

**Brain**

Cadmium concentrations show variations in brain during the entire period of study with minimum BTL at site-IV and maximum 0.013 mg/kg at site- III (Table 43). Table 44 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, cadmium levels ranged from 0.006 mg/kg to 0.011 mg/kg with maximum during post monsoon’ 07 and minimum summer’ 05. During winter, cadmium concentration was found to be 0.009±0.002 in 2005, 0.007±0.001 in 2006 and 0.009±0.002 mg/kg in 2007. During summer, mean concentration was found to be
0.006±0.00 in 2005, 0.010±0.001 in 2006 and 0.008±0.001 in 2007. During post monsoon, mean concentration was found to be 0.009±0.002 in 2005, 0.009±0.00 mg/kg in 2006 and 0.011±0.001 in 2007 (Table 43 & Figure 31). Over the period of three years, average values were found to be 0.008±0.001 mg/kg during winter, 0.008±0.002 during summer and 0.009±0.001 mg/kg during post monsoon period (Table 44).

At site-II, mean concentration ranged from 0.007 mg/kg to 0.010 mg/kg with maximum during post monsoon’ 06 and minimum during summer’ 05 and winter’ 06. During winter, mean concentration was found to be 0.008±0.001 in 2005, 0.007±0.001 in 2006 and 0.009±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.007±0.001 in 2005, 0.009±0.002 in 2006 and 0.008±0.001 in 2007. During post monsoon, mean concentration was found to be 0.008±0.001 in 2005, 0.010±0.002 in 2006 and 0.009±0.001 in 2007 (Table 43 & Figure 32). Over the period of three years, average values were found to be 0.008±0.001 mg/kg during winter, summer and 0.009±0.001 mg/kg during post monsoon period (Table 44).

At site-III, cadmium contents ranged from 0.009 mg/kg to 0.013 mg/kg with maximum during post monsoon’ 05 and winter’ 07 and minimum summer’ 05, winter’06 and post monsoon’ 07. During winter, mean concentration was found to be 0.011±0.00 in 2005, 0.009±0.002 in 2006 and 0.013±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.002 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.010±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.013±0.001 in 2005, 0.010±0.001 mg/kg in 2006 and 0.009±0.001 in 2007 (Table 43 & Figure 33). Over the period of three years, average values were found to be 0.011±0.002 mg/kg during winter, 0.010±0.001
1.4 Cirrhinus mrigala (Hamilton):

Liver

In Cirrhinus mrigala, cadmium concentrations show variations in liver during the whole period of study with minimum 0.015 mg/kg at site-I and maximum 0.024 mg/kg at site-III (Table 45). Table 46 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, cadmium concentrations ranged from 0.015 mg/kg to 0.023 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 05. During winter,
mean concentration was found to be $0.017 \pm 0.00$ mg/kg in 2005, $0.018 \pm 0.002$ mg/kg in 2006 and $0.020 \pm 0.002$ mg/kg in 2007. During summer, mean concentration was found to be $0.017 \pm 0.003$ mg/kg in 2005, $0.020 \pm 0.003$ mg/kg in 2006 and $0.023 \pm 0.002$ mg/kg in 2007. During post monsoon, mean concentration was found to be $0.015 \pm 0.002$ mg/kg in 2005, $0.017 \pm 0.002$ mg/kg in 2006 and $0.020 \pm 0.003$ mg/kg in 2007 (Table 45 & Figure 35). Over the period of three years, average values were found to be $0.018 \pm 0.001$ mg/kg during winter, $0.020 \pm 0.003$ mg/kg during summer and $0.017 \pm 0.002$ mg/kg during post monsoon period (Table 46).

At site-II, cadmium concentrations ranged from 0.016 mg/kg to 0.020 mg/kg with maximum during winter and summer’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be $0.019 \pm 0.003$ mg/kg in 2005, $0.020 \pm 0.002$ mg/kg in 2006 and $0.019 \pm 0.002$ mg/kg in 2007. During summer, mean concentration was found to be $0.018 \pm 0.002$ mg/kg in 2005, $0.020 \pm 0.002$ mg/kg in 2006 and $0.019 \pm 0.003$ mg/kg in 2007. During post monsoon, mean concentration was found to be $0.016 \pm 0.002$ mg/kg in 2005, $0.018 \pm 0.003$ mg/kg in 2006 and $0.017 \pm 0.002$ mg/kg in 2007 (Table 45 & Figure 36). Over the period of three years, average values were found to be $0.019 \pm 0.00$ mg/kg during winter, $0.019 \pm 0.001$ mg/kg during summer and $0.017 \pm 0.001$ mg/kg during post monsoon period (Table 46).

At site-III, cadmium contents ranged from 0.020 mg/kg to 0.024 mg/kg with maximum during winter and summer’ 07 and minimum during winter’ 05 and post monsoon’ 05 and 07 . During winter, mean concentration was found to be $0.020 \pm 0.004$ mg/kg in 2005, $0.023 \pm 0.002$ mg/kg in 2006 and $0.024 \pm 0.003$ mg/kg in 2007. During summer, mean concentration was found to be $0.021 \pm 0.004$ mg/kg in 2005, $0.022 \pm 0.002$ mg/kg in 2006 and $0.024 \pm 0.004$ mg/kg in 2007. During post monsoon, mean concentration was found to be $0.020 \pm 0.003$ mg/kg in 2005,
0.022±0.003 mg/kg in 2006 and 0.020±0.002 mg/kg in 2007 (Table 45 & Figure 37). Over the period of three years, average values were found to be 0.022±0.002 mg/kg during winter, 0.022±0.001 mg/kg during summer and 0.020±0.001 mg/kg during post monsoon period (Table 46).

At site-IV, cadmium levels ranged from 0.018 mg/kg to 0.023 mg/kg with maximum during summer’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.020±0.002 mg/kg in 2005, 0.021±0.002 mg/kg in 2006 and 0.019±0.004 mg/kg in 2007. During summer, mean concentration was found to be 0.020±0.003 mg/kg in 2005, 0.023±0.002 mg/kg in 2006 and 0.021±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.018±0.003 mg/kg in 2005, 0.020±0.002 mg/kg in 2006 and 0.020±0.004 mg/kg in 2007 (Table 45 & Figure 38). Over the period of three years, average values were found to be 0.020±0.001 mg/kg during winter, 0.021±0.001 mg/kg during summer and 0.019±0.001 mg/kg during post monsoon period (Table 46).

**Trends:** The data on cadmium accumulation in liver of *Cirrhinus mrigala* does not show any seasonal trend. Cadmium accumulation is maximum at site-III followed in decreasing order by site-IV, site-II and site-I.

**Muscle**

Cadmium contents show variations in muscle during the entire period of study with minimum 0.013 mg/kg at site-I and maximum 0.020 mg/kg at III (Table 45). Table 46 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, cadmium concentrations ranged from 0.013 mg/kg to 0.016 mg/kg with maximum during winter and post monsoon’ 07 and minimum during post monsoon’ 05 and 06. During winter, mean concentration was found to be 0.015±0.002 mg/kg in
2005, 0.014±0.003 in 2006 and 0.016±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.015±0.003 mg/kg in 2005, 0.015±0.002 mg/kg in 2006 and 0.015±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.013±0.002 mg/kg in 2005, 0.013±0.001 mg/kg in 2006 and 0.016±0.002 mg/kg in 2007 (Table 45 & Figure 35). Over the period of three years, average values were found to be 0.015±0.001 mg/kg during winter, 0.015±0.00 mg/kg during summer and 0.014±0.001 mg/kg during post monsoon period (Table 46).

At site-II, cadmium concentrations ranged from 0.014 mg/kg to 0.017 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.015±0.003 mg/kg in 2005, 2006 and 0.016±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.016±0.002 mg/kg in 2005, 2006 and 0.017±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.014±0.002 mg/kg in 2005, 0.015±0.002 mg/kg in 2006 and 0.016±0.003 mg/kg in 2007 (Table 45 & Figure 36). Over the period of three years, average values were found to be 0.015±0.00 mg/kg during winter, 0.016±0.00 mg/kg during summer and 0.015±0.001 mg/kg during post monsoon period (Table 46).

At site-III, cadmium contents ranged from 0.017 mg/kg to 0.020 mg/kg with maximum during summer’ 05 and minimum during all post monsoon periods and winter’ 07. During winter, mean concentration was found to be 0.018±0.002 mg/kg in 2005, 0.019±0.003 mg/kg in 2006 and 0.017±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.020±0.003 mg/kg in 2005, 0.019±0.002 mg/kg in 2006 and 2007. During post monsoon, mean concentration was found to be 0.017±0.002 mg/kg in 2005, 0.017±0.003 mg/kg in 2006 and in 2007 (Table 45 & Figure 37). Over the period of three years, average values were found to be
0.018±0.001 mg/kg during winter, 0.019±0.00 mg/kg during summer and 0.017±0.00 mg/kg during post monsoon period (Table 44).

At site-IV, cadmium levels ranged from 0.014 mg/kg to 0.020 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.017±0.002 mg/kg in 2005, 0.015±0.003 mg/kg in 2006 and 0.018±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.016±0.001 in 2005, 0.018±0.002 mg/kg in 2006 and 0.020±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.016±0.003 in 2005, 0.014±0.00 mg/kg in 2006 and 0.018±0.001 mg/kg in 2007 (Table 45 & Figure 38). Over the period of three years, average values were found to be 0.016±0.001 mg/kg during winter, 0.018±0.002 mg/kg during summer and 0.016±0.002 mg/kg during post monsoon period (Table 46).

**Trends:** As in other tissues, no seasonal trend in cadmium accumulation in muscle is indicated. The accumulation at various sites shows the order as site-III > site-IV > site-II > site-I.

**Kidney**

Cadmium concentrations show variations in kidney during the entire period of study with minimum 0.015 mg/kg at site-I and maximum 0.021 mg/kg at site-III (Table 45). Table 46 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, cadmium concentrations ranged from 0.015 mg/kg to 0.017 mg/kg with maximum during summer’ 05 and 07, winter’ 06 and 07 and minimum during post monsoon’ 05 and 06. During winter, mean concentration was found to be 0.016±0.002
mg/kg in 2005, 0.017±0.00 mg/kg in 2006 and 0.017±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.017±0.003 mg/kg in 2005, 0.016±0.003 mg/kg in 2006 and 0.017±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.015±0.001 mg/kg in 2005, 0.015±0.002 mg/kg in 2006 and 0.016±0.003 mg/kg in 2007 (Table 45 & Figure 35). Over the period of three years, average values were found to be 0.016±0.00 mg/kg during winter, 0.016±0.00 mg/kg during summer and 0.015±0.00 mg/kg during post monsoon period (Table 46).

At site-II, cadmium concentrations ranged from 0.016 mg/kg to 0.020 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.019±0.003 mg/kg in 2005, 0.018±0.003 mg/kg in 2006 and 0.017±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.019±0.002 mg/kg in 2005, 2006 and 0.020±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.017±0.002 mg/kg in 2005, 0.016±0.002 mg/kg in 2006 and 0.018±0.002 mg/kg in 2007 (Table 45 & Figure 36). Over the period of three years, average values were found to be 0.018±0.001 mg/kg during winter, 0.019±0.00 mg/kg during summer and 0.017±0.00 mg/kg during post monsoon period (Table 46).

At site-III, cadmium contents ranged from 0.018 mg/kg to 0.021 mg/kg with maximum during summer’ 05 and 06 and winter’ 06 and, minimum during summer’ 07. During winter, mean concentration was found to be 0.019±0.003 mg/kg in 2005, 0.021±0.004 mg/kg in 2006 and 0.020±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.021±0.004 mg/kg in 2005, 2006 and 0.018±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.020±0.00 mg/kg in 2005, 0.020±0.003 mg/kg in 2006 and 0.019±0.002 mg/kg in
2007 (Table 45 & Figure 37). Over the period of three years, average values were found to be 0.020±0.001 mg/kg during winter, summer and 0.019±0.001 mg/kg during post monsoon period (Table 46).

At site-IV, cadmium levels ranged from 0.017 mg/kg to 0.020 mg/kg with maximum during winter’ 06, summer’ 05 and 06 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.018±0.002 mg/kg in 2005, 0.020±0.002 mg/kg in 2006 and 0.019±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.020±0.003 in 2005, 2006 and 0.019±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.018±0.002 mg/kg in 2005, 0.017±0.003 mg/kg in 2006 and 0.018±0.002 mg/kg in 2007 (Table 45 & Figure 38). Over the period of three years, average values were found to be 0.019±0.001 mg/kg during winter, summer and 0.017±0.00 mg/kg during post monsoon period (Table 46).

**Trends:** No seasonal pattern is indicated from the three year data. Similar pattern of cadmium accumulation in kidney at various sites is revealed i.e. site-III > site-IV > site-II > site-I.

**Brain**

Cadmium concentrations show variations in brain during the entire period of study with minimum 0.007 mg/kg at site-I and IV maximum 0.012 mg/kg at site-III Table 45. Table 46 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, cadmium levels ranged from 0.007 mg/kg to 0.009 mg/kg with maximum during post monsoon’ 05 and 07, summer’ 05 and winter’ 06 and minimum winter’ 05 and 07. During winter, mean concentration was found to be 0.007±0.002 in 2005, 0.009±0.001 in 2006 and 0.007±0.002 mg/kg in 2007. During summer, mean
concentration was found to be 0.009±0.00 in 2005, 0.008±0.001 in 2006 and 2007. During post monsoon, mean concentration was found to be 0.009±0.002 in 2005, 0.008±0.00 mg/kg in 2006 and 0.009±0.001 in 2007 (Table 45 & Figure 35). Over the period of three years, average values were found to be 0.007±0.001 mg/kg during winter, 0.008±0.00 during summer and post monsoon period (Table 46).

At site-II, cadmium concentrations ranged from 0.008 mg/kg to 0.009 mg/kg. During winter, mean concentration was found to be 0.008±0.001 in 2005, 0.009±0.001 in 2006 and 0.009±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.008±0.001 in 2005, 0.009±0.002 in 2006 and 0.009±0.001 in 2007. During post monsoon, mean concentration was found to be 0.008±0.001 in 2005, 0.009±0.002 in 2006 and 0.009±0.00 in 2007 (Table 45 & Figure 36). Over the period of three years, average values were found to be 0.008±0.001 mg/kg during winter, summer and post monsoon period (Table 46).

At site-III, cadmium contents ranged from 0.008 mg/kg to 0.012 mg/kg with maximum during winter’ 06 and minimum during post monsoon’ 05, winter and summer’ 07. During winter, mean concentration was found to be 0.010±0.00 in 2005, 0.012±0.002 in 2006 and 0.008±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.002 mg/kg in 2005, 0.009±0.001 mg/kg in 2006 and 0.008±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.008±0.001 in 2005, 0.009±0.001 mg/kg in 2006 and 2007 (Table 45 & Figure 37). Over the period of three years, average values were found to be 0.010±0.002 mg/kg during winter, 0.008±0.001 mg/kg during summer and 0.008±0.00 mg/kg during post monsoon period (Table 46).

At site-IV, cadmium levels were between 0.007 mg/kg and 0.009 mg/kg. During winter, mean concentration was found to be 0.007±0.001 in 2005, 2006 and
0.009±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.008±0.002 in 2005, 0.007±0.001 in 2006 and 0.009±0.002 in 2007. During post monsoon, mean concentration was found to be 0.007±0.001 in 2005, 0.009±0.001 mg/kg in 2006 and 0.009±0.002 in 2007 (Table 45 & Figure 38). Over the period of three years, average values were found to be 0.007±0.001 mg/kg during winter, 0.008±0.001 during summer and post monsoon period (Table 46).

**Trends:** Seasonal trend is not indicated in cadmium accumulation in brain of *Cirrhinus mrigala* also. Among sites, maximum cadmium accumulation in *Cirrhinus mrigala* is at site-III followed by site-II. At site-I and IV, it is more or less similar.

A comparison of the cadmium accumulation in various tissues of *Cirrhinus mrigala* shows the pattern as:

Liver > Kidney > Muscle > Brain

Among various fish species, cadmium accumulation shows the following pattern:

*Mystus seenghala* > *Cirrhinus mrigala* > *Cyprinus carpio* > *Labeo rohita*

2. Chromium

2.1 *Labeo rohita* (Hamilton):

**Liver**

In *Labeo rohita*, chromium concentrations show variations in liver during the whole period of study with minimum 0.032 mg/kg at site-IV and maximum 0.069 mg/kg at site-III (Table 47). Table 48 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, chromium concentrations ranged from 0.038 mg/kg to 0.045 mg/kg with maximum during winter’ 06 and 07 and, minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.041±0.004 mg/kg in 2005, 0.045±0.002 mg/kg in 2006 and 0.045±0.004 mg/kg in 2007. During summer, mean concentration
was found to be 0.042±0.002 mg/kg in 2005, 0.041±0.001 mg/kg in 2006 and 0.044±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.038±0.001 mg/kg in 2005, 0.043±0.003 mg/kg in 2006 and 0.044±0.002 mg/kg in 2007 (Table 47 & Figure 39). Over the period of three years, average values were found to be 0.043±0.002 mg/kg during winter, 0.042±0.001 mg/kg during summer and 0.041±0.003 mg/kg during post monsoon period (Table 48).

At site-II, chromium concentrations ranged from 0.045 mg/kg to 0.059 mg/kg with maximum during winter’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.047±0.006 mg/kg in 2005, 0.051±0.001 mg/kg in 2006 and 0.059±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.047±0.001 mg/kg in 2005, 0.046±0.002 mg/kg in 2006 and 0.051±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.045±0.003 mg/kg in 2005, 0.046±0.004 mg/kg in 2006 and 0.047±0.001 mg/kg in 2007 (Table 47 & Figure 40). Over the period of three years, average values were found to be 0.052±0.006 mg/kg during winter, 0.048±0.002 mg/kg during summer and 0.046±0.001 mg/kg during post monsoon period (Table 48).

At site-III, chromium contents ranged from 0.056 mg/kg to 0.069 mg/kg with maximum during winter’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.061±0.003 mg/kg in 2005, 0.069±0.004 mg/kg in 2006 and 0.057±0.004 mg/kg in 2007. During summer, mean concentration was found to be 0.061±0.002 mg/kg in 2005, 0.057±0.002 mg/kg in 2006 and 0.061±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.056±0.005 mg/kg in 2005, 0.059±0.004 mg/kg in 2006 and 0.058±0.004 mg/kg in 2007 (Table 47 & Figure 41). Over the period of three years, average values were
found to be 0.062±0.006 mg/kg during winter, 0.059±0.002 mg/kg during summer and 0.057±0.001 mg/kg during post monsoon period (Table 4).

At site-IV, chromium levels ranged from 0.032 mg/kg to 0.049 mg/kg with maximum during winter’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.037±0.002 mg/kg in 2005, 0.049±0.003 mg/kg in 2006 and 0.048±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.038±0.002 mg/kg in 2005, 0.044±0.002 mg/kg in 2006 and 0.046±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.032±0.002 mg/kg in 2005, 0.045±0.003 mg/kg in 2006 and 0.046±0.001 mg/kg in 2007 (Table 47 & Figure 42). Over the period of three years, average values were found to be 0.044±0.006 mg/kg during winter, 0.042±0.004 mg/kg during summer and 0.041±0.007 mg/kg during post monsoon period (Table 48).

**Trends:** The data on chromium accumulation in liver of *Labeo rohita* does not show any seasonal pattern. The chromium accumulation is maximum at site-III followed by site-II. Between site-I and IV, chromium accumulation is more at site-IV most of the time.

**Muscle**

Chromium concentrations show variations in muscle during the entire period of study with minimum 0.030 mg/kg at site-I and IV and maximum 0.057 mg/kg at site-III (Table 47). Table 48 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, chromium concentrations ranged from 0.030 mg/kg to 0.041 mg/kg with maximum during winter’ 07 and post monsoon’ 06 and minimum during summer’ 06. During winter, mean concentration was found to be 0.033±0.003 mg/kg in 2005, 0.040±0.003 in 2006 and 0.041±0.003 mg/kg in 2007. During summer, mean
concentration was found to be 0.035±0.002 mg/kg in 2005, 0.030±0.001 mg/kg in 2006 and 0.038±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.033±0.003 mg/kg in 2005, 0.041±0.001 mg/kg in 2006 and 0.034±0.001 mg/kg in 2007 (Table 47 & Figure 39). Over the period of three years, average values were found to be 0.038±0.004 mg/kg during winter, 0.034±0.004 mg/kg during summer and 0.036±0.004 mg/kg during post monsoon period (Table 48).

At site-II, chromium concentrations ranged from 0.035 mg/kg to 0.061 mg/kg with maximum during winter’ 07 and minimum during summer’ 06. During winter, mean concentration was found to be 0.045±0.002 mg/kg in 2005, 0.051±0.001 mg/kg in 2006 and 0.061±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.046±0.002 mg/kg in 2005, 0.035±0.002 mg/kg in 2006 and 0.040±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.043±0.002 mg/kg in 2005, 0.046±0.003 mg/kg in 2006 and 0.041±0.002 mg/kg in 2007 (Table 47 & Figure 40). Over the period of three years, average values were found to be 0.052±0.008 mg/kg during winter, 0.040±0.005 mg/kg during summer and 0.043±0.002 mg/kg during post monsoon period (Table 48).

At site-III, chromium contents ranged from 0.049 mg/kg to 0.057 mg/kg with maximum during winter’ 06 and minimum during post monsoon’ 07. During winter, mean concentration was found to be 0.056±0.001 mg/kg in 2005, 0.057±0.001 mg/kg in 2006 and 0.053±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.054±0.001 mg/kg in 2005, 0.050±0.002 mg/kg in 2006 and 2007. During post monsoon, mean concentration was found to be 0.053±0.003 mg/kg in 2005, 0.051±0.002 mg/kg in 2006 and 0.049±0.004 mg/kg in 2007 (Table 47 & Figure 41). Over the period of three years, average values were found to be
0.055±0.002 mg/kg during winter, 0.051±0.002 mg/kg during summer and post monsoon period (Table 48).

At site-IV, chromium levels ranged from 0.030 mg/kg to 0.043 mg/kg with maximum during winter and post monsoon’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.031±0.002 mg/kg in 2005, 0.043±0.001 mg/kg in 2006 and 0.042±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.032±0.001 mg/kg in 2005, 0.034±0.001 mg/kg in 2006 and 0.041±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.030±0.003 mg/kg in 2005, 0.043±0.002 mg/kg in 2006 and 0.036±0.005 mg/kg in 2007 (Table 47 & Figure 42). Over the period of three years, average values were found to be 0.038±0.006 mg/kg during winter, 0.035±0.004 mg/kg during summer and 0.036±0.006 mg/kg during post monsoon period (Table 48).

**Trends:** The data does not reveal any seasonal trend. The chromium accumulation in muscle at various sites shows the pattern as site-III > site-II > site-IV > site-I.

**Kidney**

Chromium concentrations show variations in kidney during the entire period of study with minimum 0.026 mg/kg at site-I and maximum 0.051 mg/kg at site-III (Table 47). Table 48 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, chromium concentrations ranged from 0.026 mg/kg to 0.033 mg/kg with maximum during post monsoon’ 07 and minimum during summer’ 06. During winter, mean concentration was found to be 0.029±0.001 mg/kg in 2005, 0.028±0.004 mg/kg in 2006 and 0.032±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.030±0.002 mg/kg in 2005, 0.026±0.001 mg/kg in 2006 and 0.032±0.001 mg/kg in 2007. In post monsoon, mean concentration was found to be
0.028±0.004 mg/kg in 2005, 0.030±0.001 mg/kg in 2006 and 0.033±0.001 mg/kg in 2007 (Table 47 & Figure 39). Over the period of three years, average values were found to be 0.029±0.002 mg/kg during winter, 0.029±0.003 mg/kg during summer and 0.030±0.002 mg/kg during post monsoon period (Table 48).

At site-II, chromium concentrations ranged from 0.031 mg/kg to 0.047 mg/kg with maximum during winter’ 06 and minimum during summer’ 06. During winter, mean concentration was found to be 0.041±0.003 mg/kg in 2005, 0.047±0.003 mg/kg in 2006 and 0.036±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.042±0.002 mg/kg in 2005, 0.031±0.002 mg/kg in 2006 and 0.036±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.039±0.003 mg/kg in 2005, 0.034±0.002 mg/kg in 2006 and 0.036±0.002 mg/kg in 2007 (Table 47 & Figure 40). Over the period of three years, average values were found to be 0.041±0.005 mg/kg during winter, 0.036±0.005 mg/kg during summer and 0.036±0.002 mg/kg during post monsoon period (Table 48).

At site-III, chromium contents ranged from 0.039 mg/kg to 0.051 mg/kg with maximum during winter’ 05 and 06 and minimum during post monsoon’ 07. During winter, mean concentration was found to be 0.051±0.001 mg/kg in 2005, 0.051±0.00 mg/kg in 2006 and 0.049±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.049±0.002 mg/kg in 2005, 0.048±0.001 mg/kg in 2006 and 0.045±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.047±0.005 mg/kg in 2005, 0.043±0.001 mg/kg in 2006 and 0.039±0.002 mg/kg in 2007 (Table 47 & Figure 41). Over the period of three years, average values were found to be 0.050±0.001 mg/kg during winter, 0.047±0.002 mg/kg during summer and 0.045±0.002 mg/kg during post monsoon period (Table 48).
At site-IV, chromium levels ranged from 0.030 mg/kg to 0.048 mg/kg with maximum during winter’ 06 and minimum during summer’ 06. During winter, mean concentration was found to be 0.037±0.002 mg/kg in 2005, 0.048±0.001 mg/kg in 2006 and 0.034±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.038±0.001 in 2005, 0.030±0.001 mg/kg in 2006 and 0.034±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.034±0.002 mg/kg in 2005, 0.031±0.001 mg/kg in 2006 and 0.035±0.001 mg/kg in 2007 (Table 47 & Figure 42). Over the period of three years, average values were found to be 0.039±0.007 mg/kg during winter, 0.034±0.004 mg/kg during summer and 0.033±0.002 mg/kg during post monsoon period (Table 48).

**Trends:** No seasonal pattern is evident from the three year data. Site-wise pattern of chromium accumulation in kidney of *Labeo rohita* is site-III > site-II > site-IV > site-I.

**Brain**

Chromium concentrations show variations in brain during the entire period of study with minimum 0.005 mg/kg at site-I and IV and maximum 0.021 mg/kg at site-III (Table 47). Table 48 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, chromium levels ranged from 0.005 mg/kg to 0.011 mg/kg with maximum during summer’ 07 and minimum during winter’ 05, 06 and post monsoon’ 05. During winter, mean concentration was found to be 0.005±0.001 mg/kg in 2005, 2006 and 0.006±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.007±0.002 mg/kg in 2005, 0.008±0.001 in 2006 and 0.011±0.001 in 2007. During post monsoon, mean concentration was found to be 0.005±0.001 mg/kg in 2005, 0.008±0.00 mg/kg in 2006 and 0.007±0.001 mg/kg in 2007 (Table 47 &
Figure 39). Over the period of three years, average values were found to be 0.005±0.00 mg/kg during winter, 0.008±0.002 mg/kg during summer and 0.006±0.001 mg/kg during post monsoon period (Table 48).

At site-II, chromium concentration ranged from 0.007 mg/kg to 0.013 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.008±0.001 mg/kg in 2005, 0.009±0.00 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.008±0.001 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.013±0.00 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.007±0.002 mg/kg in 2005, 0.010±0.002 in 2006 and 0.009±0.001 mg/kg in 2007 (Table 47 & Figure 40). Over the period of three years, average values were found 0.009±0.001 mg/kg during winter, 0.010±0.002 mg/kg during summer and 0.008±0.001 mg/kg during post monsoon period (Table 48).

At site-III, chromium contents ranged from 0.007 to 0.021 mg/kg with maximum during summer’ 06 and minimum during post monsoon’05. During winter, mean concentration was found to be 0.009±0.00 mg/kg in 2005, 0.012±0.001 mg/kg in 2006 and 0.013±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.008±0.001 mg/kg in 2005, 0.021±0.002 mg/kg in 2006 and 0.015±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.007±0.002 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007 (Table 47 & Figure 41). Over the period of three years, average values were found to be 0.011±0.002 mg/kg during winter, 0.014±0.006 mg/kg during summer and 0.009±0.002 mg/kg during post monsoon period (Table 48).

At site-IV, chromium levels ranged from 0.005 mg/kg to 0.012 mg/kg with maximum during summer’ 06 and 07 and minimum during winter and post monsoon’
05. During winter, mean concentration was found to be 0.005±0.002 mg/kg in 2005, 0.007±0.001 mg/kg in 2006 and 0.007±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.007±0.005 mg/kg in 2005, 0.012±0.001 mg/kg in 2006 and 2007. During post monsoon, mean concentration was found to be 0.005±0.00 mg/kg in 2005, 0.009±0.002 mg/kg in 2006 and 0.009±0.001 mg/kg in 2007 (Table 47 & Figure 42). Over the period of three years, average values were found to be 0.006±0.001 mg/kg during winter, 0.010±0.002 mg/kg during summer and 0.007±0.002 mg/kg during post monsoon period (Table 48).

**Trends:** No seasonal trend is indicated. Chromium levels in *Labeo rohita* brain at various sites decrease in the following order:

Site-III > Site-II > Site-IV > Site-I

Among tissues, maximum levels are seen in liver followed in decreasing order by muscle, kidney and brain.

2.2 *Cyprinus carpio* Linnaeus:

**Liver**

In *Cyprinus carpio*, chromium concentrations show variations in liver during the whole period of study with minimum 0.049 mg/kg at site-I and maximum 0.069 mg/kg at site-III (Table 49). Table 50 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, chromium concentrations ranged from 0.049 mg/kg to 0.052 mg/kg with maximum during summer’ 07 and minimum during winter’ 05 and post monsoon’05 and 07. During winter, mean concentration was found to be 0.049±0.003 mg/kg in 2005, 0.050±0.004 mg/kg in 2006 and 2007. During summer, mean concentration was found to be 0.050±0.003 mg/kg in 2005, 0.051±0.003 mg/kg in 2006 and 0.052±0.003 mg/kg in 2007. During post monsoon, mean concentration was
found to be 0.049±0.004 mg/kg in 2005, 0.050±0.002 mg/kg in 2006 and 0.049±0.004 mg/kg in 2007 (Table 49 & Figure 43). Over the period of three years, average values were found to be 0.049±0.00 mg/kg during winter, 0.051±0.001 mg/kg during summer and 0.049±0.00 mg/kg during post monsoon period (Table 50).

At site-II, chromium concentrations ranged from 0.053 mg/kg to 0.056 mg/kg with maximum during summer’ 07 and minimum during winter’ 05, 06 and post monsoon’ 05 and 07. During winter, mean concentration was found to be 0.053±0.004 mg/kg in 2005, 0.053±0.003 mg/kg in 2006 and 0.054±0.005 mg/kg in 2007. During summer, mean concentration was found to be 0.054±0.005 mg/kg in 2005, 0.055±0.005 mg/kg in 2006 and 0.056±0.004 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.053±0.003 mg/kg in 2005, 0.055±0.003 mg/kg in 2006 and 0.053±0.004 mg/kg in 2007 (Table 49 & Figure 44). Over the period of three years, average values were found to be 0.053±0.00 mg/kg during winter, 0.055±0.001 mg/kg during summer and 0.053±0.001 mg/kg during post monsoon period (Table 50).

At site-III, chromium contents ranged from 0.059 mg/kg to 0.069 mg/kg with maximum during winter’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.063±0.004 mg/kg in 2005, 0.069±0.004 mg/kg in 2006 and 0.062±0.005 mg/kg in 2007. During summer, mean concentration was found to be 0.061±0.005 mg/kg in 2005, 0.064±0.003 mg/kg in 2006 and 0.060±0.005 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.059±0.004 mg/kg in 2005, 0.060±0.004 mg/kg in 2006 and 0.060±0.003 mg/kg in 2007 (Table 49 & Figure 45). Over the period of three years, average values were found to be 0.064±0.003 mg/kg during winter, 0.061±0.002 mg/kg during summer and 0.059±0.00 mg/kg during post monsoon period (Table 50).
At site-IV, chromium levels were between 0.051 mg/kg and 0.056 mg/kg with maximum during summer’ 07 and minimum during winter’ 05 and post monsoon’ 06. During winter, mean concentration was found to be 0.051±0.004 mg/kg in 2005, 0.053±0.002 mg/kg in 2006 and 0.054±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.052±0.004 mg/kg in 2005, 0.055±0.004 mg/kg in 2006 and 0.056±0.004 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.052±0.005 mg/kg in 2005, 0.051±0.004 mg/kg in 2006 and 0.052±0.003 mg/kg in 2007 (Table 49 & Figure 46). Over the period of three years, average values were found to be 0.052±0.001 mg/kg during winter, 0.054±0.002 mg/kg during summer and 0.051±0.00 mg/kg during post monsoon period (Table 50).

**Trends:** No define seasonal trend is evident from the three year data on chromium accumulation in liver of Cyprinus carpio. Among sites, the accumulation pattern in liver is site-III > site-II ≥ site-IV > site-I.

**Muscle**

Chromium concentrations show variations in muscle during the entire period of study with minimum 0.042 mg/kg at site-I and maximum 0.058 mg/kg at site-III (Table 49). Table 50 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, chromium concentrations ranged from 0.042 mg/kg to 0.048 mg/kg with maximum during winter and summer’ 06 and minimum during summer and post monsoon’ 05. During winter, mean concentration was found to be 0.043±0.003 mg/kg in 2005, 0.048±0.002 in 2006 and 0.044±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.042±0.001 mg/kg in 2005, 0.048±0.003 mg/kg in 2006 and 0.045±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.042±0.002 mg/kg in 2005, 0.046±0.002 mg/kg in 2006 and 0.045±0.001
mg/kg in 2007 (Table 49 & Figure 43). Over the period of three years, average values were found to be 0.045±0.002 mg/kg during winter, 0.045±0.003 mg/kg during summer and 0.044±0.002 mg/kg during post monsoon period (Table 50).

At site-II, chromium concentrations ranged from 0.047 mg/kg to 0.050 mg/kg with maximum during winter’ 05, 07 and summer’ 05 and minimum during post monsoon’ 07. During winter, mean concentration was found to be 0.050±0.003 mg/kg in 2005, 0.049±0.004 mg/kg in 2006 and 0.050±0.004 mg/kg in 2007. During summer, mean concentration was found to be 0.050±0.002 mg/kg in 2005, 0.048±0.002 mg/kg in 2006 and 0.049±0.004 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.049±0.003 mg/kg in 2005, 0.048±0.002 mg/kg in 2006 and 0.047±0.001 mg/kg in 2007 (Table 49 & Figure 44). Over the period of three years, average values were found to be 0.049±0.00 mg/kg during winter, 0.049±0.001 mg/kg during summer and 0.048±0.001 mg/kg during post monsoon period (Table 50).

At site-III, chromium contents ranged from 0.049 mg/kg to 0.058 mg/kg with maximum during winter’ 05 and minimum during post monsoon’ 07. During winter, mean concentration was found to be 0.058±0.002 mg/kg in 2005, 0.057±0.003 mg/kg in 2006 and 0.056±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.057±0.004 mg/kg in 2005, 0.051±0.001 mg/kg in 2006 and 0.053±0.004 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.051±0.001 mg/kg in 2005, 0.057±0.002 mg/kg in 2006 and 0.049±0.003 mg/kg in 2007 (Table 49 & Figure 45). Over the period of three years, average values were found to be 0.057±0.001 mg/kg during winter, 0.053±0.003 mg/kg during summer and 0.052±0.004 mg/kg during post monsoon period (Table 50).
At site-IV, chromium levels ranged from 0.046 mg/kg to 0.049 mg/kg with maximum during summer’ 07 and minimum during post monsoon’06 and 07. During winter, mean concentration was found to be 0.047±0.003 mg/kg in 2005, 0.048±0.002 mg/kg in 2006 and 0.048±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.048±0.002 mg/kg in 2005, 0.048±0.001 mg/kg in 2006 and 0.049±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.047±0.001 mg/kg in 2005, 0.046±0.002 mg/kg in 2006 and 0.046±0.004 mg/kg in 2007 (Table 49 & Figure 46). Over the period of three years, average values were found to be 0.047±0.00 mg/kg during winter, 0.048±0.00 mg/kg during summer and 0.046±0.00 mg/kg during post monsoon period (Table 50).

**Trends:** No define seasonal trend is evident from the three year data on chromium accumulation in muscle of *Cyprinus carpio*. Among sites, chromium concentrations decrease in the order as site-III > site-II > site-IV > site-I.

**Kidney**

Chromium concentrations show variations in kidney during the entire period of study with minimum 0.045 mg/kg at site-I and maximum 0.057 mg/kg at site-III (Table 49). Table 50 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, chromium concentrations ranged from 0.045 mg/kg to 0.049 mg/kg with maximum during winter and post monsoon’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.047±0.004 mg/kg in 2005, 0.049±0.005 mg/kg in 2006 and 0.048±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.047±0.003 mg/kg in 2005, 0.048±0.004 mg/kg in 2006 and 0.048±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.045±0.002 mg/kg in 2005, 0.049±0.006 mg/kg in 2006 and 0.046±0.002
mg/kg in 2007 (Table 49 & Figure 43). Over the period of three years, average values were found to be 0.048±0.001 mg/kg during winter, 0.047±0.00 mg/kg during summer and 0.046±0.002 mg/kg during post monsoon period (Table 50).

At site-II, chromium concentrations ranged from 0.051 mg/kg to 0.053 mg/kg with maximum during summer’ 06, 07 and minimum during winter’ 05 and post monsoon’ 07. During winter, mean concentration was found to be 0.051±0.004 mg/kg in 2005, 0.052±0.007 mg/kg in 2006 and 0.052±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.052±0.003 mg/kg in 2005, 0.053±0.004 mg/kg in 2006 and 2007. During post monsoon, mean concentration was found to be 0.052±0.004 mg/kg in 2005, 0.052±0.002 mg/kg in 2006 and 0.051±0.002 mg/kg in 2007 (Table 49 & Figure 44). Over the period of three years, average values were found to be 0.051±0.00 mg/kg during winter, 0.052±0.00 mg/kg during summer and 0.051±0.00 mg/kg during post monsoon period (Table 50).

At site-III, chromium contents ranged from 0.052 mg/kg to 0.057 mg/kg with maximum during summer’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.054±0.007 mg/kg in 2005, 0.055±0.003 mg/kg in 2006 and 0.055±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.056±0.006 mg/kg in 2005, 0.057±0.006 mg/kg in 2006 and 0.056±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.052±0.004 mg/kg in 2005, 0.054±0.002 mg/kg in 2006 and 0.056±0.003 mg/kg in 2007 (Table 49 & Figure 45). Over the period of three years, average values were found to be 0.054±0.00 mg/kg during winter, 0.056±0.00 mg/kg during summer and 0.054±0.002 mg/kg during post monsoon period (Table 50).

At site-IV, chromium levels ranged from 0.047 mg/kg to 0.052 mg/kg with maximum during summer’ 06 and minimum during post monsoon’ 05. During winter,
mean concentration was found to be 0.049±0.003 mg/kg in 2005, 0.048±0.005 mg/kg in 2006 and 0.050±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.049±0.004 in 2005, 0.052±0.002 mg/kg in 2006 and 0.051±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.047±0.004 mg/kg in 2005, 0.048±0.004 mg/kg in 2006 and 0.049±0.003 mg/kg in 2007 (Table 49 & Figure 46). Over the period of three years, average values were found to be 0.049±0.001 mg/kg during winter, 0.050±0.001 mg/kg during summer and 0.048±0.001 mg/kg during post monsoon period (Table 50).

**Trends:** No definite seasonal trend is evident from three year data on chromium concentrations in kidney of *Cyprinus carpio*. Chromium accumulation is seen to be maximum at site-III followed in decreasing order by site-II, site-IV and site-I.

### Brain

Chromium concentrations show variations in brain during the entire period of study with minimum 0.006 mg/kg at site-I and IV and maximum 0.012 mg/kg at site-II and III (Table 49). Table 50 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, chromium levels ranged from 0.006 mg/kg to 0.011 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.008±0.001 mg/kg in 2005, 0.008±0.00 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.008±0.001 in 2006 and 0.011±0.001 in 2007. During post monsoon, mean concentration was found to be 0.007±0.002 mg/kg in 2005, 0.006±0.001 mg/kg in 2006 and 0.009±0.001 mg/kg in 2007 (Table 49 & Figure 43). Over the period of three years, average values were found to be
0.008±0.001 mg/kg during winter, 0.009±0.001 mg/kg during summer and 0.007±0.001 mg/kg during post monsoon period (Table 50).

At site-II, chromium concentrations ranged from 0.007 mg/kg to 0.012 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 05 and 06. During winter, mean concentration was found to be 0.008±0.002 mg/kg in 2005, 2006 and 0.009±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 2006 and 0.012±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.007±0.001 mg/kg in 2005, 0.007±0.00 in 2006 and 0.010±0.001 mg/kg in 2007 (Table 49 & Figure 44). Over the period of three years, average values were found 0.008±0.00 mg/kg during winter, 0.010±0.001 mg/kg during summer and 0.008±0.001 mg/kg during post monsoon period (Table 50).

At site-III, chromium contents ranged from 0.007 to 0.012 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.008±0.002 mg/kg in 2005, 0.008±0.001 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.009±0.00 mg/kg in 2006 and 0.012±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.008±0.002 mg/kg in 2005, 0.007±0.001 mg/kg in 2006 and 0.011±0.001 mg/kg in 2007 (Table 49 & Figure 45). Over the period of three years, average values were found to be 0.008±0.001 mg/kg during winter, 0.010±0.001 mg/kg during summer and 0.008±0.002 mg/kg during post monsoon period (Table 50).

At site-IV, chromium levels ranged from 0.006 mg/kg to 0.011 mg/kg with maximum during winter and summer’ 07 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.009±0.00 mg/kg in 2005,
0.007±0.001 mg/kg in 2006 and 0.011±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.008±0.001 mg/kg in 2005, 0.009±0.001 mg/kg in 2006 and 0.011±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.007±0.001 mg/kg in 2005, 0.006±0.001 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007 (Table 49 & Figure 46). Over the period of three years, average values were found to be 0.009±0.002 mg/kg during winter, 0.009±0.001 mg/kg during summer and 0.007±0.002 mg/kg during post monsoon period (Table 50).

**Trends:** As in other organs, no definite seasonal pattern is evident from the data on chromium accumulation in brain of *Cyprinus carpio*. Chromium accumulation is higher at both site-II and III as compared to site-I and IV.

From the three year data, it is revealed that in *Cyprinus carpio*, maximum chromium accumulation is in liver followed in decreasing order by kidney, muscle and brain.

**2.3 Mystus seenghala (Sykes):**

**Liver**

In *Mystus seenghala*, chromium concentrations show variations in liver during the whole period of study with minimum 0.052 mg/kg at site-I and maximum 0.078 mg/kg at site-III (Table 51). Table 52 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, chromium concentration ranged from 0.052 mg/kg to 0.059 mg/kg with maximum during winter’ 06 and minimum during summer and post monsoon’ 07. During winter, mean concentration was found to be 0.056±0.004 mg/kg in 2005, 0.059±0.005 mg/kg in 2006 and 0.058±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.054±0.003 mg/kg in 2005, 0.058±0.004 mg/kg in 2006 and 0.052±0.003 mg/kg in 2007. During post monsoon, mean concentration was
found to be 0.053±0.002 mg/kg in 2005, 0.055±0.006 mg/kg in 2006 and 0.052±0.002 mg/kg in 2007 (Table 51 & Figure 47). Over the period of three years, average values were found to be 0.057±0.001 mg/kg during winter, 0.054±0.003 mg/kg during summer and 0.053±0.001 mg/kg during post monsoon period (Table 52).

At site-II, chromium concentration ranged from 0.060 mg/kg to 0.066 mg/kg with maximum during summer’ 06 and minimum during winter’ 05. During winter, mean concentration was found to be 0.060±0.004 mg/kg in 2005, 0.063±0.007 mg/kg in 2006 and 0.065±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.061±0.003 mg/kg in 2005, 0.066±0.004 mg/kg in 2006 and 0.064±0.004 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.063±0.004 mg/kg in 2005, 0.062±0.002 mg/kg in 2006 and 0.061±0.002 mg/kg in 2007 (Table 51 & Figure 48). Over the period of three years, average values were found to be 0.062±0.002 mg/kg during winter, 0.063±0.002 mg/kg during summer and 0.062±0.001 mg/kg during post monsoon period (Table 52).

At site-III, chromium contents ranged from 0.071 mg/kg to 0.078 mg/kg with maximum during winter’ 07 and minimum during summer ’05. During winter, mean concentration was found to be 0.074±0.007 mg/kg in 2005, 0.073±0.003 mg/kg in 2006 and 0.078±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.071±0.006 mg/kg in 2005, 0.077±0.006 mg/kg in 2006 and 0.076±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.073±0.004 mg/kg in 2005, 0.075±0.002 mg/kg in 2006 and 0.075±0.003 mg/kg in 2007 (Table 51 & Figure 49). Over the period of three years, average values were found to be 0.075±0.002 mg/kg during winter, 0.074±0.003 mg/kg during summer and 0.074±0.001 mg/kg during post monsoon period (Table 52).
At site-IV, chromium levels ranged from 0.055 mg/kg to 0.062 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.058±0.003 mg/kg in 2005, 0.061±0.005 mg/kg in 2006 and 0.060±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.059±0.004 mg/kg in 2005, 0.058±0.002 mg/kg in 2006 and 0.062±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.057±0.004 mg/kg in 2005, 0.055±0.004 mg/kg in 2006 and 0.057±0.003 mg/kg in 2007 (Table 51 & Figure 50). Over the period of three years, average values were found to be 0.059±0.001 mg/kg during winter, 0.059±0.001 mg/kg during summer and 0.056±0.002 mg/kg during post monsoon period (Table 52).

**Trends:** No seasonal pattern is evident from the data on chromium accumulation in liver of *Mystus seenghala*. Among sites, chromium accumulation shows the pattern as site-III > site-II > site-IV > site-I

**Muscle**

Chromium concentrations show variations in muscle during the entire period of study with minimum 0.048 mg/kg at site-I and maximum 0.062 mg/kg at site-III (Table 51). Table 52 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, chromium concentration ranged from 0.048 mg/kg to 0.052 mg/kg with maximum during summer’ 06 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.049±0.003 mg/kg in 2005, 0.050±0.002 in 2006 and 0.051±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.050±0.003 mg/kg in 2005, 0.052±0.005 mg/kg in 2006 and 0.050±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be
0.049±0.002 mg/kg in 2005, 0.048±0.002 mg/kg in 2006 and 0.051±0.003 mg/kg in 2007 (Table 51 & Figure 47). Over the period of three years, average values were found to be 0.050±0.001 mg/kg during winter, summer and 0.049±0.001 mg/kg during post monsoon period (Table 52).

At site-II, chromium concentrations ranged from 0.051 mg/kg to 0.057 mg/kg with maximum during winter’ 06 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.053±0.004 mg/kg in 2005, 0.057±0.003 mg/kg in 2006 and 0.053±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.054±0.003 mg/kg in 2005, 0.055±0.002 mg/kg in 2006 and 0.053±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.053±0.002 mg/kg in 2005, 0.051±0.001 mg/kg in 2006 and 0.055±0.002 mg/kg in 2007 (Table 51 & Figure 48). Over the period of three years, average values were found to be 0.054±0.002 mg/kg during winter, 0.054±0.001 mg/kg during summer and 0.053±0.002 mg/kg during post monsoon period (Table 52).

At site-III, chromium contents ranged from 0.057 mg/kg to 0.062 mg/kg with maximum during summer’ 05 and minimum during summer’ 07. During winter, mean concentration was found to be 0.061±0.008 mg/kg in 2005, 0.060±0.002 mg/kg in 2006 and 0.059±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.062±0.003 mg/kg in 2005, 0.058±0.003 mg/kg in 2006 and 0.057±0.004 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.058±0.002 mg/kg in 2005, 0.062±0.002 mg/kg in 2006 and 0.059±0.002 mg/kg in 2007 (Table 51 & Figure 49). Over the period of three years, average values were found to be 0.060±0.001 mg/kg during winter, 0.059±0.002 mg/kg during summer and post monsoon period (Table 52).
At site-IV, chromium levels ranged from 0.049 mg/kg to 0.061 mg/kg with maximum during winter’ 06 and minimum during post monsoon’ 05 and summer’ 07. During winter, mean concentration was found to be 0.057±0.003 mg/kg in 2005, 0.061±0.003 mg/kg in 2006 and 0.055±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.059±0.002 mg/kg in 2005, 0.057±0.002 mg/kg in 2006 and 0.049±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.049±0.003 mg/kg in 2005, 0.052±0.002 mg/kg in 2006 and 0.054±0.001 mg/kg in 2007 (Table 5 & Figure 50). Over the period of three years, average values were found to be 0.057±0.003 mg/kg during winter, 0.055±0.005 mg/kg during summer and 0.051±0.002 mg/kg during post monsoon period (Table 52).

**Trends:** No seasonal trend is indicated from the data on chromium accumulation in muscle of *Mystus seenghala*. Among sites, chromium accumulation shows the pattern as:

Site-III > Site-II > Site-IV > Site-I

**Kidney**

Chromium concentrations show variations in kidney during the entire period of study with minimum 0.049 mg/kg at site-I and maximum 0.063 mg/kg at site-III (Table 51). Table 52 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, chromium concentrations ranged from 0.049 mg/kg to 0.054 mg/kg with maximum during winter’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.051±0.003 mg/kg in 2005, 0.052±0.002 mg/kg in 2006 and 0.054±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.052±0.001 mg/kg in 2005, 0.053±0.003 mg/kg in 2006 and 0.052±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be
0.049±0.002 mg/kg in 2005, 0.051±0.002 mg/kg in 2006 and 0.053±0.001 mg/kg in 2007 (Table 51 & Figure 47). Over the period of three years, average values were found to be 0.052±0.001 mg/kg during winter, 0.052±0.00 mg/kg during summer and 0.051±0.002 mg/kg during post monsoon period (Table 52).

At site-II, chromium concentration ranged from 0.051 mg/kg to 0.058 mg/kg with maximum during summer’ 06 and minimum during summer’ 05. During winter, mean concentration was found to be 0.055±0.003 mg/kg in 2005, 0.054±0.004 mg/kg in 2006 and 0.057±0.004 mg/kg in 2007. During summer, mean concentration was found to be 0.051±0.002 mg/kg in 2005, 0.058±0.002 mg/kg in 2006 and 0.056±0.004 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.054±0.003 mg/kg in 2005, 0.053±0.002 mg/kg in 2006 and 0.055±0.001 mg/kg in 2007 (Table 51 & Figure 48). Over the period of three years, average values were found to be 0.055±0.001 mg/kg during winter, 0.055±0.003 mg/kg during summer and 0.054±0.001 mg/kg during post monsoon period (Table 52).

At site-III, chromium contents ranged from 0.059 mg/kg to 0.063 mg/kg with maximum during summer’ 05, winter’ 06 and post monsoon’ 07 and minimum during winter’ 05, summer’ 06, 07 and post monsoon’ 05. During winter, mean concentration was found to be 0.059±0.002 mg/kg in 2005, 0.063±0.003 mg/kg in 2006 and 0.061±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.063±0.004 mg/kg in 2005, 0.059±0.001 mg/kg in 2006 and 0.059±0.004 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.059±0.001 mg/kg in 2005, 0.061±0.002 mg/kg in 2006 and 0.063±0.003 mg/kg in 2007 (Table 51 & Figure 49). Over the period of three years, average values were found to be 0.061±0.002 mg/kg during winter, 0.060±0.002 mg/kg during summer and 0.061±0.002 mg/kg during post monsoon period (Table 52).
At site-IV, chromium levels ranged from 0.051 mg/kg to 0.060 mg/kg with maximum during summer’ 06 and winter’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.058±0.003 mg/kg in 2005, 0.059±0.002 mg/kg in 2006 and 0.060±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.058±0.002 in 2005, 0.060±0.001 mg/kg in 2006 and 0.052±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.051±0.001 mg/kg in 2005, 0.056±0.002 mg/kg in 2006 and 0.054±0.004 mg/kg in 2007 (Table 51 & Figure 50). Over the period of three years, average values were found to be 0.059±0.001 mg/kg during winter, 0.056±0.004 mg/kg during summer and 0.053±0.002 mg/kg during post monsoon period (Table 52).

**Trends:** The three year data on chromium accumulation in kidney of *Mystus seenghala* does not indicate any definite seasonal trend. Chromium accumulation is seen to be maximum at site-III followed in decreasing order by site-IV, site-II and site-I.

**Brain**

Chromium concentrations show variations in brain during the entire period of study with minimum 0.008 mg/kg at site-I and maximum 0.013 mg/kg at site-II and III (Table 51). Table 52 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, chromium levels ranged from 0.008 mg/kg to 0.012 mg/kg with maximum during winter’ 07 and minimum during winter’ 06. During winter, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.008±0.00 mg/kg in 2006 and 0.012±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.010±0.001 in 2006 and 2007. During post monsoon, mean concentration was found to be 0.011±0.002 mg/kg in 2005, 0.009±0.001 mg/kg
in 2006 and 0.010±0.001 mg/kg in 2007 (Table 51 & Figure 47). Over the period of three years, average values were found to be 0.010±0.002 mg/kg during winter, 0.009±0.00 mg/kg during summer and 0.010±0.001 mg/kg during post monsoon period (Table 49).

At site-II, chromium concentrations ranged from 0.009 mg/kg to 0.013 mg/kg with maximum during post monsoon’07 and minimum during summer and post monsoon’06. During winter, mean concentration was found to be 0.010±0.002 mg/kg in 2005, 0.012±0.002 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.011±0.001 mg/kg in 2005, 0.009±0.001 mg/kg in 2006 and 0.012±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.009±0.00 in 2006 and 0.013±0.001 mg/kg in 2007 (Table 51 & Figure 48). Over the period of three years, average values were found 0.010±0.001 mg/kg during winter, summer and 0.010±0.002 mg/kg during post monsoon period (Table 52).

At site-III, chromium contents ranged from 0.009 to 0.013 mg/kg with maximum during winter’05 and summer’07 and minimum during summer’05. During winter, mean concentration was found to be 0.013±0.002 mg/kg in 2005, 0.010±0.001 mg/kg in 2006 and 0.011±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.012±0.00 mg/kg in 2006 and 0.013±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.010±0.002 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.012±0.001 mg/kg in 2007 (Table 51 & Figure 49). Over the period of three years, average values were found to be 0.011±0.001 mg/kg during winter, 0.011±0.002 mg/kg during summer and 0.011±0.001 mg/kg during post monsoon period (Table 52).
At site-IV, chromium levels ranged from 0.009 mg/kg to 0.012 mg/kg with maximum during post monsoon’ 06 and summer’ 07 and minimum during summer’ 05 and winter’ 07. During winter, mean concentration was found to be 0.011±0.00 mg/kg in 2005, 0.010±0.001 mg/kg in 2006 and 0.009±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.012±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.011±0.001 mg/kg in 2005, 0.012±0.001 mg/kg in 2006 and 0.009±0.001 mg/kg in 2007 (Table 51 & Figure 50). Over the period of three years, average values were found to be 0.010±0.001 mg/kg during winter, summer and post monsoon period (Table 52).

**Trends:** No definite seasonal trend is indicated in chromium accumulation in brain of *Mystus seenghala*. Chromium accumulation is maximum at site-III, minimum at site-I and almost similar at site-II and site-IV.

Among various tissues, chromium accumulation in *Mystus seenghala* is maximum in liver followed in decreasing order by kidney, muscle and brain.

### 2.4 Cirrhinus mrigala (Hamilton):

**Liver**

In *Cirrhinus mrigala*, chromium concentrations show variations in liver during the whole period of study with minimum 0.049 mg/kg at site-I and maximum 0.065 mg/kg at site-III (Table 53). Table 54 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, chromium concentrations ranged from 0.049 mg/kg to 0.054 mg/kg with maximum during winter’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.050±0.004 mg/kg in 2005, 0.052±0.005 mg/kg in 2006 and 0.054±0.003 mg/kg in 2007. During summer, mean concentration was
found to be 0.051±0.003 mg/kg in 2005, 0.052±0.004 mg/kg in 2006 and 0.052±0.005 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.049±0.002 mg/kg in 2005, 0.050±0.005 mg/kg in 2006 and 0.052±0.004 mg/kg in 2007 (Table 53 & Figure 51). Over the period of three years, average values were found to be 0.052±0.002 mg/kg during winter, 0.051±0.00 mg/kg during summer and 0.050±0.001 mg/kg during post monsoon period (Table 54).

At site-II, chromium concentrations ranged from 0.052 mg/kg to 0.057 mg/kg with maximum during winter’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.053±0.003 mg/kg in 2005, 0.055±0.005 mg/kg in 2006 and 0.057±0.006 mg/kg in 2007. During summer, mean concentration was found to be 0.055±0.005 mg/kg in 2005, 0.056±0.004 mg/kg in 2006 and 0.055±0.005 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.052±0.002 mg/kg in 2005, 0.054±0.003 mg/kg in 2006 and 0.055±0.005 mg/kg in 2007 (Table 55 & Figure 52). Over the period of three years, average values were found to be 0.055±0.002 mg/kg during winter, 0.055±0.00 mg/kg during summer and 0.053±0.001 mg/kg during post monsoon period (Table 54).

At site-III, chromium contents ranged from 0.058 mg/kg to 0.065 mg/kg with maximum during winter’ 07 and minimum during post monsoon ’05. During winter, mean concentration was found to be 0.059±0.004 mg/kg in 2005, 0.063±0.007 mg/kg in 2006 and 0.065±0.007 mg/kg in 2007. During summer, mean concentration was found to be 0.062±0.003 mg/kg in 2005, 0.060±0.006 mg/kg in 2006 and 0.059±0.006 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.058±0.003 mg/kg in 2005, 0.061±0.004 mg/kg in 2006 and 0.060±0.006 mg/kg in 2007 (Table 53 & Figure 53). Over the period of three years, average values were
found to be 0.062±0.003 mg/kg during winter, 0.060±0.001 mg/kg during summer and 0.059±0.001 mg/kg during post monsoon period (Table 54).

At site-IV, chromium levels ranged from 0.051 mg/kg to 0.057 mg/kg with maximum during winter’ 07 and post monsoon’ 07 and minimum during winter’ 05 and post monsoon’ 05 and 06. During winter, mean concentration was found to be 0.051±0.002 mg/kg in 2005, 0.053±0.003 mg/kg in 2006 and 0.057±0.004 mg/kg in 2007. During summer, mean concentration was found to be 0.052±0.004 mg/kg in 2005, 0.054±0.004 mg/kg in 2006 and 0.056±0.005 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.051±0.004 mg/kg in 2005, 0.051±0.005 mg/kg in 2006 and 0.057±0.006 mg/kg in 2007 (Table 53 & Figure 54). Over the period of three years, average values were found to be 0.053±0.003 mg/kg during winter, 0.054±0.002 mg/kg during summer and 0.053±0.003 mg/kg during post monsoon period (Table 54).

**Trends:** No definite seasonal trends are indicated from the three year data on chromium accumulation in liver of *Cirrhinus mrigala*. Chromium accumulation at four sites shows the trend as Site-III > Site-II > Site-IV > Site-I.

**Muscle**

Chromium concentrations show variations in muscle during the entire period of study with minimum 0.045 mg/kg at site-I and maximum 0.056 mg/kg at site-III (Table 53). Table 54 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, chromium concentrations ranged from 0.045 mg/kg to 0.049 mg/kg with maximum during winter and summer’ 06 and minimum during winter and post monsoon’ 05. During winter, mean concentration was found to be 0.045±0.004 mg/kg in 2005, 0.049±0.002 in 2006 and 0.048±0.002 mg/kg in 2007. During summer, mean
concentration was found to be 0.047±0.003 mg/kg in 2005, 0.049±0.004 mg/kg in 2006 and 0.048±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.045±0.002 mg/kg in 2005, 0.048±0.003 mg/kg in 2006 and 0.046±0.002 mg/kg in 2007 (Table 53 & Figure 51). Over the period of three years, average values were found to be 0.047±0.002 mg/kg during winter, 0.048±0.001 mg/kg during summer and 0.046±0.00 mg/kg during post monsoon period (Table 54).

At site-II, chromium concentrations ranged from 0.051 mg/kg to 0.052 mg/kg with maximum during winter’ 06, 07 and all summer periods and minimum during winter’ 05 and all post monsoon period. During winter, mean concentration was found to be 0.051±0.004 mg/kg in 2005, 0.052±0.005 mg/kg in 2006 and 0.052±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.052±0.003 mg/kg in 2005, 0.052±0.002 mg/kg in 2006 and 0.052±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.051±0.003 mg/kg in 2005, 2006 and 0.051±0.002 mg/kg in 2007 (Table 53 & Figure 52). Over the period of three years, average values were found to be 0.051±0.00 mg/kg during winter, 0.052±0.00 mg/kg during summer and 0.051±0.00 mg/kg during post monsoon period (Table 54).

At site-III, chromium contents ranged from 0.052 mg/kg to 0.056 mg/kg with maximum during summer and post monsoon’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.054±0.005 mg/kg in 2005, 0.055±0.003 mg/kg in 2006 and 0.054±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.053±0.004 mg/kg in 2005, 0.055±0.005 mg/kg in 2006 and 0.056±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.052±0.004 mg/kg in 2005, 0.054±0.002 mg/kg in 2006 and 0.056±0.003 mg/kg in 2007 (Table 53 & Figure 53). Over the period of three years, average values
were found to be 0.054±0.001 mg/kg during winter, 0.054±0.002 mg/kg during summer and post monsoon period (Table 5).

At site-IV, chromium levels ranged from 0.047 mg/kg to 0.051 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.049±0.003 mg/kg in 2005, 2006 and 0.050±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.050±0.002 mg/kg in 2005, 2006 and 0.051±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.047±0.004 mg/kg in 2005, 0.049±0.004 mg/kg in 2006 and 0.049±0.003 mg/kg in 2007 (Table 53 & Figure 54). Over the period of three years, average values were found to be 0.049±0.00 mg/kg during winter, 0.050±0.00 mg/kg during summer and 0.048±0.001 mg/kg during post monsoon period (Table 54).

Trends: No seasonal trend is indicated from three year data on chromium accumulation in muscle of Cirrhinus mrigala. Maximum chromium accumulation is seen at site-III followed in decreasing order by site-II, site-IV and site-I.

Kidney

Chromium concentrations show variations in kidney during the entire period of study with minimum 0.049 mg/kg at site-I and maximum 0.059 mg/kg at site-III (Table 53). Table 54 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, chromium concentrations ranged from 0.049 mg/kg to 0.052 mg/kg with maximum during summer’ 07 and minimum during winter’ 05, post monsoon’ 05 and 07. During winter, mean concentration was found to be 0.049±0.003 mg/kg in 2005 and 0.050±0.004 mg/kg in 2006 and 2007. During summer, mean concentration was found to be 0.050±0.003 mg/kg in 2005, 0.051±0.003 mg/kg in 2006 and 0.052±0.003
mg/kg in 2007. During post monsoon, mean concentration was found to be 0.049±0.004 mg/kg in 2005, 0.050±0.002 mg/kg in 2006 and 0.049±0.004 mg/kg in 2007 (Table 53 & Figure 51). Over the period of three years, average values were found to be 0.049±0.00 mg/kg during winter, 0.051±0.001 mg/kg during summer and 0.049±0.00 mg/kg during post monsoon period (Table 54).

At site-II, chromium concentrations ranged from 0.053 mg/kg to 0.055 mg/kg with maximum during summer and post monsoon’ 06 and minimum during winter’ 05, 06 and post monsoon’ 05 and 07. During winter, mean concentration was found to be 0.053±0.004 mg/kg in 2005, 0.053±0.003 mg/kg in 2006 and 0.054±0.005 mg/kg in 2007. During summer, mean concentration was found to be 0.054±0.005 mg/kg in 2005, 0.055±0.005 mg/kg in 2006 and 0.054±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.053±0.003 mg/kg in 2005, 0.055±0.003 mg/kg in 2006 and 0.053±0.004 mg/kg in 2007 (Table 53 & Figure 52). Over the period of three years, average values were found to be 0.053±0.00 mg/kg during winter, 0.054±0.001 mg/kg during summer and 0.053±0.001 mg/kg during post monsoon period (Table 54).

At site-III, chromium contents ranged from 0.055 mg/kg to 0.059 mg/kg with maximum during summer’ 06 and minimum during post monsoon’ 07. During winter, mean concentration was found to be 0.057±0.004 mg/kg in 2005, 0.058±0.004 mg/kg in 2006 and 0.057±0.005 mg/kg in 2007. During summer, mean concentration was found to be 0.057±0.005 mg/kg in 2005, 0.059±0.003 mg/kg in 2006 and 0.056±0.005 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.056±0.004 mg/kg in 2005, 0.058±0.004 mg/kg in 2006 and 0.055±0.003 mg/kg in 2007 (Table 53 & Figure 53). Over the period of three years, average values were
found to be 0.057±0.001 mg/kg during winter, summer and 0.056±0.001 mg/kg during post monsoon period (Table 54).

At site-IV, chromium levels ranged from 0.051 mg/kg to 0.056 mg/kg with maximum during summer’ 07 and minimum during winter’ 05 and post monsoon’ 06. During winter, mean concentration was found to be 0.051±0.004 mg/kg in 2005, 0.053±0.002 mg/kg in 2006 and 0.054±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.052±0.004 in 2005, 0.055±0.004 mg/kg in 2006 and 0.056±0.004 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.052±0.005 mg/kg in 2005, 0.051±0.004 mg/kg in 2006 and 0.053±0.004 mg/kg in 2007 (Table 53 & Figure 54). Over the period of three years, average values were found to be 0.052±0.001 mg/kg during winter, 0.054±0.002 mg/kg during summer and 0.052±0.001 mg/kg during post monsoon period (Table 54).

**Trends:** No seasonal trend is revealed. The site-wise trend of chromium accumulation in *Cirrhinus mrigala* is Site-III > Site-II > Site-IV > Site-I.

**Brain**

Chromium concentrations show variations in brain during the entire period of study with minimum 0.007 mg/kg at site-I and maximum 0.013 mg/kg at site-III (Table 53). Table 54 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, chromium levels ranged from 0.007 mg/kg to 0.011 mg/kg with maximum during summer’ 05 and 07 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.009±0.001 mg/kg in 2005 and 0.010±0.001 mg/kg in 2006 and 2007. During summer, mean concentration was found to be 0.011±0.002 mg/kg in 2005, 0.009±0.00 in 2006 and 0.011±0.001 in 2007. During post monsoon, mean concentration was found to be 0.009±0.002 mg/kg
in 2005, 0.007±0.001 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007 (Table 53 & Figure 51). Over the period of three years, average values were found to be 0.009±0.001 mg/kg during winter, 0.010±0.001 mg/kg during summer and 0.008±0.001 mg/kg during post monsoon period (Table 54).

At site-II, chromium concentrations ranged from 0.008 mg/kg to 0.012 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.009±0.002 mg/kg in 2005, 0.011±0.002 mg/kg in 2006 and 0.009±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.001 mg/kg in 2005 and 2006 and 0.012±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.008±0.002 mg/kg in 2005, 0.009±0.001 in 2006 and 0.011±0.001 mg/kg in 2007 (Table 53 & Figure 52). Over the period of three years, average values were found 0.009±0.001 mg/kg during winter, 0.010±0.001 mg/kg during summer and 0.009±0.001 mg/kg during post monsoon period (Table 54).

At site-III, chromium contents ranged from 0.009 to 0.013 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.012±0.002 mg/kg in 2005 and 0.010±0.001 mg/kg in 2006 and 2007. During summer, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 2006 and 0.013±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.009±0.002 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.012±0.002 mg/kg in 2007 (Table 53 & Figure 53). Over the period of three years, average values were found to be 0.010±0.001 mg/kg during winter, 0.011±0.001 mg/kg during summer and 0.010±0.001 mg/kg during post monsoon period (Table 54).
At site-IV, chromium levels ranged from 0.008 mg/kg to 0.011 mg/kg with maximum during winter and summer’ 07 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.009±0.00 mg/kg in 2005, 0.010±0.001 mg/kg in 2006 and 0.011±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.009±0.001 mg/kg in 2006 and 0.011±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.008±0.001 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007 (Table 53 & Figure 54). Over the period of three years, average values were found to be 0.010±0.001 mg/kg during winter, summer and 0.009±0.001 mg/kg during post monsoon period (Table 54).

**Trends:** No seasonal trend in chromium accumulation in brain of *Cirrhinus mrigala* is indicated from the three years data. Chromium accumulation in brain at various sites shows the trend as Site-III > Site-II ≥Site-IV > Site-I.

Among various tissues of *Cirrhinus mrigala*, chromium accumulation shows the following pattern:

Liver > Kidney > Muscle > Brain

Among various fish species, chromium accumulation shows the following trend:

*Cystus seenghala* > *Cirrhinus mrigala* > *Cyprinus carpio* > *Labeo rohita*

3. **Nickel**

3.1 *Labeo rohita* (Hamilton):

**Liver**

In *Labeo rohita*, nickel concentrations show variations in liver during the whole period of study with minimum 0.014 mg/kg at site-IV and maximum 0.039 mg/kg at site-III (Table 55). Table 56 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.
At site-I, nickel concentrations ranged from 0.017 mg/kg to 0.026 mg/kg with maximum during winter’ 07 and minimum during post monsoon’05. During winter, mean concentration was found to be 0.019±0.001 mg/kg in 2005, 0.025±0.002 mg/kg in 2006 and 0.026±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.019±0.00 mg/kg in 2005, 0.021±0.002 mg/kg in 2006 and 0.023±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.017±0.001 mg/kg in 2005, 0.018±0.005 mg/kg in 2006 and 0.021±0.001 mg/kg in 2007 (Table 55 & Figure 55). Over the period of three years, average values were found to be 0.023±0.003 mg/kg during winter, 0.021±0.002 mg/kg during summer and 0.018±0.002 mg/kg during post monsoon period (Table 56).

At site-II, nickel concentrations ranged from 0.018 mg/kg to 0.033 mg/kg with maximum during winter’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.022±0.002 mg/kg in 2005, 0.033±0.002 mg/kg in 2006 and 0.029±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.022±0.002 mg/kg in 2005, 0.025±0.001 mg/kg in 2006 and 0.028±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.018±0.001 mg/kg in 2005, 0.027±0.003 mg/kg in 2006 and 0.028±0.001 mg/kg in 2007 (Table 55 & Figure 56). Over the period of three years, average values were found to be 0.028±0.005 mg/kg during winter, 0.025±0.003 mg/kg during summer and 0.024±0.005 mg/kg during post monsoon period (Table 56).

At site-III, nickel contents ranged from 0.029 mg/kg to 0.039 mg/kg with maximum during summer’ 05 and minimum during summer’ 06. During winter, mean concentration was found to be 0.037±0.003 mg/kg in 2005, 0.033±0.002 mg/kg in 2006 and 0.035±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.039±0.002 mg/kg in 2005, 0.029±0.003 mg/kg in 2006 and 0.036±0.001
mg/kg in 2007. During post monsoon, mean concentration was found to be 0.033±0.004 mg/kg in 2005, 0.036±0.004 mg/kg in 2006 and 0.034±0.002 mg/kg in 2007 (Table 55 & Figure 57). Over the period of three years, average values were found to be 0.035±0.002 mg/kg during winter, 0.034±0.005 mg/kg during summer and 0.034±0.001 mg/kg during post monsoon period (Table 56).

At site-IV, nickel levels ranged from 0.014 mg/kg to 0.027 mg/kg with maximum during winter’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.019±0.002 mg/kg in 2005, 0.023±0.003 mg/kg in 2006 and 0.027±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.017±0.001 mg/kg in 2005, 0.021±0.002 mg/kg in 2006 and 0.025±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.014±0.001 mg/kg in 2005, 0.026±0.003 mg/kg in 2006 and 0.024±0.002 mg/kg in 2007 (Table 55 & Figure 58). Over the period of three years, average values were found to be 0.023±0.003 mg/kg during winter, 0.021±0.004 mg/kg during summer and 0.021±0.006 mg/kg during post monsoon period (Table 56).

**Trends:** No seasonal trend is indicated from the three year data. Nickel concentrations in liver of *Labeo rohita* at various sites decrease in the order: site-III > site-II > site-IV > site-I.

**Muscle**

Nickel concentrations show variations in muscle during the entire period of study with minimum 0.009 mg/kg at site-I and maximum 0.031 mg/kg at site-III (Table 55). Table 56 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, nickel concentrations ranged from 0.009 mg/kg to 0.020 mg/kg with maximum during winter’ 07 and minimum during post monsoon’ 05. During winter,
mean concentration was found to be $0.010\pm0.002$ mg/kg in 2005, $0.018\pm0.003$ in 2006 and $0.020\pm0.003$ mg/kg in 2007. During summer, mean concentration was found to be $0.010\pm0.001$ mg/kg in 2005, $0.011\pm0.001$ mg/kg in 2006 and $0.019\pm0.002$ mg/kg in 2007. During post monsoon, mean concentration was found to be $0.009\pm0.001$ mg/kg in 2005, $0.014\pm0.001$ mg/kg in 2006 and $0.015\pm0.001$ mg/kg in 2007 (Table 55 & Figure 55). Over the period of three years, average values were found to be $0.016\pm0.005$ mg/kg during winter, $0.013\pm0.004$ mg/kg during summer and $0.012\pm0.003$ mg/kg during post monsoon period (Table 56).

At site-II, nickel concentrations ranged from $0.012$ mg/kg to $0.023$ mg/kg with maximum during winter and summer’ 07 and minimum during summer’ 06. During winter, mean concentration was found to be $0.020\pm0.001$ mg/kg in 2005, $0.022\pm0.001$ mg/kg in 2006 and $0.023\pm0.003$ mg/kg in 2007. During summer, mean concentration was found to be $0.021\pm0.001$ mg/kg in 2005, $0.012\pm0.001$ mg/kg in 2006 and $0.023\pm0.003$ mg/kg in 2007. During post monsoon, mean concentration was found to be $0.018\pm0.001$ mg/kg in 2005, $0.019\pm0.002$ mg/kg in 2006 and $0.019\pm0.001$ mg/kg in 2007 (Table 55 & Figure 56). Over the period of three years, average values were found to be $0.021\pm0.003$ mg/kg during winter, $0.018\pm0.005$ mg/kg during summer and post monsoon period (Table 56).

At site-III, nickel contents ranged from $0.017$ mg/kg to $0.031$ mg/kg with maximum during summer’ 05 and minimum during summer’ 06. During winter, mean concentration was found to be $0.027\pm0.002$ mg/kg in 2005, $0.026\pm0.001$ mg/kg in 2006 and $0.027\pm0.003$ mg/kg in 2007. During summer, mean concentration was found to be $0.031\pm0.001$ mg/kg in 2005, $0.017\pm0.002$ mg/kg in 2006 and $0.029\pm0.003$ mg/kg in 2007. During post monsoon, mean concentration was found to be $0.028\pm0.003$ mg/kg in 2005, $0.025\pm0.002$ mg/kg in 2006 and $0.020\pm0.002$ mg/kg in
Over the period of three years, average values were found to be 0.026±0.00 mg/kg during winter, 0.025±0.007 mg/kg during summer and 0.024±0.004 mg/kg during post monsoon period (Table 56).

At site-IV, nickel levels ranged from 0.011 mg/kg to 0.022 mg/kg with maximum during winter' 07 and minimum during winter and post monsoon’05. During winter, mean concentration was found to be 0.011±0.002 mg/kg in 2005, 0.013±0.001 mg/kg in 2006 and 0.022±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.012±0.001 mg/kg in 2005, 0.012±0.002 mg/kg in 2006 and 0.020±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.011±0.001 mg/kg in 2005, 0.017±0.001 mg/kg in 2006 and 0.018±0.001 mg/kg in 2007 (Table 55 & Figure 58). Over the period of three years, average values were found to be 0.015±0.005 mg/kg during winter, 0.014±0.004 mg/kg during summer and 0.015±0.003 mg/kg during post monsoon period (Table 56).

**Trends:** No seasonal trend is revealed from the data on nickel accumulation in muscle of *Labeo rohita*. Nickel accumulation is maximum at site-III followed in decreasing order by site-II, site-IV and site-I.

**Kidney**

Nickel concentrations show variations in kidney during the entire period of study with minimum 0.011 mg/kg at site-I and maximum 0.030 mg/kg at site-III (Table 55). Table 56 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, nickel concentrations ranged from 0.011 mg/kg to 0.020 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.014±0.004 mg/kg in 2005, 0.016±0.003 mg/kg in 2006 and 0.019±0.002 mg/kg in 2007. During summer, mean concentration was
found to be 0.014±0.003 mg/kg in 2005, 0.014±0.002 mg/kg in 2006 and 0.020±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.011±0.001 mg/kg in 2005, 0.012±0.001 mg/kg in 2006 and 0.014±0.001 mg/kg in 2007 (Table 55 & Figure 55). Over the period of three years, average values were found to be 0.016±0.002 mg/kg during winter, 0.016±0.003 mg/kg during summer and 0.012±0.001 mg/kg during post monsoon period (Table 56).

At site-II, nickel concentrations ranged from 0.015 mg/kg to 0.025 mg/kg with maximum during winter’ 07 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.019±0.001 mg/kg in 2005, 0.021±0.001 mg/kg in 2006 and 0.025±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.020±0.001 mg/kg in 2005, 0.018±0.001 mg/kg in 2006 and 0.024±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.019±0.001 mg/kg in 2005, 0.015±0.001 mg/kg in 2006 and 0.017±0.001 mg/kg in 2007 (Table 55 & Figure 56). Over the period of three years, average values were found to be 0.021±0.001 mg/kg during winter, 0.020±0.003 mg/kg during summer and 0.017±0.002 mg/kg during post monsoon period (Table 56).

At site-III, nickel contents ranged from 0.019 mg/kg to 0.030 mg/kg with maximum during summer’ 07 and minimum during post monsoon’06. During winter, mean concentration was found to be 0.028±0.001 mg/kg in 2005, 0.025±0.001 mg/kg in 2006 and 0.028±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.029±0.001 mg/kg in 2005, 0.022±0.001 mg/kg in 2006 and 0.030±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.025±0.002 mg/kg in 2005, 0.019±0.001 mg/kg in 2006 and 0.020±0.001 mg/kg in 2007 (Table 55 & Figure 57). Over the period of three years, average values were
found to be 0.027±0.001 mg/kg during winter, 0.027±0.004 mg/kg during summer and 0.021±0.004 mg/kg during post monsoon period (Table 56).

At site-IV, nickel levels ranged from 0.012 mg/kg to 0.024 mg/kg with maximum during winter’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.013±0.004 mg/kg in 2005, 0.024±0.001 mg/kg in 2006 and 0.021±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.014±0.00 in 2005, 0.018±0.00 mg/kg in 2006 and 0.022±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.012±0.001 mg/kg in 2005, 0.013±0.001 mg/kg in 2006 and 0.015±0.001 mg/kg in 2007 (Table 55 & Figure 58). Over the period of three years, average values were found to be 0.019±0.005 mg/kg during winter, 0.018±0.004 mg/kg during summer and 0.013±0.001 mg/kg during post monsoon period (Table 56).

**Trends:** A definite seasonal pattern of nickel accumulation in kidney of *Labeo rohita* is not indicated from the three year data. At different sites, nickel concentrations decrease in the order: site-III > site-II > site-IV > site-I.

**Brain**

Nickel concentrations show variations in brain during the entire period of study with minimum 0.004 mg/kg at site-I, II and IV and maximum 0.014 mg/kg at site-III (Table 55). Table 56 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, nickel levels ranged from 0.004 mg/kg to 0.008 mg/kg with maximum during summer’ 07 and minimum during winter and post monsoon’ 05. During winter, mean concentration was found to be 0.004±0.002 mg/kg in 2005, 0.005±0.001 mg/kg in 2006 and 0.006±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.005±0.003 mg/kg in 2005, 0.006±0.001 in 2006 and 0.008±0.001 in
2007. During post monsoon, mean concentration was found to be 0.004±0.00 mg/kg in 2005, 0.006±0.001 mg/kg in 2006 and 0.007±0.00 mg/kg in 2007 (Table 55 & Figure 55). Over the period of three years, average values were found to be 0.005±0.001 mg/kg during winter, 0.006±0.001 mg/kg during summer and 0.005±0.001 mg/kg during post monsoon period (Table 56).

At site-II, nickel concentrations ranged from 0.004 mg/kg to 0.010 mg/kg with maximum during summer’ 07 and minimum during all seasons of ‘05. During winter, mean concentration was found to be 0.004±0.002 mg/kg in 2005, 0.005±0.001 mg/kg in 2006 and 0.006±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.004±0.00 mg/kg in 2005, 0.009±0.00 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.004±0.001 mg/kg in 2005, 0.007±0.001 in 2006 and 0.008±0.001 mg/kg in 2007 (Table 55 & Figure 56). Over the period of three years, average values were found to be 0.005±0.001 mg/kg during winter, 0.007±0.003 mg/kg during summer and 0.006±0.002 mg/kg during post monsoon period (Table 56).

At site-III, nickel contents ranged from 0.006 mg/kg to 0.014 mg/kg with maximum during summer’ 06 and minimum during winter’ 06. During winter, mean concentration was found to be 0.007±0.00 mg/kg in 2005, 0.006±0.001 mg/kg in 2006 and 0.009±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.00 mg/kg in 2005, 0.014±0.002 mg/kg in 2006 and 0.011±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.007±0.00 mg/kg in 2005, 0.009±0.00 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007 (Table 55 & Figure 57). Over the period of three years, average values were found to be 0.007±0.001 mg/kg during winter, 0.011±0.002 mg/kg during summer and 0.008±0.001 mg/kg during post monsoon period (Table 56).
At site-IV, nickel levels ranged from 0.004 mg/kg to 0.013 mg/kg with maximum during winter’ 07 and with minimum during winter and post monsoon’ 05. During winter, mean concentration was found to be 0.004±0.002 mg/kg in 2005, 0.005±0.002 mg/kg in 2006 and 0.013±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.005±0.001 mg/kg in 2005, 0.009±0.003 mg/kg in 2006 and 0.009±0.00 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.004±0.001 mg/kg in 2005, 0.007±0.001 mg/kg in 2006 and 0.008±0.00 mg/kg in 2007 (Table 55 & Figure 58). Over the period of three years, average values were found to be 0.007±0.002 mg/kg during winter, summer and 0.006±0.002 mg/kg during post monsoon period (Table 56).

**Trends:** No seasonal trend is indicated in accumulation of nickel in brain of *Labeo rohita*. Nickel levels at various sites decrease in the following order:

Site-III > Site-II > Site-IV > Site-I

Among various tissues of *Labeo rohita*, nickel concentration is maximum in liver, minimum in brain and intermediate in muscle and kidney with higher concentration in kidney most of the time.

3.2 *Cyprinus carpio* Linnaeus:

**Liver**

In *Cyprinus carpio*, nickel concentrations show variations in liver during the whole period of study with minimum 0.028 mg/kg at site-I and IV and maximum 0.039 mg/kg at site-III (Table 57). Table 58 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, nickel concentrations ranged from 0.028 mg/kg to 0.032 mg/kg with maximum during winter’ 07 and summer’ 06 and minimum during winter and summer’ 05. During winter, mean concentration was found to be 0.028±0.002 mg/kg
in 2005, 0.030±0.003 mg/kg in 2006 and 0.032±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.028±0.003 mg/kg in 2005, 0.032±0.004 mg/kg in 2006 and 0.030±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.030±0.001 mg/kg in 2005, 0.030±0.003 mg/kg in 2006 and 0.029±0.003 mg/kg in 2007 (Table 57 & Figure 59). Over the period of three years, average values were found to be 0.030±0.002 mg/kg during winter, summer and 0.029±0.001 mg/kg during post monsoon period (Table 58).

At site-II, nickel concentrations ranged from 0.029 mg/kg to 0.035 mg/kg with maximum during summer' 07 and minimum during summer’ 05. During winter, mean concentration was found to be 0.030±0.003 mg/kg in 2005, 0.032±0.003 mg/kg in 2006 and 2007. During summer, mean concentration was found to be 0.029±0.002 mg/kg in 2005, 0.034±0.004 mg/kg in 2006 and 0.035±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.030±0.002 mg/kg in 2005, 0.031±0.002 mg/kg in 2006 and 0.033±0.004 mg/kg in 2007 (Table 57 & Figure 60). Over the period of three years, average values were found to be 0.031±0.001 mg/kg during winter, 0.032±0.003 mg/kg during summer and 0.031±0.001 mg/kg during post monsoon period (Table 58).

At site-III, nickel contents ranged from 0.032 mg/kg to 0.039 mg/kg with maximum during winter’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.035±0.002 mg/kg in 2005, 0.034±0.004 mg/kg in 2006 and 0.039±0.004 mg/kg in 2007. During summer, mean concentration was found to be 0.033±0.002 mg/kg in 2005, 0.036±0.003 mg/kg in 2006 and 0.037±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.032±0.001 mg/kg in 2005, 0.034±0.002 mg/kg in 2006 and 0.037±0.004 mg/kg in 2007 (Table 57 & Figure 61). Over the period of three years, average values were
found to be 0.036±0.002 mg/kg during winter, 0.035±0.005 mg/kg during summer and 0.034±0.002 mg/kg during post monsoon period (Table 58).

At site-IV, nickel levels ranged from 0.028 mg/kg to 0.033 mg/kg with maximum during winter’ 07 and minimum during post monsoon’ 05 and 06. During winter, mean concentration was found to be 0.029±0.003 mg/kg in 2005, 0.031±0.002 mg/kg in 2006 and 0.033±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.030±0.001 mg/kg in 2005, 0.031±0.002 mg/kg in 2006 and 0.030±0.004 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.028±0.002 mg/kg in 2005, 0.028±0.001 mg/kg in 2006 and 0.030±0.002 mg/kg in 2007 (Table 57 & Figure 62). Over the period of three years, average values were found to be 0.031±0.002 mg/kg during winter, 0.030±0.00 mg/kg during summer and 0.029±0.002 mg/kg during post monsoon period (Table 58).

**Trends:** No seasonal pattern is evident from the three year data on nickel accumulation in liver of *Cyprinus carpio*. Concentration of nickel in liver is maximum at site-III followed in decreasing order by site-II, site-IV and site-I.

**Muscle**

Nickel concentrations show variations in muscle during the entire period of study with minimum 0.024 mg/kg at site-I and maximum 0.029 mg/kg at site-II, III and IV (Table 57). Table 58 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, nickel concentrations ranged from 0.024 mg/kg to 0.027 mg/kg with maximum during summer’ 06 and 07 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.026±0.004 mg/kg in 2005, 0.026±0.002 in 2006 and 0.026±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.026±0.002 mg/kg in 2005, 0.027±0.002 mg/kg in 2006 and 0.027±0.003
mg/kg in 2007. During post monsoon, mean concentration was found to be 0.025±0.001 mg/kg in 2005, 0.024±0.003 mg/kg in 2006 and 0.025±0.002 mg/kg in 2007 (Table 57 & Figure 59). Over the period of three years, average values were found to be 0.026±0.00 mg/kg during winter, 0.026±0.00 mg/kg during summer and 0.024±0.00 mg/kg during post monsoon period (Table 58).

At site-II, nickel concentrations ranged from 0.026 mg/kg to 0.029 mg/kg with maximum during winter’ 05, 06 and all summer seasons and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.029±0.001 mg/kg in 2005, 0.029±0.002 mg/kg in 2006 and 0.028±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.029±0.002 mg/kg in 2005, 0.029±0.001 mg/kg in 2006 and 0.029±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.026±0.001 mg/kg in 2005, 0.028±0.002 mg/kg in 2006 and 0.028±0.001 mg/kg in 2007 (Table 57 & Figure 60). Over the period of three years, average values were found to be 0.028±0.00 mg/kg during winter, 0.029±0.00 mg/kg during summer and 0.027±0.001 mg/kg during post monsoon period (Table 58).

At site-III, nickel contents ranged from 0.027 mg/kg to 0.029 mg/kg with maximum during winter’ 07, summer’ 05 and 07 and minimum during all post monsoon seasons. During winter, mean concentration was found to be 0.028±0.001 mg/kg in 2005, 0.028±0.002 mg/kg in 2006 and 0.029±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.029±0.002 mg/kg in 2005, 0.028±0.003 mg/kg in 2006 and 0.029±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.027±0.003 mg/kg in 2005, 0.027±0.002 mg/kg in 2006 and 0.027±0.001 mg/kg in 2007 (Table 57 & Figure 61). Over the period of
three years, average values were found to be 0.028±0.00 mg/kg during winter, summer and 0.027±0.00 mg/kg during post monsoon period (Table 58).

At site-IV, nickel levels ranged from 0.026 mg/kg to 0.029 mg/kg with maximum during summer’ 05 and 07 and minimum during summer and post monsoon’06. During winter, mean concentration was found to be 0.028±0.001 mg/kg in 2005, 0.027±0.001 mg/kg in 2006 and 0.028±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.029±0.003 mg/kg in 2005, 0.026±0.002 mg/kg in 2006 and 0.029±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.028±0.002 mg/kg in 2005, 0.026±0.003 mg/kg in 2006 and 0.027±0.002 mg/kg in 2007 (Table 57 & Figure 62). Over the period of three years, average values were found to be 0.027±0.00 mg/kg during winter, 0.028±0.001 mg/kg during summer and 0.027±0.001 mg/kg during post monsoon period (Table 58).

**Trends:** No seasonal trend is indicated from three year data on nickel accumulation in muscle of *Cyprinus carpio*. Nickel accumulation at various sites shows the order:

Site-III > site-II > site-IV > site-I

**Kidney**

Nickel concentrations show variations in kidney during the entire period of study with minimum 0.025 mg/kg at site-I and maximum 0.038 mg/kg at site-II (Table 57). Table 58 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, nickel concentrations ranged from 0.025 mg/kg to 0.029 mg/kg with maximum during summer’ 06 and minimum during summer’ 05. During winter, mean concentration was found to be 0.027±0.002 mg/kg in 2005, 0.028±0.002 mg/kg in 2006 and 0.027±0.002 mg/kg in 2007. During summer, mean concentration was
found to be 0.025±0.001 mg/kg in 2005, 0.029±0.003 mg/kg in 2006 and 0.027±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.027±0.002 mg/kg in 2005, 0.027±0.001 mg/kg in 2006 and 0.026±0.001 mg/kg in 2007 (Table 57 & Figure 59). Over the period of three years, average values were found to be 0.027±0.00 mg/kg during winter, 0.027±0.002 mg/kg during summer and 0.026±0.00 mg/kg during post monsoon period (Table 58).

At site-II, nickel concentrations ranged from 0.028 mg/kg to 0.038 mg/kg with maximum during post monsoon’ 06 and minimum during winter’ 05, post monsoon’ 05 and 07. During winter, mean concentration was found to be 0.028±0.003 mg/kg in 2005, 0.030±0.003 mg/kg in 2006 and 0.030±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.030±0.002 mg/kg in 2005, 0.029±0.002 mg/kg in 2006 and 0.031±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.028±0.001 mg/kg in 2005, 0.038±0.002 mg/kg in 2006 and 0.028±0.001 mg/kg in 2007 (Table 57 & Figure 60). Over the period of three years, average values were found to be 0.029±0.001 mg/kg during winter, 0.030±0.001 mg/kg during summer and 0.031±0.005 mg/kg during post monsoon period (Table 58).

At site-III, nickel contents ranged from 0.029 mg/kg to 0.032 mg/kg with maximum during summer’ 06 and minimum during winter and post monsoon’ 05. During winter, mean concentration was found to be 0.029±0.002 mg/kg in 2005, 0.030±0.002 mg/kg in 2006 and 0.031±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.031±0.002 mg/kg in 2005, 0.032±0.002 mg/kg in 2006 and 0.031±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.029±0.003 mg/kg in 2005, 0.030±0.001 mg/kg in 2006 and 0.030±0.002 mg/kg in 2007 (Table 57 & Figure 61). Over the period of three years, average values
were found to be 0.030±0.001 mg/kg during winter, 0.031±0.00 mg/kg during summer and 0.029±0.00 mg/kg during post monsoon period (Table 58).

At site-IV, nickel levels ranged from 0.026 mg/kg to 0.029 mg/kg with maximum during winter’ 06, 07 and summer’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.027±0.003 mg/kg in 2005, 0.029±0.003 mg/kg in 2006 and 0.029±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.028±0.002 in 2005, 0.029±0.001 mg/kg in 2006 and 0.028±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.026±0.001 mg/kg in 2005, 0.028±0.002 mg/kg in 2006 and 0.028±0.003 mg/kg in 2007 (Table 57 & Figure 62). Over the period of three years, average values were found to be 0.028±0.001 mg/kg during winter, 0.028±0.00 mg/kg during summer and 0.027±0.001 mg/kg during post monsoon period (Table 58).

**Trends:** No definite seasonal pattern is indicated from three years data on nickel accumulation in kidney of *Cyprinus carpio*. At different sites, the trend followed is site-III > site-II > site-IV > site-I.

**Brain**

Nickel concentrations show variations in brain during the entire period of study with minimum 0.006 mg/kg at site-I and maximum 0.011 mg/kg at site-III (Table 57). Table 58 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, nickel levels ranged from 0.006 mg/kg to 0.009 mg/kg with maximum during summer’ 05 and winter’ 06 and minimum during summer’ 07. During winter, mean concentration was found to be 0.007±0.001 mg/kg in 2005, 0.009±0.001 mg/kg in 2006 and 0.008±0.00 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.008±0.001 in 2006 and 0.006±0.001 in
2007. During post monsoon, mean concentration was found to be 0.008±0.00 mg/kg in 2005, 0.008±0.002 mg/kg in 2006 and 0.007±0.001 mg/kg in 2007 (Table 57 & Figure 59). Over the period of three years, average values were found to be 0.008±0.001 mg/kg during winter, 0.007±0.001 mg/kg during summer and 0.007±0.00 mg/kg during post monsoon period (Table 58).

At site-II, nickel concentrations ranged from 0.007 mg/kg to 0.010 mg/kg with maximum during summer’ 06 and minimum during summer’ 05. During winter, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.008±0.001 mg/kg in 2006 and 0.009±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.007±0.001 mg/kg in 2005, 0.010±0.001 mg/kg in 2006 and 0.009±0.00 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 2006 and 0.008±0.001 mg/kg in 2007 (Table 57 & Figure 60). Over the period of three years, average values were found to be 0.008±0.00 mg/kg during winter, 0.008±0.001 mg/kg during summer and 0.008±0.00 mg/kg during post monsoon period (Table 58).

At site-III, nickel contents ranged from 0.008 mg/kg to 0.011 mg/kg with maximum during summer’ 06 and minimum during post monsoon’ 05 and 07. During winter, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.009±0.001 mg/kg in 2006 and 0.009±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.009±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.008±0.00 mg/kg in 2005, 0.010±0.00 mg/kg in 2006 and 0.008±0.001 mg/kg in 2007 (Table 57 & Figure 61). Over the period of three years, average values were found to be 0.009±0.00 mg/kg during winter, 0.010±0.001 mg/kg during summer and 0.008±0.001 mg/kg during post monsoon period (Table 58).
At site-IV, nickel levels ranged from 0.007 mg/kg to 0.009 mg/kg with maximum during winter’ 06, 07, summer’ 06 and post monsoon’ 07 and with minimum during summer’ 07 and post monsoon’ 05. During winter, mean concentration was found to be 0.008±0.001 mg/kg in 2005, 0.009±0.001 mg/kg in 2006 and 0.009±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.008±0.001 mg/kg in 2005, 0.009±0.001 mg/kg in 2006 and 0.007±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.007±0.00 mg/kg in 2005, 0.008±0.00 mg/kg in 2006 and 0.009±0.00 mg/kg in 2007 (Table 57 & Figure 62). Over the period of three years, average values were found to be 0.008±0.00 mg/kg during winter, 0.008±0.001 mg/kg during summer and post monsoon period (Table 58).

**Trends:** No seasonal trend is indicated from three year data on nickel accumulation in brain of *Cyprinus carpio*. Nickel accumulation is maximum at site-III, minimum at site-I and more or less similar at site-II and IV.

Among tissues, nickel accumulation decreases in the order as:

Liver > Kidney > Muscle > Brain

3.3 *Mystus seenghala* (Sykes):

**Liver**

In *Mystus seenghala*, nickel concentrations show variations in liver during the whole period of study with minimum 0.033 mg/kg at site-IV and maximum 0.049 mg/kg at site-III (Table 59). Table 60 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, nickel concentrations ranged from 0.035 mg/kg to 0.039 mg/kg with maximum during winter’ 06 and minimum during winter’ 05, summer’ 06, 07 and post monsoon’ 05. During winter, mean concentration was found to be 0.035±0.002
mg/kg in 2005, 0.039±0.002 mg/kg in 2006 and 0.035±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.036±0.001 mg/kg in 2005, 0.035±0.003 mg/kg in 2006 and 0.035±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.035±0.002 mg/kg in 2005, 0.038±0.001 mg/kg in 2006 and 0.034±0.001 mg/kg in 2007 (Table 59 & Figure 63). Over the period of three years, average values were found to be 0.036±0.002 mg/kg during winter, 0.035±0.001 mg/kg during summer and 0.035±0.002 mg/kg during post monsoon period (Table 60).

At site-II, nickel concentrations ranged from 0.036 mg/kg to 0.041 mg/kg with maximum during winter’ 07 and minimum during winter’ 05. During winter, mean concentration was found to be 0.036±0.003 mg/kg in 2005, 0.037±0.003 mg/kg in 2006 and 0.041±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.038±0.002 mg/kg in 2005, 0.039±0.002 mg/kg in 2006 and 0.040±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.038±0.001 mg/kg in 2005, 0.040±0.002 mg/kg in 2006 and 0.038±0.001 mg/kg in 2007 (Table 59 & Figure 64). Over the period of three years, average values were found to be 0.038±0.002 mg/kg during winter, 0.039±0.001 mg/kg during summer and 0.038±0.001 mg/kg during post monsoon period (Table 60).

At site-III, nickel contents ranged from 0.039 mg/kg to 0.049 mg/kg with maximum during post monsoon’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.040±0.002 mg/kg in 2005, 0.044±0.002 mg/kg in 2006 and 0.046±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.043±0.002 mg/kg in 2005, 0.048±0.002 mg/kg in 2006 and 0.045±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.039±0.003 mg/kg in 2005, 0.042±0.001 mg/kg in 2006 and 0.049±0.002 mg/kg
in 2007 (Table 59 & Figure 65). Over the period of three years, average values were found to be 0.043±0.003 mg/kg during winter, 0.045±0.002 mg/kg during summer and 0.043±0.005 mg/kg during post monsoon period (Table 60).

At site-IV, nickel levels ranged from 0.033 mg/kg to 0.039 mg/kg with maximum during winter’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.036±0.003 mg/kg in 2005, 0.039±0.003 mg/kg in 2006 and 0.038±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.038±0.002 mg/kg in 2005, 0.037±0.001 mg/kg in 2006 and 0.035±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.033±0.001 mg/kg in 2005, 0.038±0.002 mg/kg in 2006 and 0.038±0.003 mg/kg in 2007 (Table 59 & Figure 66). Over the period of three years, average values were found to be 0.037±0.001 mg/kg during winter, 0.036±0.001 mg/kg during summer and 0.036±0.002 mg/kg during post monsoon period (Table 60).

**Trends:** No definite seasonal trend is revealed from the three years data on nickel accumulation in liver of *Mystus seenghala*. Nickel levels in liver depict the trends as

Site- III > Site-II > Site-IV > Site-I

**Muscle**

Nickel concentrations show variations in muscle during the entire period of study with minimum 0.028 mg/kg at site-I and IV and maximum 0.037 mg/kg at site-III (Table 59). Table 60 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, nickel concentrations ranged from 0.028 mg/kg to 0.032 mg/kg with maximum during summer’ 06 and minimum during winter and summer’ 07 and post monsoon’ 05 and 07. During winter, mean concentration was found to be 0.030±0.003 mg/kg in 2005, 0.029±0.002 in 2006 and 0.028±0.003 mg/kg in 2007. During
summer, mean concentration was found to be 0.029±0.002 mg/kg in 2005, 0.032±0.002 mg/kg in 2006 and 0.028±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.028±0.001 mg/kg in 2005, 0.031±0.003 mg/kg in 2006 and 0.028±0.002 mg/kg in 2007 (Table 59 & Figure 63). Over the period of three years, average values were found to be 0.029±0.001 mg/kg during winter, 0.029±0.002 mg/kg during summer and 0.029±0.001 mg/kg during post monsoon period (Table 60).

At site-II, nickel concentrations ranged from 0.031 mg/kg to 0.036 mg/kg with maximum during winter’ 07 and post monsoon’ 06 and minimum during winter’ 06, summer’ 07 and post monsoon’ 05. During winter, mean concentration was found to be 0.033±0.002 mg/kg in 2005, 0.031±0.001 mg/kg in 2006 and 0.036±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.032±0.001 mg/kg in 2005, 0.035±0.002 mg/kg in 2006 and 0.031±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.031±0.003 mg/kg in 2005, 0.036±0.002 mg/kg in 2006 and 0.033±0.001 mg/kg in 2007 (Table 59 & Figure 64). Over the period of three years, average values were found to be 0.033±0.002 mg/kg during winter, 0.032±0.002 mg/kg during summer and 0.033±0.002 mg/kg during post monsoon period (Table 60).

At site-III, nickel contents ranged from 0.029 mg/kg to 0.037 mg/kg with maximum during winter’ 06 and minimum during summer’ 06. During winter, mean concentration was found to be 0.033±0.001 mg/kg in 2005, 0.037±0.001 mg/kg in 2006 and 0.034±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.035±0.003 mg/kg in 2005, 0.029±0.002 mg/kg in 2006 and 0.035±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.034±0.001 mg/kg in 2005, 0.033±0.001 mg/kg in 2006 and 0.036±0.002 mg/kg in
(Table 59 & Figure 65). Over the period of three years, average values were found to be 0.034±0.002 mg/kg during winter, 0.033±0.003 mg/kg during summer and 0.034±0.001 mg/kg during post monsoon period (Table 60).

At site-IV, nickel levels ranged from 0.028 mg/kg to 0.031 mg/kg with maximum during winter’ 07 and minimum during summer’ 05. During winter, mean concentration was found to be 0.031±0.002 mg/kg in 2005, 0.030±0.001 mg/kg in 2006 and 0.032±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.028±0.001 mg/kg in 2005, 0.031±0.002 mg/kg in 2006 and 0.031±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.029±0.002 mg/kg in 2005, 0.031±0.002 mg/kg in 2006 and 0.030±0.002 mg/kg in 2007 (Table 59 & Figure 66). Over the period of three years, average values were found to be 0.031±0.001 mg/kg during winter, 0.030±0.001 mg/kg during summer and 0.030±0.001 mg/kg during post monsoon period (Table 60).

**Trends:** No definite seasonal trend is indicated from the three year data. Nickel concentration is higher at site-II and site-III as compared to site-I and site-IV.

**Kidney**

Nickel concentrations show variations in kidney during the entire period of study with minimum 0.028 mg/kg at site-I and IV and maximum 0.037 mg/kg at site-II and III Table 59. Table 60 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, nickel concentrations ranged from 0.028 mg/kg to 0.033 mg/kg with maximum during winter’ 05 and summer’ 06 and minimum during summer’ 05. During winter, mean concentration was found to be 0.033±0.004 mg/kg in 2005, 0.029±0.002 mg/kg in 2006 and 0.030±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.028±0.002 mg/kg in 2005, 0.033±0.002 mg/kg in
2006 and 0.032±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.029±0.001 mg/kg in 2005, 0.031±0.003 mg/kg in 2006 and 0.030±0.002 mg/kg in 2007 (Table 59 & Figure 63). Over the period of three years, average values were found to be 0.030±0.002 mg/kg during winter, 0.031±0.002 mg/kg during summer and 0.030±0.001 mg/kg during post monsoon period (Table 60).

At site-II, nickel concentrations ranged from 0.030 mg/kg to 0.037 mg/kg with maximum during winter’ 06 and summer’ 06 and minimum during winter’ 07 and post monsoon’ 05. During winter, mean concentration was found to be 0.034±0.001 mg/kg in 2005, 0.037±0.002 mg/kg in 2006 and 0.030±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.034±0.002 mg/kg in 2005, 0.033±0.001 mg/kg in 2006 and 0.030±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.032±0.001 mg/kg in 2005, 0.034±0.002 mg/kg in 2006 and 0.032±0.001 mg/kg in 2007 (Table 59 & Figure 64). Over the period of three years, average values were found to be 0.033±0.003 mg/kg during winter, 0.032±0.001 mg/kg during summer and post monsoon period (Table 60).

At site-III, nickel contents ranged from 0.030 mg/kg to 0.037 mg/kg with maximum during winter’ 06 and post monsoon’ 07 and minimum during summer’ 07. During winter, mean concentration was found to be 0.032±0.001 mg/kg in 2005, 0.037±0.002 mg/kg in 2006 and 0.034±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.032±0.002 mg/kg in 2005, 0.036±0.003 mg/kg in 2006 and 0.030±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.034±0.003 mg/kg in 2005, 0.033±0.002 mg/kg in 2006 and 0.037±0.001 mg/kg in 2007 (Table 59 & Figure 65). Over the period of three years, average values were found to be 0.034±0.002 mg/kg during winter, 0.032±0.003 mg/kg during summer and 0.034±0.003 mg/kg during post monsoon period (Table 60).
At site-IV, nickel levels ranged from 0.028 mg/kg to 0.036 mg/kg with maximum during summer’ 06 and minimum during winter’ 05. During winter, mean concentration was found to be 0.028±0.001 mg/kg in 2005, 0.035±0.001 mg/kg in 2006 and 0.031±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.030±0.003 in 2005, 0.036±0.002 mg/kg in 2006 and 0.031±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.030±0.002 mg/kg in 2005, 0.034±0.003 mg/kg in 2006 and 0.029±0.002 mg/kg in 2007 (Table 59 & Figure 66). Over the period of three years, average values were found to be 0.031±0.001 mg/kg during winter, 0.032±0.003 mg/kg during summer and 0.031±0.002 mg/kg during post monsoon period (Table 60).

Trends: No definite seasonal trend is indicated from three years data on nickel accumulation in kidney of *Mystus seenghala*. Nickel accumulation in kidney at various sites shows the following trend: site-III > site-II > site-IV > site-I.

**Brain**

Nickel concentrations show variations in brain during the entire period of study with minimum 0.009 mg/kg at site-I, II and IV and maximum 0.014 mg/kg at site-II, site-III and site-IV (Table 59). Table 60 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, nickel levels ranged from 0.009 mg/kg to 0.013 mg/kg with maximum during winter’ 07 and minimum during winter and post monsoon’ 05. During winter, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.013±0.00 mg/kg in 2007. During summer, mean concentration was found to be 0.011±0.001 mg/kg in 2005, 0.012±0.001 in 2006 and 0.010±0.001 in 2007. During post monsoon, mean concentration was found to be 0.009±0.00 mg/kg in 2005, 0.010±0.002 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007 (Table 59 &
Figure 63). Over the period of three years, average values were found to be 0.011±0.002 mg/kg during winter, 0.011±0.001 mg/kg during summer and 0.009±0.00 mg/kg during post monsoon period (Table 60).

At site-II, nickel concentrations ranged from 0.009 mg/kg to 0.014 mg/kg with maximum during summer’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.011±0.001 mg/kg in 2005, 0.013±0.001 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.014±0.001 mg/kg in 2006 and 0.011±0.00 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.012±0.001 in 2006 and 0.012±0.001 mg/kg in 2007 (Table 59 & Figure 64). Over the period of three years, average values were found to be 0.011±0.001 mg/kg during winter, 0.011±0.002 mg/kg during summer and 0.010±0.002 mg/kg during post monsoon period (Table 60).

At site-III, nickel contents ranged from 0.010 mg/kg to 0.014 mg/kg with maximum during summer’ 07 and minimum during winter’ 05, 07 and post monsoon’ 06. During winter, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.012±0.001 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.012±0.001 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.014±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.011±0.00 mg/kg in 2005, 0.010±0.00 mg/kg in 2006 and 0.012±0.001 mg/kg in 2007 (Table 59 & Figure 65). Over the period of three years, average values were found to be 0.010±0.001 mg/kg during winter, 0.012±0.001 mg/kg during summer and 0.011±0.001 mg/kg during post monsoon period (Table 60).

At site-IV, nickel levels ranged from 0.009 mg/kg to 0.014 mg/kg with maximum during winter’ 06 and minimum during winter and summer’ 05. During
winter, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.014±0.001 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.010±0.001 mg/kg in 2006 and 0.012±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.010±0.00 mg/kg in 2005, 0.011±0.00 mg/kg in 2006 and 0.010±0.00 mg/kg in 2007 (Table 59 & Figure 66). Over the period of three years, average values were found to be 0.011±0.002 mg/kg during winter, 0.010±0.001 mg/kg during summer and 0.010±0.00 mg/kg during post monsoon period (Table 60).

**Trends:** No seasonal trend is evident from the data. Nickel concentration in brain of *Mystus seenghala* at various sites shows the trend as site-III > site-II > site-IV > site-I. Among tissues nickel concentration decreases in the following order:

Liver > Kidney > muscle > brain

### 3.4 *Cirrhinus mrigala* (Hamilton):

#### Liver

In *Cirrhinus mrigala*, nickel concentrations show variations in liver during the whole period of study with minimum 0.030 mg/kg at site-IV and maximum 0.042 mg/kg at site-III (Table 61). Table 62 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, nickel concentrations ranged from 0.031 mg/kg to 0.037 mg/kg with maximum during summer’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.033±0.003 mg/kg in 2005, 0.035±0.003 mg/kg in 2006 and 0.032±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.033±0.003 mg/kg in 2005, 0.037±0.004 mg/kg in 2006 and 0.030±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.031±0.004 mg/kg in 2005, 0.035±0.003 mg/kg in 2006 and 0.032±0.002 mg/kg in
2007 (Table 61 & Figure 67). Over the period of three years, average values were found to be 0.033±0.001 mg/kg during winter, 0.033±0.003 mg/kg during summer and 0.032±0.002 mg/kg during post monsoon period (Table 62).

At site-II, nickel concentrations ranged from 0.032 mg/kg to 0.039 mg/kg with maximum during winter and summer’ 07 and minimum during winter’ 05. During winter, mean concentration was found to be 0.032±0.002 mg/kg in 2005, 0.037±0.003 mg/kg in 2006 and 0.039±0.004 mg/kg in 2007. During summer, mean concentration was found to be 0.034±0.004 mg/kg in 2005, 0.038±0.004 mg/kg in 2006 and 0.039±0.004 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.034±0.003 mg/kg in 2005, 0.037±0.002 mg/kg in 2006 and 0.037±0.003 mg/kg in 2007 (Table 61 & Figure 68). Over the period of three years, average values were found to be 0.036±0.003 mg/kg during winter, 0.037±0.002 mg/kg during summer and 0.036±0.001 mg/kg during post monsoon period (Table 62).

At site-III, nickel contents ranged from 0.034 mg/kg to 0.042 mg/kg with maximum during winter’ 06, summer and post monsoon’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.039±0.004 mg/kg in 2005, 0.042±0.004 mg/kg in 2006 and 0.040±0.004 mg/kg in 2007. During summer, mean concentration was found to be 0.041±0.003 mg/kg in 2005, 0.039±0.002 mg/kg in 2006 and 0.042±0.004 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.034±0.004 mg/kg in 2005, 0.039±0.003 mg/kg in 2006 and 0.042±0.003 mg/kg in 2007 (Table 61 & Figure 69). Over the period of three years, average values were found to be 0.040±0.001 mg/kg during winter, summer and 0.038±0.003 mg/kg during post monsoon period (Table 62).

At site-IV, nickel levels ranged from 0.030 mg/kg to 0.037 mg/kg with maximum during winter’ 06 and minimum during post monsoon’ 05. During winter,
mean concentration was found to be 0.031±0.002 mg/kg in 2005, 0.037±0.003 mg/kg in 2006 and 0.036±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.033±0.002 mg/kg in 2005, 0.035±0.002 mg/kg in 2006 and 0.034±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.030±0.003 mg/kg in 2005, 0.035±0.003 mg/kg in 2006 and 0.036±0.004 mg/kg in 2007 (Table 61 & Figure 70). Over the period of three years, average values were found to be 0.034±0.003 mg/kg during winter, 0.034±0.001 mg/kg during summer and 0.033±0.003 mg/kg during post monsoon period (Table 62).

**Trends:** No seasonal trend is recorded. Nickel levels in liver of *Cirrhinus mrigala* show following site-wise trend: site-III > site-II > site-IV > site-I.

**Muscle**

Nickel concentrations show variations in muscle during the entire period of study with minimum 0.025 mg/kg at site-I and maximum 0.032 mg/kg at site-II and III (Table 61). Table 62 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, nickel concentrations ranged from 0.025 mg/kg to 0.029 mg/kg with maximum during summer’ 06 and minimum during summer’ 05. During winter, mean concentration was found to be 0.027±0.002 mg/kg in 2005, 0.027±0.003 in 2006 and 0.027±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.025±0.001 mg/kg in 2005, 0.029±0.003 mg/kg in 2006 and 0.028±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.027±0.002 mg/kg in 2005, 0.027±0.001 mg/kg in 2006 and 0.026±0.001 mg/kg in 2007 (Table 61 & Figure 67). Over the period of three years, average values were found to be 0.027±0.00 mg/kg during winter, 0.027±0.002 mg/kg during summer and 0.026±0.00 mg/kg during post monsoon period (Table 62).
At site-II, mean concentrations ranged from 0.029 mg/kg to 0.032 mg/kg with maximum during post monsoon’ 06 and minimum during summer and post monsoon’ 05. During winter, mean concentration was found to be 0.030±0.003 mg/kg in 2005, 2006 and 0.030±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.029±0.002 mg/kg in 2005, 0.030±0.002 mg/kg in 2006 and 0.031±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.029±0.001 mg/kg in 2005, 0.032±0.003 mg/kg in 2006 and 0.030±0.003 mg/kg in 2007 (Table 61 & Figure 68). Over the period of three years, average values were found to be 0.030±0.00 mg/kg during winter, 0.030±0.001 mg/kg during summer and post monsoon period (Table 62).

At site-III, nickel contents ranged from 0.029 mg/kg to 0.032 mg/kg with maximum during summer’ 06 and minimum during winter’ 05. During winter, mean concentration was found to be 0.029±0.002 mg/kg in 2005, 0.030±0.002 mg/kg in 2006 and 0.030±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.031±0.002 mg/kg in 2005, 0.032±0.003 mg/kg in 2006 and 0.031±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.031±0.003 mg/kg in 2005, 0.030±0.001 mg/kg in 2006 and 0.030±0.002 mg/kg in 2007 (Table 61 & Figure 69). Over the period of three years, average values were found to be 0.029±0.00 mg/kg during winter, 0.031±0.00 mg/kg during summer and 0.030±0.00 mg/kg during post monsoon period (Table 62).

At site-IV, nickel levels ranged from 0.027 mg/kg to 0.030 mg/kg with maximum during winter’ 06 and minimum during winter’ 05. During winter, mean concentration was found to be 0.027±0.003 mg/kg in 2005, 0.030±0.003 mg/kg in 2006 and 0.029±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.028±0.002 mg/kg in 2005, 0.029±0.001 mg/kg in 2006 and 2007.
During post monsoon, mean concentration was found to be $0.028 \pm 0.001$ mg/kg in 2005, $0.028 \pm 0.002$ mg/kg in 2006 and $0.028 \pm 0.003$ mg/kg in 2007 (Table 61 & Figure 70). Over the period of three years, average values were found to be $0.028 \pm 0.001$ mg/kg during winter, $0.028 \pm 0.00$ mg/kg during summer and post monsoon period (Table 62).

**Trends:** No seasonal trend is indicated in nickel accumulation in muscle of *Cirrhinus mrigala*. Among sites, the trend of nickel accumulation in muscle is site-III > site-II > site-IV > site-I.

**Kidney**

Nickel concentrations show variations in kidney during the entire period of study with minimum $0.028$ mg/kg at site-I and IV and maximum $0.037$ mg/kg at site-III (Table 61). Table 62 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, nickel concentrations ranged from $0.028$ mg/kg to $0.032$ mg/kg with maximum during summer’ 06 and 07 and minimum during winter’ 05. During winter, mean concentration was found to be $0.028 \pm 0.002$ mg/kg in 2005, $0.030 \pm 0.003$ mg/kg in 2006 and $0.029 \pm 0.003$ mg/kg in 2007. During summer, mean concentration was found to be $0.030 \pm 0.003$ mg/kg in 2005, $0.032 \pm 0.004$ mg/kg in 2006 and $0.032 \pm 0.002$ mg/kg in 2007. During post monsoon, mean concentration was found to be $0.030 \pm 0.003$ mg/kg in 2005, 2006 and $0.029 \pm 0.003$ mg/kg in 2007 (Table 61 & Figure 67). Over the period of three years, average values were found to be $0.029 \pm 0.001$ mg/kg during winter, $0.031 \pm 0.001$ mg/kg during summer and $0.029 \pm 0.001$ mg/kg during post monsoon period (Table 62).

At site-II, nickel concentrations ranged from $0.030$ mg/kg to $0.035$ mg/kg with maximum during summer’ 07 and minimum during winter and post monsoon’ 05.
During winter, mean concentration was found to be 0.030±0.003 mg/kg in 2005, 0.032±0.003 mg/kg in 2006 and 2007. During summer, mean concentration was found to be 0.032±0.003 mg/kg in 2005, 0.034±0.004 mg/kg in 2006 and 0.035±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.030±0.002 mg/kg in 2005, 0.033±0.003 mg/kg in 2006 and 0.032±0.00 mg/kg in 2007 (Table 61 & Figure 68). Over the period of three years, average values were found to be 0.031±0.003 mg/kg during winter, 0.033±0.001 mg/kg during summer and 0.031±0.001 mg/kg during post monsoon period (Table 62).

At site-III, nickel contents ranged from 0.030 mg/kg to 0.037 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.031±0.003 mg/kg in 2005, 0.034±0.004 mg/kg in 2006 and 0.033±0.004 mg/kg in 2007. During summer, mean concentration was found to be 0.033±0.002 mg/kg in 2005, 0.036±0.003 mg/kg in 2006 and 0.037±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.030±0.001 mg/kg in 2005, 0.032±0.002 mg/kg in 2006 and 0.033±0.002 mg/kg in 2007 (Table 61 & Figure 69). Over the period of three years, average values were found to be 0.032±0.001 mg/kg during winter, 0.035±0.002 mg/kg during summer and 0.031±0.001 mg/kg during post monsoon period (Table 62).

At site-IV, nickel levels ranged from 0.028 mg/kg to 0.035 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.030±0.003 mg/kg in 2005, 0.031±0.002 mg/kg in 2006 and 0.030±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.030±0.003 mg/kg in 2005, 0.031±0.003 mg/kg in 2006 and 0.035±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.028±0.002 mg/kg in 2005, 0.029±0.001 mg/kg in 2006 and 0.030±0.002 mg/kg in 2007 (Table
61 & Figure 70). Over the period of three years, average values were found to be 0.030±0.00 mg/kg during winter, 0.032±0.002 mg/kg during summer and 0.029±0.001 mg/kg during post monsoon period (Table 62).

Trends: No definite seasonal trend is indicated from the three years data on nickel accumulation in kidney of *Cirrhinus mrigala*. Nickel accumulation at various sites shows the trend as site-III > site-II > site-I ≥site-IV.

Brain

Nickel concentrations show variations in brain during the entire period of study with minimum 0.008 mg/kg at site-I and IV and maximum 0.014 mg/kg at site-III (Table 61). Table 62 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, nickel levels ranged from 0.008 mg/kg to 0.011 mg/kg with maximum during summer’ 06 and minimum during winter’ 07 and post monsoon’ 06. During winter, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.009±0.001 mg/kg in 2006 and 0.008±0.00 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.011±0.001 in 2006 and 0.009±0.001 in 2007. During post monsoon, mean concentration was found to be 0.010±0.00 mg/kg in 2005, 0.008±0.002 mg/kg in 2006 and 0.007±0.001 mg/kg in 2007 (Table 61 & Figure 67). Over the period of three years, average values were found to be 0.009±0.001 mg/kg during winter, summer and 0.008±0.001 mg/kg during post monsoon period (Table 62).

At site-II, nickel concentrations ranged from 0.009 mg/kg to 0.012 mg/kg with maximum during winter’ 05 and summer’ 06 and minimum summer’ 05, 07 and during post monsoon’ 05 and 07. During winter, mean concentration was found to be 0.012±0.001 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 2007. During summer,
mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.012±0.001 mg/kg in 2006 and 0.009±0.00 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.010±0.001 in 2006 and 0.009±0.001 mg/kg in 2007 (Table 61 & Figure 68). Over the period of three years, average values were found to be 0.011±0.001 mg/kg during winter, 0.010±0.001 mg/kg during summer and 0.009±0.00 mg/kg during post monsoon period (Table 62).

At site-III, nickel contents ranged from 0.009 mg/kg to 0.014 mg/kg with maximum during winter’ 07 and minimum during winter’ 06. During winter, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.009±0.001 mg/kg in 2006 and 0.014±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 2007. During post monsoon, mean concentration was found to be 0.010±0.00 mg/kg in 2005, 2006 and 0.011±0.001 mg/kg in 2007 (Table 61 & Figure 69). Over the period of three years, average values were found to be 0.011±0.002 mg/kg during winter, 0.010±0.001 mg/kg during summer and 0.010±0.001 mg/kg during post monsoon period (Table 62).

At site-IV, nickel levels ranged from 0.008 mg/kg to 0.012 mg/kg with maximum during winter’ 06 and minimum during winter’ 05 and post monsoon’ 06. During winter, mean concentration was found to be 0.008±0.001 mg/kg in 2005, 0.012±0.001 mg/kg in 2006 and 0.009±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.010±0.001 mg/kg in 2006 and 0.011±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.009±0.00 mg/kg in 2005, 0.008±0.00 mg/kg in 2006 and 0.011±0.00 mg/kg in 2007 (Table 61 & Figure 70). Over the period of three years, average values
were found to be 0.009±0.002 mg/kg during winter, 0.010±0.001 mg/kg during summer and 0.009±0.001 mg/kg during post monsoon period (Table 62).

**Trends:** No definite seasonal trend is indicated from the three years data on nickel accumulation in brain of *Cirrhinus mrigala*. Nickel accumulation in brain shows a very slight gradation at various sites. It is slightly higher at site-III followed in decreasing order by site-II, site-IV and site-I.

Among various tissues of *Cirrhinus mrigala*, nickel contents are highest in liver followed in decreasing order by kidney, muscle and brain.

Among various fish species, nickel accumulation shows the following pattern:

*Mystus seenghala* > *Cirrhinus mrigala* > *Cyprinus carpio* > *Labeo rohita*

### 4 Lead

#### 4.1 *Labeo rohita* (Hamilton):

**Liver**

In *Labeo rohita*, lead concentrations show variations in liver during the whole period of study with minimum 0.044 mg/kg at site-I and maximum 0.055 mg/kg at site-II and site-III (Table 63). Table 64 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, lead concentrations ranged from 0.044 mg/kg to 0.051 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.049±0.008 mg/kg in 2005, 0.052±0.00 mg/kg in 2006 and 0.050±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.049±0.003 mg/kg in 2005, 0.050±0.003 mg/kg in 2006 and 0.051±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.047±0.001 mg/kg in 2005, 0.044±0.001 mg/kg in 2006 and 0.048±0.003 mg/kg in 2007 (Table 63 & Figure 71). Over the period of three years, average values were
found to be 0.050±0.001 mg/kg during winter, summer and 0.046±0.002 mg/kg during post monsoon period (Table 64).

At site-II, lead concentrations ranged from 0.049 mg/kg to 0.055 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.052±0.006 mg/kg in 2005, 0.050±0.001 mg/kg in 2006 and 0.054±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.052±0.005 mg/kg in 2005, 0.052±0.001 mg/kg in 2006 and 0.055±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.050±0.001 mg/kg in 2005, 0.049±0.007 mg/kg in 2006 and 0.052±0.004 mg/kg in 2007 (Table 63 & Figure 72). Over the period of three years, average values were found to be 0.052±0.002 mg/kg during winter, 0.053±0.001 mg/kg during summer and 0.050±0.001 mg/kg during post monsoon period (Table 64).

At site-III, lead contents ranged from 0.051 mg/kg to 0.055 mg/kg with maximum during winter’ 06 and summer’ 07 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.052±0.003 mg/kg in 2005, 0.055±0.001 mg/kg in 2006 and 0.053±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.054±0.002 mg/kg in 2005, 0.053±0.001 mg/kg in 2006 and 0.055±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.052±0.006 mg/kg in 2005, 0.051±0.003 mg/kg in 2006 and 0.053±0.003 mg/kg in 2007 (Table 63 & Figure 73). Over the period of three years, average values were found to be 0.053±0.003 mg/kg during winter, 0.054±0.00 mg/kg during summer and 0.052±0.001 mg/kg during post monsoon period (Table 64).

At site-IV, lead levels ranged from 0.048 mg/kg to 0.054 mg/kg with maximum during winter’ 07 and minimum during winter’ 05. During winter, mean concentration was found to be 0.048±0.008 mg/kg in 2005, 0.052±0.001 mg/kg in 2006 and
0.054±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.050±0.003 mg/kg in 2005, 0.052±0.001 mg/kg in 2006 and 2007. During post monsoon, mean concentration was found to be 0.051±0.001 mg/kg in 2005, 0.049±0.002 mg/kg in 2006 and 0.050±0.002 mg/kg in 2007 (Table 63 & Figure 74). Over the period of three years, average values were found to be 0.051±0.003 mg/kg during winter, 0.051±0.001 mg/kg during summer and 0.049±0.001 mg/kg during post monsoon period (Table 64).

**Trends:** No definite seasonal pattern emerges from the three years data on lead accumulation in liver of *Labeo rohita*. Lead accumulation is maximum at site-III followed in decreasing order by site-II, site-IV and site-I.

**Muscle**

Lead concentrations show variations in muscle during the entire period of study with minimum 0.034 mg/kg at site-I and maximum 0.053 mg/kg at site-III (Table 63). Table 64 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, lead concentrations ranged from 0.034 mg/kg to 0.049 mg/kg with maximum during winter’ 06 and minimum during winter’ 07. During winter, mean concentration was found to be 0.040±0.002 mg/kg in 2005, 0.049±0.002 in 2006 and 0.034±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.042±0.002 mg/kg in 2005, 0.044±0.003 mg/kg in 2006 and 0.044±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.044±0.001 mg/kg in 2005, 0.043±0.001 mg/kg in 2006 and 0.042±0.002 mg/kg in 2007 (Table 63 & Figure 71). Over the period of three years, average values were found to be 0.041±0.007 mg/kg during winter, 0.043±0.001 mg/kg during summer and post monsoon period (Table 64).
At site-II, lead concentrations ranged from 0.042 mg/kg to 0.048 mg/kg with maximum during winter’ 05 and minimum during winter’ 07. During winter, mean concentration was found to be 0.048±0.001 mg/kg in 2005, 0.044±0.001 mg/kg in 2006 and 0.042±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.046±0.001 mg/kg in 2005, 0.047±0.001 mg/kg in 2006 and 0.045±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.045±0.003 mg/kg in 2005, 0.046±0.003 mg/kg in 2006 and 0.044±0.001 mg/kg in 2007 (Table 63 & Figure 72). Over the period of three years, average values were found to be 0.044±0.003 mg/kg during winter, 0.046±0.001 mg/kg during summer and 0.043±0.002 mg/kg during post monsoon period (Table 64).

At site-III, lead contents ranged from 0.045 mg/kg to 0.053 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.052±0.004 mg/kg in 2005, 0.050±0.001 mg/kg in 2006 and 0.052±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.051±0.005 mg/kg in 2005, 0.051±0.001 mg/kg in 2006 and 0.053±0.006 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.045±0.001 mg/kg in 2005, 0.048±0.003 mg/kg in 2006 and 0.048±0.002 mg/kg in 2007 (Table 63 & Figure 73). Over the period of three years, average values were found to be 0.051±0.001 mg/kg during winter, summer and 0.047±0.001 mg/kg during post monsoon period (Table 64).

At site-IV, lead levels ranged from 0.040 mg/kg to 0.048 mg/kg with maximum during winter’ 07 and minimum during winter’ 05. During winter, mean concentration was found to be 0.040±0.003 mg/kg in 2005, 0.045±0.002 mg/kg in 2006 and 0.048±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.046±0.001 mg/kg in 2005, 0.044±0.001 mg/kg in 2006 and 0.045±0.001 mg/kg in
2007. During post monsoon, mean concentration was found to be 0.042±0.003 mg/kg in 2005, 0.045±0.00 mg/kg in 2006 and 0.044±0.001 mg/kg in 2007 (Table 63 & Figure 74). Over the period of three years, average values were found to be 0.044±0.004 mg/kg during winter, 0.045±0.001 mg/kg during summer and 0.045±0.002 mg/kg during post monsoon period (Table 64).

**Trends:** No definite seasonal trend is indicated by the three years data on lead accumulation in muscle of *Labeo rohita*. Lead accumulation at various sites shows the trend as site-III > site-II ≥ site-IV > site-I.

**Kidney**

Lead concentrations show variations in kidney during the entire period of study with minimum 0.038 mg/kg at IV and maximum 0.051 mg/kg at site-III (Table 63). Table 64 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, lead concentrations ranged from 0.040 mg/kg to 0.044 mg/kg with maximum during winter’ 05 and minimum during winter’ 06 and 07, summer’ 07 and post monsoon’ 05 and 07. During winter, mean concentration was found to be 0.044±0.004 mg/kg in 2005, 0.040±0.005 mg/kg in 2006 and 0.040±0.004 mg/kg in 2007. During summer, mean concentration was found to be 0.044±0.004 mg/kg in 2005, 0.042±0.002 mg/kg in 2006 and 0.040±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.040±0.001 mg/kg in 2005, 0.042±0.001 mg/kg in 2006 and 0.042±0.002 mg/kg in 2007 (Table 63 & Figure 71). Over the period of three years, average values were found to be 0.041±0.002 mg/kg during winter, 0.042±0.002 mg/kg during summer and 0.040±0.001 mg/kg during post monsoon period (Table 64).
At site-II, mean concentrations ranged from 0.040 mg/kg to 0.046 mg/kg with maximum during summer’ 06 and minimum during summer’ 05. During winter, mean concentration was found to be 0.043±0.002 mg/kg in 2005, 0.045±0.001 mg/kg in 2006 and 0.045±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.040±0.00 mg/kg in 2005, 0.042±0.001 mg/kg in 2006 and 0.046±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.044±0.001 mg/kg in 2005, 0.043±0.001 mg/kg in 2006 and 0.042±0.004 mg/kg in 2007 (Table 63 & Figure 72). Over the period of three years, average values were found to be 0.044±0.001 mg/kg during winter, 0.042±0.003 mg/kg during summer and 0.043±0.001 mg/kg during post monsoon period (Table 64).

At site-III, lead contents ranged from 0.043 mg/kg to 0.051 mg/kg with maximum during summer’ 06 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.047±0.003 mg/kg in 2005, 0.049±0.003 mg/kg in 2006 and 0.046±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.049±0.003 mg/kg in 2005, 0.051±0.001 mg/kg in 2006 and 0.048±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.047±0.005 mg/kg in 2005, 0.043±0.001 mg/kg in 2006 and 0.046±0.001 mg/kg in 2007 (Table 63 & Figure 73). Over the period of three years, average values were found to be 0.047±0.001 mg/kg during winter, 0.049±0.001 mg/kg during summer and 0.045±0.002 mg/kg during post monsoon period (Table 64).

At site-IV, lead levels ranged from 0.038 mg/kg to 0.050 mg/kg with maximum during winter’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.040±0.002 mg/kg in 2005, 0.050±0.003 mg/kg in 2006 and 0.040±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.041±0.002 in 2005, 0.046±0.002 mg/kg in 2006 and 0.041±0.002 mg/kg
in 2007. During post monsoon, mean concentration was found to be 0.038±0.001 mg/kg in 2005, 0.043±0.001 mg/kg in 2006 and 0.040±0.002 mg/kg in 2007 (Table 63 & Figure 74). Over the period of three years, average values were found to be 0.043±0.005 mg/kg during winter, 0.042±0.002 mg/kg during summer and 0.041±0.002 mg/kg during post monsoon period (Table 64).

**Trends:** No define seasonal pattern is revealed from the three years data on lead accumulation in kidney of *Labeo rohita*. Lead accumulation at different sites decreases in the order: site-III > site-II > site-IV > site-I.

**Brain**

Lead concentrations show variations in brain during the entire period of study with minimum (BTL) and maximum 0.015 mg/kg at site-III (Table 63). Table 64 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, lead levels ranged from BTL to 0.010 mg/kg with maximum during post monsoon’ 06. During winter, mean concentration was found to be 0.004±0.00 mg/kg in 2005, BTL in 2006 and 2007. During summer, mean concentration was found to be 0.006±0.001 mg/kg in 2005, 2006 and 2007. During post monsoon, mean concentration was found to be 0.003±0.002 mg/kg in 2005, 0.010±0.001 mg/kg in 2006 and BTL in 2007 (Table 63 & Figure 71). Over the period of three years, average values were found to be 0.004±0.00 mg/kg during winter, 0.006±0.00 mg/kg during summer and 0.006±0.004 mg/kg during post monsoon period (Table 64).

At site-II, lead contents ranged from BTL to 0.013 mg/kg with maximum during post monsoon’ 06. During winter, mean concentration was found to be 0.008±0.001 mg/kg in 2005, BTL in 2006 and 0.011±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.008±0.002 mg/kg in
2006 and 0.009±0.00 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.007±0.00 mg/kg in 2005, 0.013±0.001 mg/kg in 2006 and BTL in 2007 (Table 63 & Figure 72). Over the period of three years, average values were found to be 0.009±0.002 mg/kg during winter, 0.008±0.00 mg/kg during summer and 0.010±0.004 mg/kg during post monsoon period (Table 64).

At site-III, lead contents ranged from BTL to 0.015 mg/kg with maximum during post monsoon’ 06. During winter, mean concentration was found to be 0.008±0.002 mg/kg in 2005, BTL in 2006 and 0.013±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.008±0.002 mg/kg in 2005, 0.012±0.002 mg/kg in 2006 and 0.011±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.007±0.001 mg/kg in 2005, 0.015±0.002 mg/kg in 2006 and BTL in 2007 (Table 63 & Figure 73). Over the period of three years, average values were found to be 0.010±0.003 mg/kg during winter, 0.010±0.002 mg/kg during summer and 0.011±0.005 mg/kg during post monsoon period (Table 64).

At site-IV, lead levels were between BTL and 0.011 mg/kg with maximum during post monsoon’ 06. During winter, mean concentration was found to be BTL in 2005, 2006 and 2007. During summer, mean concentration was found to be 0.005±0.001 mg/kg in 2005, 0.008±0.003 mg/kg in 2006 and 0.008±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.004±0.001 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and BTL in 2007 (Table 63 & Figure 74). Over the period of three years, average values were found to be BTL during winter, 0.007±0.001 mg/kg during summer and 0.007±0.004 mg/kg during post monsoon period (Table 64).
Trends: No seasonal trend in lead accumulation in brain of *Labeo rohita* is indicated from the data. Lead levels are maximum at site-III followed in decreasing order by site-II, site-IV and site-I. Among various tissues of *Labeo rohita*, lead accumulation decreases in the following order:

Liver > kidney > muscle > brain

4.2 *Cyprinus carpio* Linnaeus:

Liver

In *Cyprinus carpio*, lead concentrations show variations in liver during the whole period of study with minimum 0.048 mg/kg at site-I and maximum 0.058 mg/kg at site-III (Table 65). Table 66 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, lead concentrations ranged from 0.048 mg/kg to 0.054 mg/kg with maximum during winter and summer’ 06 and minimum during winter’ 07. During winter, mean concentration was found to be 0.053±0.003 mg/kg in 2005, 0.054±0.004 mg/kg in 2006 and 0.048±0.004 mg/kg in 2007. During summer, mean concentration was found to be 0.052±0.002 mg/kg in 2005, 0.054±0.003 mg/kg in 2006 and 0.050±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.050±0.004 mg/kg in 2005, 0.052±0.004 mg/kg in 2006 and 0.050±0.002 mg/kg in 2007 (Table 65 & Figure 75). Over the period of three years, average values were found to be 0.051±0.003 mg/kg during winter, 0.052±0.001 mg/kg during summer and 0.050±0.001 mg/kg during post monsoon period (Table 66).

At site-II, lead concentrations ranged from 0.054 mg/kg to 0.056 mg/kg with maximum during summer’ 05 and 06 and minimum during winter’ 06, 07 and post monsoon’ 05. During winter, mean concentration was found to be 0.055±0.003 mg/kg
in 2005, 0.054±0.004 mg/kg in 2006 and 0.054±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.056±0.002 mg/kg in 2005, 0.056±0.003 mg/kg in 2006 and 0.055±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.054±0.003 mg/kg in 2005, 0.055±0.004 mg/kg in 2006 and 2007 (Table 65 & Figure 76). Over the period of three years, average values were found to be 0.054±0.00 mg/kg during winter, 0.055±0.00 mg/kg during summer and 0.054±0.00 mg/kg during post monsoon period (Table 66).

At site-III, lead contents ranged from 0.054 mg/kg to 0.058 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 05 and 07. During winter, mean concentration was found to be 0.055±0.002 mg/kg in 2005, 0.057±0.002 mg/kg in 2006 and 0.056±0.004 mg/kg in 2007. During summer, mean concentration was found to be 0.057±0.003 mg/kg in 2005, 0.056±0.004 mg/kg in 2006 and 0.058±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.054±0.001 mg/kg in 2005, 0.055±0.003 mg/kg in 2006 and 0.054±0.001 mg/kg in 2007 (Table 65 & Figure 77). Over the period of three years, average values were found to be 0.056±0.001 mg/kg during winter, 0.057±0.001 mg/kg during summer and 0.054±0.00 mg/kg during post monsoon period (Table 66).

At site-IV, lead levels ranged from 0.051 mg/kg to 0.055 mg/kg with maximum during winter’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.052±0.003 mg/kg in 2005, 0.055±0.004 mg/kg in 2006 and 0.054±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.052±0.003 mg/kg in 2005, 0.052±0.003 mg/kg in 2006 and 0.054±0.004 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.051±0.002 mg/kg in 2005, 0.052±0.003 mg/kg in 2006 and 2007 (Table 65 & Figure 78). Over the period of three years, average values were found to be
0.053±0.001 mg/kg during winter, 0.052±0.001 mg/kg during summer and 0.051±0.00 mg/kg during post monsoon period (Table 66).

**Trends:** The three data of lead accumulation in liver of *Cyprinus carpio* does not reveal any seasonal trend. Among sites, maximum accumulation is at site-III followed in decreasing order by site-II, site-IV and site-I.

**Muscle**

Lead concentrations show variations in muscle during the entire period of study with minimum 0.048 mg/kg at site-I and maximum 0.054 mg/kg at site-III (Table 65). Table 66 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, lead concentrations ranged from 0.048 mg/kg to 0.051 mg/kg with maximum during summer’ 05 and minimum during post monsoon’ 05 and 06. During winter, mean concentration was found to be 0.050±0.002 mg/kg in 2005, 0.049±0.003 in 2006 and 2007. During summer, mean concentration was found to be 0.051±0.002 mg/kg in 2005, 0.049±0.001 mg/kg in 2006 and 0.050±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.048±0.003 mg/kg in 2005, 0.048±0.002 mg/kg in 2006 and 0.049±0.001 mg/kg in 2007 (Table 65 & Figure 75). Over the period of three years, average values were found to be 0.049±0.00 mg/kg during winter, 0.050±0.001 mg/kg during summer and 0.048±0.00 mg/kg during post monsoon period (Table 66).

At site-II, lead concentrations ranged from 0.049 mg/kg to 0.052 mg/kg with maximum during winter and summer’ 05 and minimum during post monsoon’ 06 and 07. During winter, mean concentration was found to be 0.052±0.002 mg/kg in 2005, 0.050±0.003 mg/kg in 2006 and 0.051±0.004 mg/kg in 2007. During summer, mean concentration was found to be 0.052±0.003 mg/kg in 2005, 0.051±0.002 mg/kg in
2006 and 0.051±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.050±0.004 mg/kg in 2005, 0.049±0.001 mg/kg in 2006 and 2007 (Table 65 & Figure 76). Over the period of three years, average values were found to be 0.051±0.001 mg/kg during winter, mg/kg during summer and 0.049±0.00 mg/kg during post monsoon period (Table 66).

At site-III, lead contents ranged from 0.050 mg/kg to 0.054 mg/kg with maximum during winter and post monsoon’ 05 and minimum during post monsoon’ 07. During winter, mean concentration was found to be 0.051±0.004 mg/kg in 2005, 0.052±0.003 mg/kg in 2006 and 0.051±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.052±0.003 mg/kg in 2005, 0.052±0.001 mg/kg in 2006 and 0.053±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.054±0.002 mg/kg in 2005, 0.052±0.002 mg/kg in 2006 and 0.050±0.002 mg/kg in 2007 (Table 65 & Figure 77). Over the period of three years, average values were found to be 0.051±0.00 mg/kg during winter, 0.052±0.00 mg/kg during summer and 0.052±0.002 mg/kg during post monsoon period (Table 66).

At site-IV, lead levels ranged from 0.049 mg/kg to 0.051 mg/kg with maximum during winter’ 06, summer’ 05 and 06 and minimum during winter’ 07 and post monsoon’ 05 and 07. During winter, mean concentration was found to be 0.050±0.001 mg/kg in 2005, 0.051±0.001 mg/kg in 2006 and 0.049±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.051±0.003 mg/kg in 2005, 0.051±0.002 mg/kg in 2006 and 0.050±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.049±0.002 mg/kg in 2005, 0.050±0.003 mg/kg in 2006 and 0.049±0.003 mg/kg in 2007 (Table 65 & Figure 78). Over the period of three years, average values were found to be 0.050±0.001 mg/kg during winter, summer and 0.049±0.00 mg/kg during post monsoon period (Table 66).
**Trends:** The three years data on lead accumulation in muscle of *Cyprinus carpio* reveals no definite seasonal trend. Among different sites, lead accumulation is maximum at site-III followed in decreasing order by site-II, site-IV and site-I.

**Kidney**

Lead concentrations show variations in kidney during the entire period of study with minimum 0.047 mg/kg at site-II and maximum 0.057 mg/kg at site-III (Table 65). Table 66 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, lead concentrations ranged from 0.049 mg/kg to 0.053 mg/kg with maximum during winter’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.052±0.002 mg/kg in 2005, 0.053±0.003 mg/kg in 2006 and 0.050±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.050±0.003 mg/kg in 2005, 0.052±0.002 mg/kg in 2006 and 2007. During post monsoon, mean concentration was found to be 0.049±0.002 mg/kg in 2005, 0.052±0.004 mg/kg in 2006 and 0.050±0.003 mg/kg in 2007 (Table 65 & Figure 75). Over the period of three years, average values were found to be 0.051±0.001 mg/kg during winter, summer and 0.050±0.001 mg/kg during post monsoon period (Table 66).

At site-II, lead concentrations ranged from 0.047 mg/kg to 0.056 mg/kg with maximum during winter’ 07 and minimum during winter’ 05. During winter, mean concentration was found to be 0.047±0.003 mg/kg in 2005, 0.055±0.003 mg/kg in 2006 and 0.056±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.050±0.003 mg/kg in 2005, 0.052±0.002 mg/kg in 2006 and 0.052±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.053±0.002 mg/kg in 2005, 0.052±0.003 mg/kg in 2006 and 0.054±0.002 mg/kg in
2007 (Table 65 & Figure 76). Over the period of three years, average values were found to be 0.052±0.004 mg/kg during winter, 0.051±0.001 mg/kg during summer and 0.053±0.001 mg/kg during post monsoon period (Table 66).

At site-III, lead contents ranged from 0.051 mg/kg to 0.057 mg/kg with maximum during summer’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.055±0.004 mg/kg in 2005, 0.054±0.002 mg/kg in 2006 and 0.055±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.056±0.003 mg/kg in 2005, 0.057±0.003 mg/kg in 2006 and 0.054±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.051±0.002 mg/kg in 2005, 0.054±0.001 mg/kg in 2006 and 0.053±0.001 mg/kg in 2007 (Table 65 & Figure 77). Over the period of three years, average values were found to be 0.054±0.00 mg/kg during winter, 0.055±0.001 mg/kg during summer and 0.052±0.001 mg/kg during post monsoon period (Table 66).

At site-IV, lead levels ranged from 0.049 mg/kg to 0.053 mg/kg with maximum during winter and summer’ 05 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.053±0.003 mg/kg in 2005, 0.051±0.003 mg/kg in 2006 and 0.051±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.053±0.002 in 2005, 0.051±0.003 mg/kg in 2006 and 0.052±0.004 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.050±0.004 mg/kg in 2005, 0.049±0.002 mg/kg in 2006 and 0.051±0.003 mg/kg in 2007 (Table 65 & Figure 78). Over the period of three years, average values were found to be 0.051±0.001 mg/kg during winter, 0.052±0.001 mg/kg during summer and 0.050±0.001 mg/kg during post monsoon period (Table 66).
**Trends:** No definite seasonal trend is indicated from the three years data on lead accumulation in kidney of *Cyprinus carpio*. Accumulation levels are maximum at site-III followed in decreasing order by site-II, site-IV and site-I.

**Brain**

Lead concentrations show variations in brain during the entire period of study with minimum 0.007 mg/kg at site-II and maximum 0.011 mg/kg at site-III (Table 65). Table 66 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, lead levels ranged from 0.008 mg/kg to 0.010 mg/kg with maximum during summer’ 06 and minimum during winter’ 05 and post monsoon’ 06. During winter, mean concentration was found to be 0.008±0.001 mg/kg in 2005, 0.009±0.001 mg/kg in 2006 and 0.009±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.002 mg/kg in 2005, 0.010±0.001 in 2006 and 0.009±0.001 in 2007. During post monsoon, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.008±0.00 mg/kg in 2006 and 0.009±0.001 in 2007 (Table 65 & Figure 75). Over the period of three years, average values were found to be 0.008±0.00 mg/kg during winter, 0.009±0.00 mg/kg during summer and 0.008±0.00 mg/kg during post monsoon period (Table 66).

At site-II, lead concentration ranged from 0.007 mg/kg to 0.010 mg/kg with maximum during winter’ 07 and summer’ 05 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 2006 and 0.010±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.009±0.002 mg/kg in 2006 and 0.009±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.008±0.00 mg/kg in 2005, 0.007±0.001 in 2006 and 0.009±0.001 mg/kg in 2007 (Table 65 & Figure
Over the period of three years, average values were found to be 0.009±0.00 mg/kg during winter, summer and 0.008±0.001 mg/kg during post monsoon period (Table 66).

At site-III, lead contents ranged from 0.009 mg/kg to 0.011 mg/kg with maximum during post monsoon’ 05 and minimum winter and post monsoon’ 06 and summer’ 05. During winter, mean concentration was found to be 0.010±0.002 mg/kg in 2005, 0.009±0.001 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.002 mg/kg in 2005, 0.010±0.001 mg/kg in 2006 and 0.010±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.011±0.001 mg/kg in 2005, 0.009±0.001 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007 (Table 65 & Figure 77). Over the period of three years, average values were found to be 0.009±0.00 mg/kg during winter, summer and 0.010±0.001 mg/kg during post monsoon period (Table 66).

At site-IV, lead levels were between 0.008 mg/kg and 0.010 mg/kg with maximum during summer’ 07 and post monsoon’ 06 and minimum during winter’ 07 and post monsoon’ 05. During winter, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 2006 and 0.008±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 2006 and 0.010±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.008±0.001 mg/kg in 2005, 0.010±0.00 mg/kg in 2006 and 0.009±0.001 in 2007 (Table 65 & Figure 78). Over the period of three years, average values were found to be 0.008±0.00 mg/kg during winter, 0.009±0.00 mg/kg during summer and 0.009±0.001 mg/kg during post monsoon period (Table 66).
**Trends:** No seasonal trend is indicated. Lead accumulation in brain of *Cyprinus carpio* is maximum at site-III followed in decreasing order by site-II, site-IV and site-I.

Among various tissues, lead accumulation decreases in following order:

Liver > Kidney > Muscle > Brain

### 4.3 Mystus seenghala (Sykes):

**Liver**

In *Mystus seenghala*, lead concentrations show variations in liver during the whole period of study with minimum 0.054 mg/kg at site-I and maximum 0.067 mg/kg at site-III (Table 67). Table 68 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, lead concentrations ranged from 0.054 mg/kg to 0.061 mg/kg with maximum during winter’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.058±0.002 mg/kg in 2005, 0.061±0.003 mg/kg in 2006 and 0.056±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.059±0.003 mg/kg in 2005, 0.059±0.002 mg/kg in 2006 and 0.056±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.054±0.002 mg/kg in 2005, 0.057±0.004 mg/kg in 2006 and 0.055±0.003 mg/kg in 2007 (Table 67 & Figure 79). Over the period of three years, average values were found to be 0.058±0.001 mg/kg during winter, 0.058±0.001 mg/kg during summer and 0.055±0.003 mg/kg during post monsoon period (Table 68).

At site-II, lead concentrations ranged from 0.058 mg/kg to 0.063 mg/kg with maximum during winter’ 07 and summer’ 06 and minimum during winter’ 06. During winter, mean concentration was found to be 0.059±0.003 mg/kg in 2005, 0.058±0.003 mg/kg in 2006 and 0.063±0.003 mg/kg in 2007. During summer, mean concentration
was found to be 0.061±0.003 mg/kg in 2005, 0.063±0.002 mg/kg in 2006 and 0.059±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.062±0.002 mg/kg in 2005, 0.059±0.003 mg/kg in 2006 and 0.059±0.002 mg/kg in 2007 (Table 67 & Figure 80). Over the period of three years, average values were found to be 0.060±0.002 mg/kg during winter, 0.061±0.002 mg/kg during summer and 0.060±0.001 mg/kg during post monsoon period (Table 68).

At site-III, lead contents ranged from 0.062 mg/kg to 0.067 mg/kg with maximum during winter’ 07, summer’ 05 and post monsoon’06 and minimum during winter’ 05 and post monsoon’ 07. During winter, mean concentration was found to be 0.062±0.004 mg/kg in 2005, 0.064±0.002 mg/kg in 2006 and 0.067±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.067±0.003 mg/kg in 2005, 0.066±0.003 mg/kg in 2006 and 0.063±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.064±0.002 mg/kg in 2005, 0.067±0.001 mg/kg in 2006 and 0.062±0.001 mg/kg in 2007 (Table 67 & Figure 81). Over the period of three years, average values were found to be 0.064±0.002 mg/kg during winter, 0.065±0.002 mg/kg during summer and 0.064±0.002 mg/kg during post monsoon period (Table 68).

At site-IV, lead levels ranged from 0.057 mg/kg to 0.061 mg/kg with maximum during winter’ 07 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.058±0.003 mg/kg in 2005, 0.059±0.003 mg/kg in 2006 and 0.061±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.059±0.002 mg/kg in 2005, 0.060±0.003 mg/kg in 2006 and 0.058±0.004 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.060±0.004 mg/kg in 2005, 0.057±0.002 mg/kg in 2006 and 0.059±0.003 mg/kg in 2007 (Table 67 & Figure 82). Over the period of three years, average values were
found to be 0.059±0.001 mg/kg during winter, summer and 0.058±0.001 mg/kg during post monsoon period (Table 68).

Trends: No definite seasonal trend is indicated from the three years data on lead accumulation in liver of Mystus seenghala. Lead levels at different sites decrease in the following order: site-III > site-II > site-IV > site-I.

Muscle

Lead concentrations show variations in muscle during the entire period of study with minimum 0.051 mg/kg at site-I and site-IV and maximum 0.062 mg/kg at site-III (Table 67). Table 68 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, lead concentrations ranged from 0.051 mg/kg to 0.058 mg/kg with maximum during summer’ 05 and minimum during post monsoon’ 07. During winter, mean concentration was found to be 0.057±0.001 mg/kg in 2005, 0.056±0.002 in 2006 and 0.053±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.058±0.002 mg/kg in 2005, 0.054±0.003 mg/kg in 2006 and 0.056±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.054±0.003 mg/kg in 2005, 0.055±0.001 mg/kg in 2006 and 0.051±0.002 mg/kg in 2007 (Table 67 & Figure 79). Over the period of three years, average values were found to be 0.055±0.002 mg/kg during winter, 0.056±0.002 mg/kg during summer and 0.053±0.002 mg/kg during post monsoon period (Table 68).

At site-II, lead concentrations ranged from 0.055 mg/kg to 0.059 mg/kg with maximum during summer’ 06 and 07 and minimum during winter’ 05. During winter, mean concentration was found to be 0.055±0.002 mg/kg in 2005, 0.057±0.003 mg/kg in 2006 and 0.057±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.058±0.003 mg/kg in 2005, 0.059±0.002 mg/kg in 2006 and 0.059±0.003
mg/kg in 2007. During post monsoon, mean concentration was found to be 0.057±0.003 mg/kg in 2005, 0.058±0.002 mg/kg in 2006 and 0.057±0.001 mg/kg in 2007 (Table 67 & Figure 80). Over the period of three years, average values were found to be 0.056±0.001 mg/kg during winter, 0.058±0.00 mg/kg during summer and 0.057±0.00 mg/kg during post monsoon period (Table 68).

At site-III, lead contents ranged from 0.055 mg/kg to 0.062 mg/kg with maximum during summer’ 07 and minimum during winter’ 06. During winter, mean concentration was found to be 0.059±0.004 mg/kg in 2005, 0.055±0.003 mg/kg in 2006 and 0.060±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.059±0.003 mg/kg in 2005, 0.060±0.001 mg/kg in 2006 and 0.062±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.057±0.001 mg/kg in 2005, 0.059±0.001 mg/kg in 2006 and 0.057±0.002 mg/kg in 2007 (Table 67 & Figure 81). Over the period of three years, average values were found to be 0.058±0.002 mg/kg during winter, 0.060±0.001 mg/kg during summer and 0.057±0.001 mg/kg during post monsoon period (Table 68).

At site-IV, lead levels ranged from 0.051 mg/kg to 0.059 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 07. During winter, mean concentration was found to be 0.058±0.00 mg/kg in 2005, 0.056±0.001 mg/kg in 2006 and 0.057±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.058±0.002 mg/kg in 2005, 0.057±0.002 mg/kg in 2006 and 0.059±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.056±0.001 mg/kg in 2005, 0.052±0.002 mg/kg in 2006 and 0.051±0.001 mg/kg in 2007 (Table 67 & Figure 82). Over the period of three years, average values were found to be 0.057±0.001 mg/kg during winter, 0.058±0.001 mg/kg during summer and 0.053±0.002 mg/kg during post monsoon period (Table 68).
**Trends:** No definite seasonal trend is indicated from the three years data on lead accumulation in muscle of *Mystus seenghala*. Lead levels are maximum at site-III, intermediate at site-II and site-IV and minimum at site-I.

**Kidney**

Lead concentrations show variations in kidney during the entire period of study with minimum 0.052 mg/kg at site-I and maximum 0.062 mg/kg at site-III (Table 67). Table 68 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, lead concentrations ranged from 0.052 mg/kg to 0.059 mg/kg with maximum during winter’05 and summer’06 and minimum during post monsoon’06 and 07. During winter, mean concentration was found to be 0.059±0.002 mg/kg in 2005, 0.055±0.003 mg/kg in 2006 and 0.056±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.058±0.002 mg/kg in 2005, 0.059±0.001 mg/kg in 2006 and 0.058±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.055±0.003 mg/kg in 2005, 0.052±0.002 mg/kg in 2006 and 0.052±0.001 mg/kg in 2007 (Table 67 & Figure 79). Over the period of three years, average values were found to be 0.056±0.002 mg/kg during winter, 0.058±0.00 mg/kg during summer and 0.053±0.001 mg/kg during post monsoon period (Table 68).

At site-II, lead concentrations ranged from 0.056 mg/kg to 0.061 mg/kg with maximum during summer’06 and minimum during post monsoon’07. During winter, mean concentration was found to be 0.058±0.002 mg/kg in 2005, 0.059±0.003 mg/kg in 2006 and 0.059±0.004 mg/kg in 2007. During summer, mean concentration was found to be 0.059±0.003 mg/kg in 2005, 0.061±0.002 mg/kg in 2006 and 0.057±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.058±0.004 mg/kg in 2005, 0.059±0.001 mg/kg in 2006 and 0.056±0.001 mg/kg in
Over the period of three years, average values were found to be 0.053±0.001 mg/kg during winter, 0.058±0.002 mg/kg during summer and 0.059±0.002 mg/kg during post monsoon period (Table 68).

At site-III, lead contents ranged from 0.057 mg/kg to 0.062 mg/kg with maximum during winter’ 07, summer’ 06 and post monsoon’ 07 and minimum during summer and post monsoon’ 05. During winter, mean concentration was found to be 0.059±0.004 mg/kg in 2005, 0.060±0.003 mg/kg in 2006 and 0.062±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.057±0.003 mg/kg in 2005, 0.062±0.001 mg/kg in 2006 and 0.060±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.057±0.002 mg/kg in 2005, 0.059±0.002 mg/kg in 2006 and 0.062±0.002 mg/kg in 2007 (Table 67 & Figure 81). Over the period of three years, average values were found to be 0.060±0.001 mg/kg during winter, 0.059±0.001 mg/kg during summer and 0.059±0.002 mg/kg during post monsoon period (Table 68).

At site-IV, lead levels ranged from 0.053 mg/kg to 0.060 mg/kg with maximum during winter’ 06 and summer’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.059±0.001 mg/kg in 2005, 0.060±0.001 mg/kg in 2006 and 0.057±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.057±0.003 in 2005, 0.057±0.002 mg/kg in 2006 and 0.060±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.053±0.002 mg/kg in 2005, 0.057±0.003 mg/kg in 2006 and 0.054±0.003 mg/kg in 2007 (Table 67 & Figure 82). Over the period of three years, average values were found to be 0.058±0.001 mg/kg during winter, summer and 0.054±0.002 mg/kg during post monsoon period (Table 68).
Trends: As in other tissues, no seasonal trend is indicated in kidney also. Among sites, lead accumulation in kidney of *Mystus seenghala* is maximum at site-III, intermediate at site-II and IV and minimum at site-I.

Brain

Lead concentrations show variations in brain during the entire period of study with minimum 0.009 mg/kg at site-I and IV and maximum 0.013 mg/kg at all the sites (Table 67). Table 68 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, lead levels ranged from 0.009 mg/kg to 0.013 mg/kg with maximum during post monsoon’ 06 and minimum during winter’ 06 and post monsoon’ 07. During winter, mean concentration was found to be 0.012±0.001 mg/kg in 2005, 0.009±0.001 mg/kg in 2006 and 0.011±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.011±0.002 mg/kg in 2005, 0.012±0.001 in 2006 and 0.010±0.001 in 2007. During post monsoon, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.013±0.00 mg/kg in 2006 and 0.009±0.001 in 2007 (Table 67 & Figure 79). Over the period of three years, average values were found to be 0.010±0.001 mg/kg during winter, 0.011±0.001 mg/kg during summer and 0.010±0.002 mg/kg during post monsoon period (Table 68).

At site-II, lead concentrations ranged from 0.010 mg/kg to 0.013 mg/kg with maximum during summer’ 06 and minimum during winter’ 05, summer and post monsoon’ 07. During winter, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.012±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.012±0.001 mg/kg in 2005, 0.013±0.002 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.012±0.00 mg/kg in 2005, 0.012±0.001 in 2006
and 0.010±0.001 mg/kg in 2007 (Table 67 & Figure 80). Over the period of three years, average values were found to be 0.011±0.001 mg/kg during winter, summer and post monsoon period (Table 68).

At site-III, lead contents ranged from 0.010 mg/kg to 0.013 mg/kg with maximum during winter’ 05, summer’ 07 and post monsoon’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.013±0.002 mg/kg in 2005, 0.012±0.001 mg/kg in 2006 and 0.011±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.011±0.002 mg/kg in 2005, 0.012±0.001 mg/kg in 2006 and 0.013±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.013±0.001 mg/kg in 2006 and 0.011±0.001 mg/kg in 2007 (Table 67 & Figure 81). Over the period of three years, average values were found to be 0.012±0.001 mg/kg during winter, summer and 0.011±0.001 mg/kg during post monsoon period (Table 68).

At site-IV, lead levels were between 0.009 mg/kg and 0.013 mg/kg with maximum during summer’ 06 and minimum during winter’ 05. During winter, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.012±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.013±0.001 mg/kg in 2006 and 0.011±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.013±0.001 mg/kg in 2005, 0.011±0.00 mg/kg in 2006 and 0.010±0.001 in 2007 (Table 67 & Figure 82). Over the period of three years, average values were found to be 0.010±0.001 mg/kg during winter, 0.011±0.001 mg/kg during summer and post monsoon period (Table 68).
**Trends:** No definite seasonal trend in lead accumulation in brain of *Mystus seenghala* is indicated from the three years data. Accumulation levels are maximum at site-III followed in decreasing order by site-II, site-IV and site-I.

Among various tissues of *Mystus seenghala*, the lead accumulation is maximum in liver followed in decreasing order by kidney, muscle and brain.

4.4 *Cirrhinus mrigala* (Hamilton):

**Liver**

In *Cirrhinus mrigala*, lead concentrations show variations in liver during the whole period of study with minimum 0.052 mg/kg at site-I and IV and maximum 0.061 mg/kg at site-III (Table 69). Table 70 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, lead concentrations ranged from 0.052 mg/kg to 0.058 mg/kg with maximum during winter’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.056±0.004 mg/kg in 2005, 0.058±0.004 mg/kg in 2006 and 0.054±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.056±0.005 mg/kg in 2005, 0.057±0.003 mg/kg in 2006 and 0.054±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.052±0.004 mg/kg in 2005, 0.055±0.005 mg/kg in 2006 and 0.052±0.004 mg/kg in 2007 (Table 69 & Figure 83). Over the period of three years, average values were found to be 0.056±0.002 mg/kg during winter, 0.055±0.001 mg/kg during summer and 0.053±0.003 mg/kg during post monsoon period (Table 70).

At site-II, lead concentrations ranged from 0.055 mg/kg to 0.058 mg/kg with maximum during winter, summer and post monsoon’ 07 and minimum during summer’ 06 and post monsoon’ 05. During winter, mean concentration was found to be 0.057±0.005 mg/kg in 2005, 0.057±0.003 mg/kg in 2006 and 0.058±0.002 mg/kg
in 2007. During summer, mean concentration was found to be 0.057±0.003 mg/kg in 2005, 0.055±0.005 mg/kg in 2006 and 0.058±0.005 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.055±0.004 mg/kg in 2005, 0.056±0.004 mg/kg in 2006 and 0.058±0.002 mg/kg in 2007 (Table 69 & Figure 84). Over the period of three years, average values were found to be 0.057±0.00 mg/kg during winter, 0.056±0.00 mg/kg during summer and 0.056±0.001 mg/kg during post monsoon period (Table 70).

At site-III, lead contents ranged from 0.055 mg/kg to 0.061 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.057±0.002 mg/kg in 2005, 0.057±0.004 mg/kg in 2006 and 0.058±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.059±0.004 mg/kg in 2005, 0.060±0.006 mg/kg in 2006 and 0.061±0.006 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.055±0.005 mg/kg in 2005, 0.057±0.004 mg/kg in 2006 and 0.058±0.003 mg/kg in 2007 (Table 69 & Figure 85). Over the period of three years, average values were found to be 0.057±0.00 mg/kg during winter, 0.060±0.001 mg/kg during summer and 0.056±0.001 mg/kg during post monsoon period (Table 70).

At site-IV, lead levels ranged from 0.052 mg/kg to 0.059 mg/kg with maximum during winter and summer’ 07 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.055±0.004 mg/kg in 2005, 0.057±0.003 mg/kg in 2006 and 0.059±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.056±0.003 mg/kg in 2005, 0.055±0.002 mg/kg in 2006 and 0.059±0.005 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.052±0.003 mg/kg in 2005, 0.055±0.004 mg/kg in 2006 and 2007 (Table 69 & Figure 86). Over the period of three years, average values were found to be
0.057±0.002 mg/kg during winter, 0.056±0.002 mg/kg during summer and 0.054±0.001 mg/kg during post monsoon period (Table 70).

**Trends:** No definite seasonal trend in lead accumulation in liver of *Cirrihinus mrigala* is indicated from the three years data. Accumulation levels are maximum at site-III followed in decreasing order by site-II, site-IV and site-I.

**Muscle**

Lead concentrations show variations in muscle during the entire period of study with minimum 0.045 mg/kg at site-IV and maximum 0.059 mg/kg at site-II and site-III (Table 69). Table 70 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, lead contents ranged from 0.052 mg/kg to 0.055 mg/kg with maximum during summer’ 05 and minimum during winter’ 07 and all post monsoon seasons. During winter, mean concentration was found to be 0.054±0.002 mg/kg in 2005, 0.054±0.003 in 2006 and 0.052±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.055±0.005 mg/kg in 2005, 0.054±0.002 mg/kg in 2006 and 0.052±0.005 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.052±0.002 mg/kg in 2005, 0.052±0.005 mg/kg in 2006 and 2007 (Table 69 & Figure 83). Over the period of three years, average values were found to be 0.053±0.001 mg/kg during winter, 0.054±0.00 mg/kg during summer and 0.052±0.00 mg/kg during post monsoon period (Table 70).

At site-II, lead contents ranged from 0.053 mg/kg to 0.059 mg/kg with maximum during summer’ 07 and minimum during winter’ 05. During winter, mean concentration was found to be 0.053±0.003 mg/kg in 2005, 0.055±0.003 mg/kg in 2006 and 0.056±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.056±0.003 mg/kg in 2005, 0.057±0.002 mg/kg in 2006 and 0.059±0.005
mg/kg in 2007. During post monsoon, mean concentration was found to be 0.054±0.004 mg/kg in 2005, 0.054±0.005 mg/kg in 2006 and 0.055±0.002 mg/kg in 2007 (Table 69 & Figure 84). Over the period of three years, average values were found to be 0.054±0.001 mg/kg during winter, 0.057±0.001 mg/kg during summer and 0.054±0.00 mg/kg during post monsoon period (Table 70).

At site-III, lead contents ranged from 0.054 mg/kg to 0.059 mg/kg with maximum during summer’ 07 and minimum during winter’ 07. During winter, mean concentration was found to be 0.056±0.004 mg/kg in 2005, 0.055±0.002 mg/kg in 2006 and 0.054±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.057±0.003 mg/kg in 2005, 0.058±0.005 mg/kg in 2006 and 0.059±0.005 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.055±0.005 mg/kg in 2005, 0.055±0.003 mg/kg in 2006 and 0.056±0.004 mg/kg in 2007 (Table 69 & Figure 85). Over the period of three years, average values were found to be 0.055±0.001 mg/kg during winter, 0.058±0.001 mg/kg during summer and 0.055±0.001 mg/kg during post monsoon period (Table 70).

At site-IV, lead levels ranged from 0.045 mg/kg to 0.056 mg/kg with maximum during summer’ 07 and minimum during post monsoon’ 06. During winter, mean concentration was found to be 0.055±0.003 mg/kg in 2005, 0.054±0.003 mg/kg in 2006 and 0.055±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.053±0.002 mg/kg in 2005, 0.054±0.003 mg/kg in 2006 and 0.056±0.004 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.053±0.003 mg/kg in 2005, 0.045±0.004 mg/kg in 2006 and 0.055±0.003 mg/kg in 2007 (Table 69 & Figure 86). Over the period of three years, average values were found to be 0.054±0.00 mg/kg during winter, 0.054±0.001 mg/kg during summer and 0.051±0.005 mg/kg during post monsoon period (Table 70).
**Trends:** No definite seasonal trend in lead accumulation in muscle of *Cirrihinus mrigala* is indicated from the three years data. Accumulation levels are maximum at site-III followed in decreasing order by site-II, site-IV and site-I.

**Kidney**

Lead concentrations show variations in kidney during the entire period of study with minimum 0.051 mg/kg at site-I and IV and maximum 0.059 mg/kg at site-III (Table 69). Table 70 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, lead concentrations ranged from 0.051 mg/kg to 0.057 mg/kg with maximum during summer’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.055±0.003 mg/kg in 2005, 0.054±0.004 mg/kg in 2006 and 0.053±0.004 mg/kg in 2007. During summer, mean concentration was found to be 0.055±0.005 mg/kg in 2005, 0.057±0.005 mg/kg in 2006 and 0.052±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.051±0.004 mg/kg in 2005, 0.052±0.004 mg/kg in 2006 and 0.053±0.003 mg/kg in 2007 (Table 69 & Figure 83). Over the period of three years, average values were found to be 0.054±0.001 mg/kg during winter, 0.054±0.002 mg/kg during summer and 0.052±0.001 mg/kg during post monsoon period (Table 70).

At site-II, lead concentrations ranged from 0.054 mg/kg to 0.057 mg/kg with maximum during winter’ 06 and summer’ 05 and 07 and minimum during winter’ 07. During winter, mean concentration was found to be 0.056±0.003 mg/kg in 2005, 0.057±0.003 mg/kg in 2006 and 0.054±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.057±0.003 mg/kg in 2005, 0.056±0.003 mg/kg in 2006 and 0.057±0.003 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.056±0.003 mg/kg in 2005, 0.055±0.004 mg/kg in 2006 and 0.055±0.005
mg/kg in 2007 (Table 69 & Figure 84). Over the period of three years, average values were found to be 0.055±0.001 mg/kg during winter, 0.056±0.00 mg/kg during summer and 0.055±0.00 mg/kg during post monsoon period (Table 70).

At site-III, lead contents ranged from 0.054 mg/kg to 0.059 mg/kg with maximum during summer’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.056±0.003 mg/kg in 2005, 0.057±0.002 mg/kg in 2006 and 0.055±0.005 mg/kg in 2007. During summer, mean concentration was found to be 0.057±0.003 mg/kg in 2005, 0.059±0.003 mg/kg in 2006 and 0.058±0.005 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.054±0.002 mg/kg in 2005, 0.058±0.003 mg/kg in 2006 and 0.055±0.003 mg/kg in 2007 (Table 69 & Figure 85). Over the period of three years, average values were found to be 0.056±0.001 mg/kg during winter, 0.058±0.001 mg/kg during summer and 0.055±0.002 mg/kg during post monsoon period (Table 70).

At site-IV, lead levels ranged from 0.051 mg/kg to 0.058 mg/kg with maximum during winter’ 06 and minimum during post monsoon’ 05. During winter, mean concentration was found to be 0.055±0.003 mg/kg in 2005, 0.058±0.005 mg/kg in 2006 and 0.054±0.003 mg/kg in 2007. During summer, mean concentration was found to be 0.055±0.005 in 2005, 0.054±0.005 mg/kg in 2006 and 0.054±0.004 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.051±0.002 mg/kg in 2005, 0.054±0.003 mg/kg in 2006 and 0.052±0.005 mg/kg in 2007 (Table 69 & Figure 86). Over the period of three years, average values were found to be 0.055±0.002 mg/kg during winter, 0.054±0.00 mg/kg during summer and 0.052±0.001 mg/kg during post monsoon period (Table 70).
**Trends:** No definite seasonal trend in lead accumulation in kidney of *Cirrihinus mrigala* is indicated from the three years data. Accumulation levels are maximum at site-III followed in decreasing order by site-II, site-IV and site-I.

**Brain**

Lead concentrations show variations in brain during the entire period of study with minimum 0.009 mg/kg at site-I, II and IV and maximum 0.014 mg/kg at site-III (Table 69). Table 70 shows summary comprising mean and standard deviation at selected sites of the river during the entire period of study.

At site-I, lead levels ranged from 0.009 mg/kg to 0.012 mg/kg with maximum during post monsoon’ 06 and minimum during summer and post monsoon’ 05 and winter, summer and post monsoon’ 07. During winter, mean concentration was found to be 0.011±0.001 mg/kg in 2005, 0.010±0.001 mg/kg in 2006 and 0.009±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.002 mg/kg in 2005, 0.010±0.001 in 2006 and 0.009±0.001 in 2007. During post monsoon, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.012±0.002 mg/kg in 2006 and 0.009±0.001 in 2007 (Table 69 & Figure 83). Over the period of three years, average values were found to be 0.010±0.001 mg/kg during winter, 0.0090±0.001 mg/kg during summer and 0.010±0.001 mg/kg during post monsoon period (Table 70).

At site-II, lead concentrations ranged from 0.009 mg/kg to 0.012 mg/kg with maximum during winter’ 05 and minimum during winter and post monsoon’ 06. During winter, mean concentration was found to be 0.012±0.001 mg/kg in 2005, 0.009±0.001 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.010±0.001 mg/kg in 2005, 0.011±0.002 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007. During post monsoon, mean concentration was
found to be 0.011±0.00 mg/kg in 2005, 0.009±0.001 in 2006 and 0.010±0.001 mg/kg in 2007 (Table 69 & Figure 84). Over the period of three years, average values were found to be 0.010±0.001 mg/kg during winter, summer and post monsoon period (Table 70).

At site-III, lead contents ranged from 0.010 mg/kg to 0.014 mg/kg with maximum during summer’ 06 and minimum during summer’ 05, post monsoon’ 06 and 07. During winter, mean concentration was found to be 0.012±0.002 mg/kg in 2005, 0.011±0.001 mg/kg in 2006 and 0.012±0.001 mg/kg in 2007. During summer, mean concentration was found to be 0.010±0.002 mg/kg in 2005, 0.014±0.001 mg/kg in 2006 and 0.012±0.002 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.011±0.001 mg/kg in 2005, 0.010±0.001 mg/kg in 2006 and 0.012±0.002 mg/kg in 2007. Over the period of three years, average values were found to be 0.011±0.001 mg/kg during winter, 0.012±0.002 mg/kg during summer and 0.010±0.001 mg/kg during post monsoon period (Table 70).

At site-IV, lead levels were between 0.009 mg/kg and 0.012 mg/kg with maximum during summer’ 06 and minimum during winter’ 05, 06 and summer’ 05 and post monsoon’ 07. During winter, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 2006 and 0.010±0.002 mg/kg in 2007. During summer, mean concentration was found to be 0.009±0.001 mg/kg in 2005, 0.012±0.001 mg/kg in 2006 and 0.010±0.001 mg/kg in 2007. During post monsoon, mean concentration was found to be 0.011±0.001 mg/kg in 2005, 0.010±0.00 mg/kg in 2006 and 0.009±0.001 mg/kg in 2007 (Table 69 & Figure 86). Over the period of three years, average values were found to be 0.009±0.00 mg/kg during winter, 0.010±0.001 mg/kg during summer and post monsoon period (Table 70).
Trends: No definite seasonal trend in lead accumulation in brain of *Cirrhinus mrigala* is indicated from the three years data. Accumulation levels are maximum at site-III, minimum at site-I and intermediate at site-II and IV.

Among various tissues of *Cirrhinus mrigala*, lead accumulation is maximum in liver followed in decreasing order by kidney, muscle and brain.

Among various fish species, lead accumulation shows the following pattern:

*Mystus senghala* > *Cirrhinus mrigala* > *Cyprinus carpio* > *Labeo rohita*

**CORRELATION ANALYSIS**

To understand the relationship amongst various physico-chemical parameters, metal levels in water, sediment and fish, correlation analysis was carried out with “STATISTICA” computer software. The results of the correlation analysis are presented in the Tables 71-105.

Tables 71-73 show the correlation matrix among the physico-chemical parameters and contents of heavy metals in water during winter, summer and post monsoon periods throughout the study period. Water temperature shows significant positive correlation with pH during winter and summer, and weak negative during post monsoon period. With dissolved oxygen and total hardness, it shows a significant negative and positive correlation respectively during all seasons. pH shows significant negative correlation with dissolved oxygen and a strong positive with total hardness during winter and summer. But during post monsoon, its relationship with dissolved oxygen and total hardness has been found to be weakly positive and negative respectively. Dissolved oxygen shows negative correlation with hardness during all seasons.

All metals in water are positively correlated with each other, and also with temperature and total hardness, and negative with dissolved oxygen during all
seasons. With pH, strong correlation is indicated during winter and summer but only a weak correlation during post monsoon.

The data on correlation matrix among physico-chemical parameters of water and metal contents in various tissues are presented in the Tables 74-77 for *Labeo rohita*, Tables 78-81 for *Cyprinus carpio*, Tables 82-85 for *Mystus seenghala* and Tables 86-89 for *Cirrhinus mrigala*. Metal levels in various tissues of all fish species are positively correlated with temperature, pH and total hardness, and negatively correlated with dissolved oxygen of water. Accumulations of all metals in tissues are positively correlated with one another. One exception is seen in *Cyprinus carpio* in which, lead shows insignificant negative correlation with temperature and cadmium.

Correlation matrix among accumulation levels of cadmium, chromium, nickel and lead in water, sediment and various tissues of four fish species have been calculated and are depicted in the Tables 90-105. The correlation analysis shows that, in over all terms, levels of all metals in sediment are positively and significantly correlated with their levels in water. It is further recorded that metal concentrations in fish tissues are positively and significantly dependent on their concentrations in water and sediment. Mostly, the relationships are very strong. However, some exceptions are also revealed. In *Cyprinus carpio*, nickel accumulation in muscle is not much strongly correlated with its own concentration in water and sediment, and of other metals in water, sediment and muscle though in other tissues, correlations are strongly positive. This indicated that nickel has comparatively less tendency to get concentrated in muscle in *Cyprinus carpio*. Cadmium accumulation in liver or kidney of *Mystus seenghala, Labeo rohita* and *Cirrhinus mrigala* is not very strongly positively correlated with accumulation of nickel and lead.