Chapter-IV
PROPERTIES OF WATER OF RIVER VARUNA

Physico-chemical properties and heavy metals analyses of the river Varuna water was done fortnightly, from April 2001 to March 2002. The collected data are expressed as monthly mean along with the standard deviations. The same data were analysed for BLOCK ANOVA and correlated to test the significance of variation. All the selected four sites were further subdivided into five sub-sites to collect the true representative sample. Out of the five sub-sites, first and second sub-sites were located very close to the bank at cis and trans sides of the river, sub-sites three, four and five were located in the mid stream varying vertically. All the sub-sites were located 100 feet downstream from the point of addition of the respective nalas. The parameters analysed during the study were as given below:

**Temperature**

Temperature of the river water was found to be higher at site 4, followed by site 3 and site 2, as an average, the least temperature was recorded at site 1.

At site 1 temperature of the river water was minimum (20.75±0.243°C) during October 2001 and maximum (32.9±0.276°C) during April 2001. At site 2 the temperature was found to be minimum (21.00±0.110°C) during November 2001. Temperature was maximum (33.68±0.893°C) during April 2001 at this site. At site 3 temperature was recorded to be minimum (21.43±0.083°C) during November 2001 and it was found to be maximum (33.73±0.121°C) during the month of May 2001. At site 4, the minimum temperature (21.96±0.118°C) of the river water was found during November 2001 and maximum (34.35±0.190°C) during April 2001 (Fig. 4.1). Annual mean temperature of site 1, site 2, site 3 and site 4 was recorded to be 26.371, 26.753, 27.108 and 27.677°C, respectively.
Comparative study of all the sites show that in river Varuna the minimum temperature of water ($20.75 \pm 0.243^\circ C$) was recorded during October 2001 at site 1 and the maximum temperature ($34.35 \pm 0.190^\circ C$) during April 2001 at the site 4. Seasonally, temperature of water was found to be highest during summer followed by rainy season and it was minimum during winter at all the sites.

Mean level of variance of temperature at the study sites show significant difference among the sites ($F = 17.13$, $p<0.001$) and among the months ($F = 469.84$, $p<0.001$) (Appendix-I).

**pH**

pH of the river water was found to be higher at site 1, followed by site 2 and site 3, as an average the least pH was recorded at site 4 throughout the study.

At site 1 pH of the river water was minimum ($8.14 \pm 0.07$) during April 2001 and maximum ($8.66 \pm 0.05$) during November 2001. At site 2 the pH was found to be minimum ($8.11 \pm 0.04$) during April 2001. pH was maximum ($8.50 \pm 0.03$) during August 2001 at this site. At site 3 pH was recorded to be minimum ($7.92 \pm 0.07$) during March 2002 and it was found to be maximum ($8.33 \pm 0.03$) during the month of September 2001. At site 4, the minimum pH ($7.61 \pm 0.05$) was found during April 2001 and maximum ($8.08 \pm 0.04$) of the river water during June 2001 (Fig. 4.2). Annual mean pH of site 1, site 2, site 3 and site 4 was recorded to be 8.406, 8.325, 8.087 and 7.842, respectively.

Comparative study of all the sites show that in the river Varuna the minimum pH of water ($7.61 \pm 0.05$) was recorded during April 2001 at site 4 and the maximum pH ($8.66 \pm 0.05$) during November 2001 at the site 1. Seasonally, pH was found to be highest during rainy season followed by winter and summer season at all the sites.
Fig. 4.1: Temperature of the river water

Fig. 4.2: pH of the river water (Apr. 2001- Mar. 2002)
Mean level of variance of pH at the study sites show significant difference among the sites ($F = 67.98$, $p<0.001$) and among the months ($F = 4.71$, $p<0.001$) (Appendix-I).

**Acidity**

Acidity of the river water was found to be higher at site 4, followed by site 3 and site 2, as an average the least acidity was recorded at site 1 throughout the study.

At site 1 acidity of the river water was minimum (0.21±0.052 mg/l CaCO$_3$) during April 2001 and maximum (0.73±0.075 mg/l CaCO$_3$) during December 2001. At site 2 the acidity was found to be minimum during July and August 2001, and it was 0.25±0.055 and 0.25±0.050 mg/l CaCO$_3$ respectively. At site 2 it was maximum (6.6±0.103 mg/l CaCO$_3$) during December 2001. At site 3 acidity was recorded to be minimum (0.42±0.141 mg/l CaCO$_3$) during July 2001 and it was found to be maximum (8.35±0.187 mg/l CaCO$_3$) during the month of January 2002. At site 4, the maximum acidity (34.46±0.819 mg/l CaCO$_3$) was found during April 2001 and minimum (10.36±0.314 mg/l CaCO$_3$) during November 2001 (Fig. 4.3). Annual mean acidity of site 1, site 2, site 3 and site 4 was recorded to be 0.386, 2.429, 6.526 and 18.516 mg/l CaCO$_3$, respectively.

Comparative study of the river water all the sites show that minimum acidity (0.21±0.052 mg/l CaCO$_3$) was recorded during April 2001 at site 1 and the maximum acidity (34.46±0.819 mg/l CaCO$_3$) during April 2001 at the site 4. Seasonally, acidity of the river water was found to be highest during summer season followed by rainy and winter season at most of the sites.

Mean level of variance of acidity at the study sites show significant difference among the sites ($F = 42.34$, $p<0.001$), but among the months the level of variance is non-significant ($F = 0.82$, N.S.) (Appendix-I).
Alkalinity

Alkalinity of the river water was found to be higher at site 1, followed by site 2 and site 3, as an average the least alkalinity was recorded at site 4 throughout the study.

At site 1 alkalinity of the river water was minimum (193.66±3.98 mg/l CaCO₃) during April 2001 and maximum (461.66±3.14 mg/l CaCO₃) during November 2001. At site 2 the alkalinity was found to be minimum (142.33±3.50 mg/l CaCO₃) during April 2001. Alkalinity was maximum (347.33±6.18 mg/l CaCO₃) during September 2001 at this site. At site 3 alkalinity was recorded to be minimum (126.00±5.85 mg/l CaCO₃) during March 2002 and it was found to be maximum (262.83±3.06 mg/l CaCO₃) during the month of October 2001. At site 4, the minimum alkalinity (120.83±5.11 mg/l CaCO₃) was found during April 2001 and maximum (243.83±7.11 mg/l CaCO₃) during February 2002 (Fig. 4.4). Annual mean alkalinity of site 1, site 2, site 3 and site 4 was recorded to be 345.233, 250.316, 218.066 and 193.331 mg/l CaCO₃, respectively.

Comparative study of the river water of all the sites show that minimum alkalinity (126.00±5.85 mg/l CaCO₃) was recorded during March 2002 at site 3 and the maximum alkalinity (461.66±3.14 mg/l CaCO₃) during November 2001 at the site 1. Seasonally, alkalinity of the river water was found to be highest during rainy season followed by winter and summer season at all the sites.

Mean level of variance of alkalinity at the study sites show significant difference among the sites (F = 44.90, p<0.001) and among the months (F = 9.23, p<0.001) (Appendix-I).

Nitrate

Nitrate in the river water was found to be higher at site 4, followed by site 3 and site 2 and it was minimum at site 1 throughout the study.
Fig. 4.3: Acidity of the river water (Apr. 2001 - Mar. 2002)

Fig. 4.4: Alkalinity of the river water (Apr. 2001 - Mar. 2002)
At site 1 nitrate in the river water was minimum (0.023±0.005 mg/l) during May 2001 and January 2002. In both the months the values were same. Maximum nitrate content (0.007±0.014 mg/l) was found during July 2001 at this site. At site 2 the nitrate was found to be minimum (0.092±0.015 mg/l) during November 2001. Nitrate at this site was maximum (0.255±0.014 mg/l) during December 2001. At site 3 nitrate was recorded to be minimum (0.137±0.026 mg/l) during July 2001 and it was found to be maximum (0.292±0.021 mg/l) during the month of March 2002. At site 4, the minimum nitrate (0.517±0.021 mg/l) in the river water was found during July 2001 and maximum (0.968±0.026 mg/l) during April 2001 (Fig. 4.5). Annual mean nitrate of site 1, site 2, site 3 and site 4 was recorded to be 0.041, 0.163, 0.203 and 0.721 mg/l, respectively.

Comparative study of the river water of all the sites show that minimum nitrate (0.023±0.005 mg/l) was recorded during May 2001 and January 2002 at site 1 and the maximum nitrate (0.968±0.028 mg/l) during April 2001 at the site 4. Seasonally, nitrate of the river water was found to be highest during summer season followed by winter and rainy season at all the sites.

Mean level of variance of nitrate at the study sites show significant difference among the sites (F = 184.62, p<0.001) and among the months (F = 2.196, p<0.05) (Appendix-I).

Phosphate

Phosphate content in the river water was found to be higher at site 4, followed by site 3 and site 2 and it was minimum at site 1 throughout the study.

At site 1 phosphate in the river water was minimum (0.015±0.002 mg/l) during August and September 2001. In both the months the values were same. Maximum phosphate content (0.092±0.008 mg/l) in the river water at site 1 was
Fig. 4.5: Nitrate in the river water (Apr. 2001- Mar. 2002)

Fig. 4.6: Phosphate in the river water (Apr. 2001- Mar. 2002)
found during December 2001. At site 2 the phosphate was found to be minimum (0.088±0.008 mg/l) during February 2002. Phosphate at this site was maximum (0.652±0.019 mg/l) during April 2001. At site 3 phosphate was recorded to be minimum (0.205±0.019 mg/l) during November 2001 and it was found to be maximum (1.001±0.041 mg/l) during the month of April 2001. At site 4, the minimum phosphate content in water (0.297±0.022 mg/l) was found during November 2001 and maximum (1.565±0.028 mg/l) during April 2001 (Fig. 4.6). Annual mean phosphate of site 1, site 2, site 3 and site 4 was recorded to be 0.034, 0.274; 0.545 and 1.097 mg/l, respectively.

Comparative study of all the sites show that minimum phosphate content (0.015±0.002 mg/l) in water of river Varuna was recorded during August and September 2001 at site 1 and the maximum phosphate (1.565±0.028 mg/l) during April 2001 at the site 4. Seasonally, phosphate content in river water was found to be highest during summer season followed by rainy and winter season at all the sites.

Mean level of variance of phosphate at the study sites show significant difference among the sites (F = 71.61, p<0.001) and among the months (F = 3.64, p<0.001) (Appendix-I).

**Chloride**

Analysis of chloride in the river water shows that the highest value was at site 4 and the lowest at site 1. The same value at site 3 was higher than that at the site 2 throughout the study.

At site 1 chloride in the river water was minimum (12.66±1.63 mg/l) during July 2001 and maximum chloride content (68.66±2.06 mg/l) was found during April 2001. At site 2 the chloride was found to be minimum (14.83±1.63 mg/l)
during August 2001. Chloride at this site was maximum (70.00±2.58 mg/l) during April 2001. At site 3 chloride was recorded to be minimum (14.66±1.36 mg/l) during July 2001 and it was found to be maximum (71.5±2.75 mg/l) during the month of April 2001 in the river water. At site 4, the minimum chloride (29.16±1.94 mg/l) was found during July 2001 and maximum (79.5±2.58 mg/l) during April 2001 (Fig. 4.7). Annual mean chloride of site 1, site 2, site 3 and site 4 was recorded to be 34.246, 35.677, 39.053 and 53.872 mg/l, respectively.

Comparative study of the river water of all the sites show that minimum chloride (12.66±1.63 mg/l) was recorded during July 2001 at site 1 and the maximum chloride (79.50±2.58 mg/l) during April 2001 at the site 4. Seasonally, chloride in the river water was found to be highest during summer season followed by winter and rainy season at all the sites.

Mean level of variance of chloride at the study sites show significant difference among the sites (F = 44.64, p<0.001) and among the months (F = 47.10, p<0.001) (Appendix-I).

**Dissolved Oxygen (DO)**

Analysis of DO in the river water shows that the highest value was at site 1 and the lowest at site 4. The same value at site 2 was higher than that at the site 3 throughout the study.

At site 1 DO in the river water was minimum (5.80±0.30 mg/l) during April 2001. Maximum DO content (9.16±0.25 mg/l) was found during November 2001 at this site. At site 2 the DO was found to be minimum (4.38±0.21 mg/l) during April 2001. DO at this site was maximum (6.40±0.17 mg/l) during November 2001. At site 3 DO was recorded to be minimum (3.30±0.19 mg/l) during April 2001 and it was found to be maximum (5.28±0.25 mg/l) during the month of
Fig. 4.7: Chloride in the river water (Apr. 2001 - Mar. 2002)

Fig. 4.8: Dissolved oxygen of the river water (2001-2002)
November 2001. At site 4, the minimum DO (1.93±0.30 mg/l) was found during April 2001 and maximum (4.48±0.11 mg/l) during November 2001 (Fig. 4.8). Annual mean DO of site 1, site 2, site 3 and site 4 was recorded to be 7.399, 5.358, 4.458 and 3.478 mg/l, respectively.

Comparative study of the river water of all the sites show that minimum DO (1.93±0.30 mg/l) was recorded during April 2001 at site 4 and the maximum DO (9.16±0.25 mg/l) during November 2001 at the site 1. Seasonally, DO in the river water was found to be highest during winter season followed by rainy and summer season at all the sites.

Mean level of variance of DO at the study sites show significant difference among the sites (F = 66.40, p<0.001) and among the months (F = 4.74, p<0.001) (Appendix-I).

**Biochemical Oxygen Demand (BOD)**

Analysis of BOD of the river water shows that the highest value was at site 3 and the lowest at site 1. The same value at site 4 was higher than that at the site 2 throughout the study.

At site 1 BOD of the river water was minimum (1.81±0.07 mg/l) during August 2001 and maximum BOD content (2.96±0.12 mg/l) was found during June 2001. At site 2 the BOD was found to be minimum (16.5±1.04 mg/l) during September 2001. BOD at this site was maximum (38.16±1.94 mg/l) during April 2001. At site 3 BOD was recorded to be minimum (26.00±1.41 mg/l) during June 2001 and it was found to be maximum (84.16±3.40 mg/l) during the month of April 2001. At site 4, the minimum BOD (21.83±1.16 mg/l) was found during June 2001 and maximum (71.68±3.13 mg/l) during April 2001 (Fig. 4.9). Annual mean BOD of site 1, site 2, site 3 and site 4 was recorded to be 2.108, 22.846, 52.108, 42.993 mg/l, respectively.
Comparative study of the river water of all the sites show that minimum BOD (1.81±0.07 mg/l) was recorded during August 2001 at site 1 and the maximum BOD (84.16±3.40 mg/l) during April 2001 at the site 3. Seasonally, BOD of the river water was found to be highest during summer season followed by winter and rainy season at all the sites.

Mean level of variance of BOD at the study sites show significant difference among the sites (F = 73.20, p<0.001) and among the months (F = 4.69, p<0.001) (Appendix-I).

Chemical Oxygen Demand (COD)

Analysis of COD of the river water shows that the highest value was at site 3 and the lowest at site 1. The same value at site 4 was higher than that at the site 2 throughout the study.

At site 1 COD of the river water was minimum (5.10±0.23 mg/l) during July 2001. Maximum COD content (6.90±0.19 mg/l) was found during April 2001 at site 1. At site 2 the COD was found to be minimum (22.83±2.13 mg/l) during September 2001. COD at this site was maximum (54.00±2.75 mg/l) during April 2001. At site 3 COD was recorded to be minimum (48.50±4.23 mg/l) during June 2001 and it was found to be maximum (136.66±5.46 mg/l) during the month of April 2001. At site 4, the minimum COD (28.16±1.94 mg/l) was found during July 2001 and maximum (114.66±4.22 mg/l) during April 2001 (Fig. 4.10). Annual mean COD of site 1, site 2, site 3 and site 4 was recorded to be 5.766, 32.096, 81.303 and 59.578 mg/l, respectively.

Comparative study of the river water of all the sites show that minimum COD (5.10±0.23 mg/l) was recorded during June 2001 at site 1 and the maximum COD (136.66±5.46 mg/l) during April 2001 at the site 3. Seasonally, COD of the
Fig. 4.9: BOD of the river water (Apr. 2001 - Mar. 2002)

Fig. 4.10: COD of the river water (Apr. 2001 - Mar. 2002)
river water was found to be highest during summer season followed by winter and
rainy season at all the sites.

Mean level of variance of COD at the study sites show significant
difference among the sites (F = 60.44, p<0.001) and among the months (F = 4.57,
p<0.001) (Appendix-I).

**Total Solids**

Analysis of total solids in the river water shows that the highest value was
at site 4 and the lowest at site 1. The same value at site 3 was higher than that at
the site 2 throughout the study.

At site 1 total solids in the river water was minimum (193.50±1.41 mg/l)
during October 2001 and maximum total solids content (282.16±3.06 mg/l) was
found during July 2001. At site 2 the total solids was found to be minimum
(284.50±6.25 mg/l) during November 2001. Total solids at this site was maximum
(385.00±4.47 mg/l) during July 2001. At site 3 total solids was recorded to be
minimum (389.16±6.01 mg/l) during November 2001 and it was found to be
maximum (973.50±14.08 mg/l) during the month of June 2001. At site 4, the
minimum total solid (563.00±8.53 mg/l) was found during November 2001 and
maximum (1128.50±10.80 mg/l) during May 2001 (Fig. 4.11). Annual mean total
solids of site 1, site 2, site 3 and site 4 was recorded to be 239.790, 326.096,
672.830 and 856.372 mg/l, respectively.

Comparative study of the river water of all the sites show that minimum
total solids (193.50±1.41 mg/l) was recorded during October 2001 at site 1 and the
maximum total solids (1128.50±10.80 mg/l) during May 2001 at the site 4.
Seasonally, total solids in the river water was found to be highest during rainy
season followed by summer and winter season at all the sites.
Mean level of variance of total solids at the study sites show significant difference among the sites ($F = 85.05$, $p<0.001$) and among the months ($F = 4.90$, $p<0.001$) (Appendix-I).

**Total Hardness**

Analysis of total hardness of the river water shows that the highest value was at site 4 and the lowest at site 1. The same value at site 3 was higher than that at the site 2 throughout the study.

At site 1 total hardness of the river water was minimum ($38.83 \pm 2.31$ mg/l CaCO$_3$) during August 2001 and maximum total hardness content ($82.50 \pm 2.88$ mg/l CaCO$_3$) was found during April 2001. At site 2 the total hardness was found to be minimum ($159.33 \pm 5.40$ mg/l CaCO$_3$) during August 2001. Total hardness at this site was maximum ($6.44 \pm 2.73$ mg/l CaCO$_3$) during March 2002. At site 3 total hardness was recorded to be minimum ($531.50 \pm 3.11$ mg/l CaCO$_3$) during June 2001 and it was found to be maximum ($911.50 \pm 4.11$ mg/l CaCO$_3$) during the month of April 2001. At site 4, the minimum total hardness ($639.00 \pm 2.65$ mg/l CaCO$_3$) was found during August 2001 and maximum ($963.83 \pm 5.56$ mg/l CaCO$_3$) during April 2001 (Fig. 4.12). Annual mean total hardness of site 1, site 2, site 3 and site 4 was recorded to be $58.429$, $385.483$, $672.267$ and $737.123$ mg/l CaCO$_3$, respectively.

Comparative study of the river water of all the sites show that minimum total hardness ($38.83 \pm 2.31$ mg/l CaCO$_3$) was recorded during August 2001 at site 1 and the maximum total hardness ($963.83 \pm 5.56$ mg/l CaCO$_3$) during April 2001 at the site 4. Seasonally, total hardness of the river water was found to be highest during summer season followed by winter and rainy season at all the sites.

Mean level of variance of total hardness at the study sites show significant difference among the sites ($F = 191.33$, $p<0.001$) and among the months ($F = 4.89$, $p<0.001$) (Appendix-I).
Fig. 4.11: Total solids in the river water (Apr. 2001- Mar. 2002)

Fig. 4.12: Total hardness of the river water (Apr. 2001- Mar. 2002)
Electrical Conductance (EC)

Analysis of electrical conductance of the river water shows that the highest value was at site 4 and the lowest at site 1. The same value at site 3 was higher than that at the site 2 throughout the study.

At site 1 electrical conductance of the river water was minimum (114.66±7.29 μS/cm) during July 2001 and maximum electrical conductance content (517.50±4.16 μS/cm) was found during February 2002. At site 2 the electrical conductance was found to be minimum (180.83±5.32 μS/cm) during July 2001. Electrical conductance at this site was maximum (522.66±7.26 μS/cm) during February 2002. At site 3 electrical conductance was recorded to be minimum (215.50±6.31 μS/cm) during March 2002 and it was found to be maximum (669.11±6.51 μS/cm) during the month of February 2002. At site 4, the minimum electrical conductance (315.15±5.26 μS/cm) was found during July 2001 and maximum (857.50±9.13 μS/cm) during November 2001 (Fig. 4.13). Annual mean electrical conductance of site 1, site 2, site 3 and site 4 was recorded to be 363.941, 400.128, 450.685 and 626.830 μS/cm, respectively.

Comparative study of the river water of all the sites show that minimum electrical conductance (114.66±7.29 μS/cm) was recorded during July 2001 at site 1 and the maximum electrical conductance (857.50±9.13 μS/cm) during November 2001 at the site 4. Seasonally, electrical conductance of the river water was found to be highest during winter season followed by rainy and summer season at all the sites.

Mean level of variance of electrical conductance at the study sites show significant difference among the sites (F = 38.86, p<0.001) and among the months (F = 20.64, p<0.001) (Appendix-I).
Oil & Grease

Analysis of oil & grease in the river water shows that the highest value was at site 3 and the lowest at site 1. The same value at site 4 was higher than that at the site 2 throughout the study.

At site 1 oil & grease was minimum (0.11±0.030 mg/l) in the river water during August 2001 and maximum (0.63±0.021 mg/l) was found during April 2001. At site 2 the oil & grease was found to be minimum (0.35±0.042 mg/l) during August 2001. Oil & grease at this site was maximum (1.89±0.025 mg/l) during April 2001. At site 3 oil & grease was recorded to be minimum (1.09±0.051 mg/l) during August 2001 and it was found to be maximum (6.09±0.09 mg/l) during the month of March 2002. At site 4, the minimum oil & grease (0.95±0.052 mg/l) was found during August 2001 and maximum (3.90±0.063 mg/l) during April 2001 (Fig. 4.14). Annual mean oil & grease of site 1, site 2, site 3 and site 4 was recorded to be 0.420, 1.120, 4.197 and 2.718 mg/l, respectively.

Comparative study of the river water of all the sites show that minimum oil & grease (0.11±0.030 mg/l) was recorded during August 2001 at site 1 and the maximum oil & grease (6.09±0.09 mg/l) during March 2002 at the site 3. Seasonally, oil & grease of the river water was found to be highest during summer season followed by winter and rainy season at all the sites.

Mean level of variance of oil & grease at the study sites show significant difference among the sites ($F = 67.96$, $p<0.001$) and among the months ($F = 6.16$, $p<0.001$) (Appendix-I).

Heavy Metal Analysis

Heavy metals analyses in the water of river Varuna at all the four sites were also conducted throughout the year. This was based on analysis of the selected
Fig. 4.13: Electrical conductance of the river water (Apr. 2001-Mar. 2002)

Fig. 4.14: Oil & grease in the river water (Apr. 2001-Mar. 2002)
heavy metals which were supposed to be discharged from the small scale industries dominantly being found in the area. Thus six heavy metals were analysed at the research sites, their results are given below -

**Cadmium**

Analysis of Cd in the river water shows that the highest value was at site 4 and the lowest at site 1. The same value at site 2 was higher than that at the site 3 throughout the study.

At site 1 Cd in the river water was found absolutely absent during June, July and August 2001. Maximum Cd content (0.004 μg/l) at this site was found during April, May, December 2001 and also during January and February 2002. At site 2 the Cd was found to be minimum (0.008 μg/l) during August 2001. Cd at this site was maximum (0.039 μg/l) during April as well as May 2001. At site 3 Cd was recorded to be minimum (0.003 μg/l) during July 2001 and it was found to be maximum (0.020 μg/l) during the month of May 2001. At site 4, the minimum Cd (0.015 μg/l) was found during July 2001 and maximum (0.049 μg/l) during April 2001 and March 2002 (Fig. 4.15). Annual mean Cd of site 1, site 2, site 3 and site 4 was recorded to be 0.002, 0.026, 0.011 and 0.034 μg/l, respectively.

Comparative study of the river water of all the sites show that Cd was not found during June, July and August 2001 at site 1 and the maximum Cd (0.049 μg/l) during April 2001 and March 2002 at the site 4. Seasonally, Cd in the river water was found to be highest during summer season followed by winter and rainy season at all the sites.

Mean level of variance of Cd at the study sites show significant difference among the sites (F = 72.53, p<0.001) and among the months (F = 6.97, p<0.001) (Appendix-I).
Copper

Analysis of Cu in the river water shows that the highest value was at site 4 and the lowest at site 1. The same value at site 3 was higher than that at the site 2 throughout the study.

At site 1 Cu in the river water was found absolutely absent during July and September 2001. Maximum Cu content (0.020 μg/l) at this site was found during May 2001. At site 2 the Cu was found to be minimum (0.021 μg/l) during July 2001. Cu at this site was maximum (0.145 μg/l) during May 2001. At site 3 Cu was recorded to be minimum (0.118 μg/l) during September 2001 and it was found to be maximum (0.375 μg/l) during the month of April 2001. At site 4, the minimum Cu (0.113 μg/l) was found during August 2001 and maximum (0.496 μg/l) during May 2001 (Fig. 4.16). Annual mean Cu of site 1, site 2, site 3 and site 4 was recorded to be 0.007, 0.094, 0.262 and 0.332 μg/l, respectively.

Comparative study of all the sites show that Cu was not found during July and September 2001 in the river water at site 1 and the maximum Cu (0.496 μg/l) during May 2001 at the site 4. Seasonally, Cu in the river water was found to be highest during summer season followed by winter and rainy season at all the sites.

Mean level of variance of Cu at the study sites show significant difference among the sites (F = 66.40, p<0.001) and among the months (F = 4.74, p<0.001) (Appendix-I).

Chromium

Analysis of Cr in the river water shows that the highest value was at site 4 and the lowest at site 1. The same value at site 3 was higher than that at the site 2 throughout the study.
Fig. 4.15: Cadmium in the river water (Apr. 2001 - Mar. 2002)

Fig. 4.16: Copper in the river water (Apr. 2001 - Mar. 2002)
At site 1 Cr in the river water was found absolutely absent during August 2001. Maximum Cr content (0.010 μg/l) at this site was found during April 2001. At site 2 the Cr was found to be minimum (0.001 μg/l) during July and August 2001. Cr at this site was maximum (0.015 μg/l) during April 2001 and March 2002. At site 3 Cr was recorded to be minimum (0.003 μg/l) during September 2001 and it was found to be maximum (0.038 μg/l) during the month of May 2001. At site 4, the minimum Cr (0.006 μg/l) was found during August 2001 and maximum (0.081 μg/l) during April 2001 (Fig. 4.17). Annual mean Cr of site 1, site 2; site 3 and site 4 was recorded to be 0.006, 0.008, 0.019 and 0.041 μg/l, respectively.

Comparative study of all the sites show that Cr was not found during August 2001 at site 1 and the maximum Cr (0.081 μg/l) during April 2001 at the site 4 in the river water. Seasonally, Cr was found to be highest during summer season followed by winter and rainy season at all the sites.

Mean level of variance of Cr at the study sites show significant difference among the sites (F = 27.37, p<0.001) and among the months (F = 4.20, p<0.001) (Appendix-I).

Nickel

Analysis of Ni in the river water shows that the highest value was at site 4 and the lowest at site 1. The same value at site 3 was higher than that at the site 2 throughout the study.

At site 1 Ni in the river water was found absolutely absent during August 2001. Maximum Ni content (0.007 μg/l) at this site was found during May 2001, January and March 2002. At site 2 the Ni was found to be minimum (0.001 μg/l) during August and September 2001. Ni at this site was maximum (0.019 μg/l)
Fig. 4.17: Chromium in the river water (Apr. 2001 - Mar. 2002)

Fig. 4.18: Nickel in the river water (2001-2002)
during April and May 2001. At site 3 Ni was recorded to be minimum (0.001 μg/l) during September 2001 and it was found to be maximum (0.023 μg/l) during the month of May 2001. At site 4, the minimum Ni (0.015 μg/l) was found during August 2001 and maximum (0.048 μg/l) during April 2001 (Fig. 4.18). Annual mean Ni of site 1, site 2, site 3 and site 4 was recorded to be 0.005, 0.011, 0.013 and 0.032 μg/l, respectively.

Comparative study of all the sites show that Ni was not found during August 2001 at site 1 and the maximum Ni (0.050 μg/l) during April 2001 at the site 4. Seasonally, Ni in the river water was found to be highest during summer season followed by winter and rainy season at all the sites.

Mean level of variance of Ni at the study sites show significant difference among the sites (F = 67.56, p<0.001) and among the months (F = 8.28, p<0.001) (Appendix-I).

Lead

Analysis of Pb in the river water shows that the highest value was at site 2 and the lowest at site 1. The same value at site 4 was higher than that at the site 3 throughout the study.

At site 1 Pb in the river water was found to be minimum (0.001 μg/l) during July 2001. Maximum Pb content (0.015 μg/l) at this site was found during April 2001. At site 2 the Pb was found to be minimum (0.027 μg/l) during August 2001. Pb at this site was maximum (0.021 μg/l) during April 2001. At site 3 Pb was recorded to be minimum (0.010 μg/l) during August 2001 and it was found to be maximum (0.130 μg/l) during the month of March 2002. At site 4, the minimum Pb (0.009 μg/l) was found during August 2001 and maximum (0.139 μg/l) during
April 2001 (Fig. 4.19). Annual mean Pb of site 1, site 2, site 3 and site 4 was recorded to be 0.009, 0.115, 0.072 and 0.078 μg/l, respectively.

Comparative study of the river water of all the sites show that Pb was minimum (0.001 μg/l) during July 2001 at site 1 and the maximum Pb (0.201 μg/l) during April 2001 at the site 2. Seasonally, Pb in the river water was found to be highest during summer season followed by winter and rainy season at all the sites.

Mean level of variance of Pb at the study sites show significant difference among the sites (F = 33.33, p<0.001) and among the months (F = 10.06, p<0.001) (Appendix-I).

Zinc

Analysis of Zn in the river water shows that the highest value was at site 2 and the lowest at site 1. The same value at site 3 was higher than that at the site 4 throughout the study.

At site 1 Zn in the river water was found to be minimum (0.042 μg/l) during September 2001. Maximum Zn content (0.107 μg/l) at this site was found during March 2002. At site 2 the Zn was found to be minimum (0.892 μg/l) during August 2001. Zn at this site was maximum (1.712 μg/l) during April 2001. At site 3 Zn was recorded to be minimum (0.658 μg/l) during September 2001 and it was found to be maximum (1.304 μg/l) during the month of May 2001. At site 4, the minimum Zn (0.228 μg/l) was found during September 2001 and maximum (1.051 μg/l) during April 2001 and March 2002 (Fig. 4.20). Annual mean Zn of site 1, site 2, site 3 and site 4 was recorded to be 0.076, 1.271, 1.004 and 0.744, respectively.
Fig. 4.19: Lead in the river water (Apr. 2001 - Mar. 2002)

Fig. 4.20: Zinc in the river water (Apr. 2001 - Mar. 2002)
Comparative study of all the sites show that Zn was minimum (0.042 µg/l) during September 2001 at site 1 and the maximum Zn (1.712 µg/l) during April 2001 at the site 2 in the river water. Seasonally, Zn in the river water was found to be highest during summer season followed by winter and rainy season at all the sites.

Mean level of variance of Zn at the study sites show significant difference among the sites (F = 71.90, p<0.001) and among the months (F = 5.58, p<0.001) (Appendix-I).