DISSCUSION

DISCUSSION

A series of changes can be observed in the lotic water ecosystem, which might be due to a variety of factors. Though these ecosystems might be influenced by the seasonal and some man made activities, such as addition of industrial waste, agricultural runoff, domestic waste and sewage. Some of the parameters especially of the physico-chemical parameters and biological characteristics might be responsible for unprecedented changes. Present investigation on heavy metal load in the water , sediment and bivalve molluscs from Krishna river, gives some information regarding the biotic and abiotic factors and their influence on the status of the river, will be of great value for proper management of different wastes and utilization of river water.

The physical parameters like water temperature, turbidity, transparency, total solids, total dissolved solids and total suspended solids were studied. During chemical investigation nine major chemical parameters namely pH (Hydrogen ion concentration), dissolved oxygen, free carbondioxide, hardness, chlorides, alkalinity, acidity and important plant nutrients like inorganic phosphates and nitrates were studied.

There was increase and decrease in water temperature which was related to summer and winter seasons, respectively, while studying the quality of Koshi river water at Purnia

(Pandey, et.al; 1993) similarly Shaikh et.al; (1997) also reported that, the water temperature was at its peak during summer and minimum during winter, while studying hydrobiology of Sina river at Ahmadnagar, Maharashtra. In the present study, surface water temperature was observed to be more or less uniform at all three stations. The fluctuations in surface water temperature were in the range of 20^0C to 29^0C. The increase in water temperature during summer months was observed, while during monsoon and winter, water temperature drops down considerably. This pattern of natural variations in the temperature influences the distribution of biota (Belli Belli, 2000).

In the present study, turbidity of natural water may be due to the suspended inorganic substances such as silt, clay or due to any planktonic organisms, but in river water turbidity is due to addition of industrial wastewater, agricultural runoff and sewage. It is important limiting factor in the primary productivity. Turbidity also depends upon the types of the bottom; if it is rocky with sand or gravel, then there will be low turbidity (Jhingran, 1983). In the present study, turbidity at all stations was influenced by addition of sewage. Comparatively higher turbidity was observed at station 'A' and station 'B' than the station 'C', it may be due to human activities around these sites. Turbidity was maximum (23 NTU) in May, 2000 at station 'A' followed by station 'B' (20 NTU) in January, 1999 and station 'C' (17 NTU) in August, 2000. Whereas it was minimum in November, 2000 at stations 'A' and 'B' but at station 'C' in September, 2000. Similarly Bisht and Kumar (1993) also reported the maximum turbidity during monsoon season, while studying the water quality and phytoplankton of Song river.

Turbidity and Transparency has shown negative correlation. In the present study transparency was less at station 'A' and 'B' than at station 'C'. At station 'A' and 'B' industrial wastewater and sewage was released in the river water hence transparency was less. At station 'C' maximum transparency was recorded which was due to less human activities and release of water through Warana river from time to time. Several investigators reported lower values of transparency in rainy season, whereas higher values were recorded during summer and winter seasons (Pandy, et.al; 1993). Similarly Joshi (1996) also reported the least transparency in July and August, when river influxed with floods, draining huge mount of debris, silt and sand, while studying hydrobiological profile of river Sutlej in its middle stretch in western Himalaya.

The amount of total solids is very high in the Cauvery river water due to paper mill effluent which can create an imbalance for aquatic life (Ganbuganapathi, et.al; 1998). In the present study, higher values of transparency were observed in winter and summer season and minimum in monsoon season. While comparing these values with ISI standards, it was observed that, these values are beyond permissible level. The maximum values were recorded at station 'A' and station 'B' whereas at station 'C' it was below the permissible level.

In the present study, total dissolved solids were higher at station 'A' and 'B' during winter and summer season, while lower values were observed during rainy season. Klein (1972) reported that, more serious effect can be suspected due to the large amount of dissolved solids, which may indirectly disturb the osmotic regulation; resulting in suffocation of aquatic life even in the presence of good amount of dissolved oxygen.

In the present study, the total suspended solids were maximum in winter season and minimum in the monsoon season, it may be due to increase in water level and dilution of organic matter during monsoon.

Hydrogen-ion concentration is considered as one of the important parameters in understanding the chemical condition of river water. Whose importance assumes much more significance under the circumstances of an aquatic habitat being polluted by the influx of untreated sewage. pH values were recorded from the water samples at three stations. The maximum pH (8.5) was recorded in the month of April at station 'A', Ellis (1937) and Klein (1973) have suggested that pH values between 6.7 to 8.4 are suitable, while the pH value below 5.0 and above 8.8 are detrimental to aquatic organisms. A comparatively uniform trend of pH values of river water is due to the continuous flow of water.

There was maximum pH in winter, less identical in summer and monsoon. The pH showed an alkaline range throughout the study, while working on hydrobiological studies of Sina river at Ahmednagar, Maharashtra (Shaikh, et.al; 1997). Similarly Joshi (1996) also reported that, pH values were always on the alkaline side ranging between 7.6 - 8.1 being lowest in the summer and monsoon months, when the river was swollen with floods during investigation on hydrobiological profile of river Sutlej in its middle stretch of western Himalayas.

Dissolved oxygen has an important role to play in an aquatic ecosystem and is the basic requirement of all living organisms. It directly affects survival and distribution of flora and fauna in an ecosystem. Diffusion of air and photosynthesis are two main sources of dissolved oxygen, while major factors responsible for its depletion are biochemical oxidation and respiration by flora and fauna. The quantity of dissolved oxygen in water is directly or indirectly dependent on water temperature, partial pressure of oxygen in the air, concentration of dissolved salts, amount of chlorophyll content etc. (Welch, 1952) and temperature and hydrogen ion concentration (Wetzel, 1975). The dissolved was highest during January (winter) and (monsoon). The increased dissolved might be due to photosynthesis, while i dissolved oxygen might be due to high which reduces the rate of photosynthesis (Pandey, et.al; 1993). Similar observations were made by Shaikh, et.al; (1997), while studying on hydrobiology of Sina river. Bisht and Kumar (1993) also reported that, the temperature is inversely proportional to dissolved oxygen. The maximum dissolved oxygen was recorded during winter season. In general, the oxygen concentration of water varies inversely with carbondioxide. Phillips (1927) reported a similar trend of relationship.

Present study reveals gradual increase in oxygen content from rainy season to winter season, while it gradually decrease during summer. The increased dissolved oxygen content during winter might be due to the increased rate of photosynthesis and decrease in water temperature, while in summer low concentration of dissolved oxygen might be due to increased water temperature and more addition of sewage in the river, which reduces the D.O. content.

Free carbondioxide acquires significant status in the aquatic ecosystem, because of its governance of photosynthesis activity and thereby biotic productivity. The amount of free carbondioxide depends on the decomposition of organic matter entered in river water, from sewage waste, decomposition of top soil and chemical nature of the river bottom. In the day time CO_2 is utilized by plants for photosynthesis. Hence in the early morning it will be maximum than that of the evening (Mann, 1958). The presence of free carbondioxide was not highest during the rainy season which might be due to entry of organic rich surface runoff into the river from the catchment area, which result in the increase of bacterial population (Pandey, et.al; 1993). Similarly, Sharan and Singh (1988) reported that the increased bacterial population caused depletion of oxygen and production of more free carbondioxide. Doriyal (1981), Joshi (1985) and Nautiyal (1985) also observed that, free carbondioxide was highest during summer and monsoon seasons.

During the period of investigation, water samples were collected in the morning hence interesting results were observed. Free carbondioxide values ranged from 8.8 mg/l to 39 mg/l. Maximum value was recorded at station 'A' and 'B', while minimum value at station 'C'. The maximum values of free carbondioxide was recorded at all stations (A, B, C) in February and minimum values were recorded at all stations (A, B, C) in July.

Hardness is another important parameter in the assessment of water quality. Hardness to water is imported by alkaline earth metal cations, mainly calcium and magnesium present in it. In aquatic ecosystem temporary hardness plays a key role in buffering capacity thus, neutralising an offset in pH due to addition of acidic products. This has great effect on biotic diversity of an ecosystem. Hardness of water also restricts water uses (Gaikwad, 1996).

In the present study, total hardness of water ranges from 60 mg/l to 480 mg/l $CaCO_3$. Maximum values were recorded at station 'A' (480 mg/l), station 'B' (350 mg/l) and station 'C' (242 mg/l) during winter season. High values of hardness in these months are due to the concentration of carbonates and bicarbonates through runoff from sewage water and industrial effluent mixed in the water. In the present study, it is clear that, at station 'A' and station 'B' hardness is high when compared to standard values (100 ppm) of WHO (1971) and values (200 ppm) of ministry of work and housing (1975). The water is not suitable for drinking and domestic use as well as agriculture. Similar observations were made by earlier workers (Shaikh, et.al; 1997) wherein total hardness was maximum in winter and minimum during summer and monsoon.

Natural water normally contains low chlorides than bicarbonates and sulfates. High content of chlorides in freshwater is an indication of organic pollution (Thrash, et.al; 1944). Though chlorides level as high as 200 to 250 mg/l is safe for human consumption, a level above this imparts salty test to the water. Chlorides content in natural water appears to be mainly due to sewage discharge and their principle sources are drained, rich in animal refuse. The highest value of chloride during summer and lower during winter was reported, while studying the physico-chemical quality of the river Koshi at Purnia (Pandey, et.al; 1993). The highest value of chloride during summer might be due to evaporation of water (Venkateswarlu, 1969; Mishra and Yadav 1978).

In the present study, the chloride content was maximum (175 mg/l) in the month of May, at station 'A' and 'B' (137.5 mg/l) and at station 'C' (86.6 mg/l) in April, 2000. Low values of chlorides was observed in July, it might be due to large volume of water. It clearly indicates that the river water has low value of chloride content.

While studying on hydrobiology of Sina river at Ahmednagar, Maharashtra, Shaikh, et.al; (1997) reported that, total alkalinity was maximum in winter and monsoon. The alkaline nature of Indian river water has been reported by few investigators as in the Moosi river by Venkateshwarlu (1986); Krishna river by Mitra (1982). Prasad, et.al; (1980) reported that, the concentration of anion is one of the factors to determine the alkaline nature of water. The effect of alkalinity on river water is responsible for increased algal productivity, reported during study on effect of paper mill effluent on Cauvery river (Ganbuganapathi, 1998). The direct relationship between alkalinity and pH was reported by Lauft (1953), George (1961), Verma (1967) and Khan et.al; (1970). The greater volume of water in the river was found to influence the alkalinity values, with a sharp decrease during the summer and monsoon months when water level in the river was high due to snow melts and floods (Joshi, 1996).

Total alkalinity in the present observation was ranged from 80 mg/l to 400 mg/l. Maximum value of alkalinity (400 mg/l) was observed at station 'A' and at station 'C' (200 mg/l) in January. The minimum values were recorded (120 mg/l, 80 mg/l and 90 mg/l) in the month of September 2000 at respective stations. The alkalinity values accounted for the bicarbonates only during the lean period at low water level in winter months, which has close relationship with the richness of salts like Ca and Mg due to their solubility at low temperature.

Acidity in the present observation was ranged from 15 mg/l to 255 mg/l. Maximum values of acidity (255 mg/l, 230 mg/l and 175 mg/l) was observed in May at A, B and C stations and minimum values (35 mg/l, 20 mg/l and 15 mg/l) were observed in August 2000 at respective stations.

Plant nutrients like phosphates and nitrates determine the establishment of food chain and productivity. The two major nutrients phosphate phosphorus and nitrate nitrogen were estimated during the present study, from water samples at three stations. Phosphate-phosphorus was observed to exhibit the peaks during monsoon and summer for water samples. During summer and monsoon, increase in the values of these variables is directly related to their flushing from the catchment with the rainwater. During summer the water level of the river was low. The Phosphate (PO_4) in natural waters occur in very small quantities. In an aquatic ecosystem phosphorus occurs as both, in inorganic and organic forms. The inorganic phosphorus play an important role as a nutrient along with nitrates. In Krishna river phosphate phosphorus content was recorded during present study maximum values of phosphates at station 'A' (494 ± 13.63 μg/l), station 'B' (294 ± 42.80 μg/l), station 'C' (304 ± 11.14 μg/l) were observed in July. while minimum (20 ± 2.62 mg/l, 11 ± 1.7 μg/l and 24 ± 2.6 mg/l) were observed at respective stations in the month of May. The phosphate content more than 2 mg/l in open water gives a sign of organic pollution (Pomeroy, et.al; 1965). The reason for high phosphate during monsoon might be due to influence of rainwater containing fertilizers from the fields, which brings phosphate from catchment (Pandey, et.al; 1993).

In the present study, nitrogen occuring in the freshwater is in the form of an element or nitrogenous compound. Nitrogen is mostly derived from atmosphere and denitrifying bacteria giving nitrates and ammonia. It may be derived from outside source like rain, surface runoff, sewage, agricultural runoff etc. Nitrate-nitrogen values fluctuates between 66.6 ± 16.43 μg/l. to 974 ± 31.04 μg/l. Maximum values of nitrate at station 'A' (941 ± 42.12 μg/l), station 'B' (974 ± 31.04 μg/l) and station 'C' (766 ± 19.68 μg/l) was recorded in May. The minimum values (112 ± 5.37 mg/l, 101 ± 35.82 mg/l and 66.6 ± 16.43 mg/l) were in the month of September at respective stations.

Generally concentration of the nutrients like nitrates and phosphates were quite low in the river water with an average values of 0.114 ppm and 0.007 ppm respectively. However, they increased considerably in July, during summer, monsoon and in April with the incursion of the snow melt (Joshi, 1996). The increase in the values of these variables is directly related to their flushing from the catchment with the rain water during monsoon months and due to snow melt during spring months. These findings lend support of the studies of Hutchinson (1941), Voiget (1960) and Ray, et. al; (1967) who observed that, besides rain washing, the rain water itself appears to contribute substantially towards the supply of nitrates in the aquatic systems. Coinciding the studies of Taylor (1948) a direct relationship between nitrates and phosphates was also observed. Since the water level of the river was low during winter months, the concentrations of these variables were considerably high (Joshi, 1996) while studying hydrobiological profile of river Sutlej in its middle stretch in western Himalayas.

The bioaccumulation of metals varies from metal to metal and differs among various organisms. Some of the metals are bioaccumulated through the food chain, so that predators have highest concentrations, but the highest concentrations of metals appear to occur in the invertebrates (Vernberg and Vernberg, 1974).

Trace metal analysis of textile mill effluents, sediments and water of river Khan and Kshipra showed high concentration of Fe, Zn, Pb, Cd and Hg in sediments, effluents, and lower values in water. The concentration of trace metals were found in the following order. Effluents : Fe > Zn > Cu > Cr > Cd > Pb > Hg, sediments :

Fe > Zn > Cu > Cr > Pb > Cd > Hg, water : Fe > Zn > Cu > Cr > Pb > Cd > Hg. Higher concentrations were usually obtained in the upstream regions. Pure textile dyes are the major source of all these metals.

The heavy metal concentrations in sediments were very high with Fe ranging from 1483 to 72656 mg Kg^{-1}. The concentration ranges of other metals at various sampling sites were : Zn-12 to 1475 mg Kg^{-1}, Cu - 15 to 100 mg Kg^{-1}, Cr - 1.25 to 281 mg Kg^{-1}, Cd- 0.0 to 2.6 mg Kg^{-1}, Pb - 1.25 to 110 mg Kg^{-1} and Hg 2.5 to 5.4 mg kg^{-1}. These concentrations were generally low during July (Ganasan, 1991).

High concentration of trace metals in the sediments shows that, the sediments are an important reservoir of these contaminants in the riverine system. The role of sediments in adsorption of cations has been demonstrated in a number of studies on rivers (Mani, et.al; 1989, Ayyavoo, 1989, Mariarty and Hanson, 1989, Kurian and Banerjee, 1989) and lake (Nriagu, et. al; 1981) sediments. The high organic matter content, sulphides and alkalinity also contributed to the high adsorption rate in the sediments.

The zinc concentrations in sediments were very high at station A (Sangli) in winter (January,2000) 71 ppm, in summer (May, 2000) 64.5 ppm while in monsoon (July, 2000) 36.5 ppm. At station B (Haripur) in winter season (January, 2000) it was 74 ppm, in summer (May) 54.1 ppm, while in monsoon season (July) 39.9 ppm.

At station C (Ankali) in winter season (January) the concentration was 53 ppm, in summer (May) 59.2 ppm, while in monsoon season (July) 35.9 ppm. The concentration of other metals at various sampling sites were : Nickel in winter, summer and monsoon season at station 'A' 0.002, 0.0028 and 0.0014 ppm; at station 'B' 0.0001, 0.0012 and 0.0014 ppm; while at station 'C' Nil, 0.0002 and 0.00022 ppm respectively. Lead in winter, summer and monsoon seasons at station 'A' was 0.00082, 0.00082 and 0.00040 ppm; at station 'B' 0.0042, 0.00042 and 0.00044 ppm; while at station 'C' Nil, 0.00011 and 0.00009 ppm respectively, whereas aluminium in winter, summer and monsoon seasons at station 'A' was 0.082, 0.081 and 0.061 ppm; at station 'B' 0.042, 0.066 and 0.066 ppm; while at station 'C' 0.051, 0.058 and 0.058 ppm respectively. The values of nickel, lead and aluminium as compared with ISI standard are below permissible level.

Heavy metal pollution in three rivers of Andhra Pradesh, viz Moosi, Godavari and Tungabhadra has been investigated, taking into consideration some important metals and algal flora present in these environments. In general, metal concentrations were higher in the river, Tungabhadra except iron which was more in the river Godavari (Venkateswarlu et.al; 1994).

Among the heavy metals analysed Fe, Zn, Pb and Mn are very common and present in considerable concentration in both organically and industrially polluted river waters. The yearly averages have revealed that the concentrations of a number of elements are less than 0.1 mg/l, except Fe, Zn and Cu which are between 0.01 and 0.05 mg/l. This clearly suggests that, the metal concentrations are well within the standard stipulated by a number of agencies. Perhaps, this could be due to the alkaline nature of the river waters with high concentrations of bicarbonates, total hardness, calcium and magnesium. pH influences the toxicity of heavy metals in various ways. It may cause the complexing of metals to the organic constituents of the medium (Babich and Stotzky, 1980).

Concentration of Zn at different stations varied between 1 μg/l and 39 μg/l. At station 1 the concentration of zinc gradually decreases from 33.4 μg/l (Feb.) to 7.9 μg/l (May) and then increase reaching a maximum of 24.5 μg/l in the month of July. Lower concentrations (3.9 and 2.9 μg/l) are recorded during August-September followed by high concentrations (14.5 μg/l and 14.8 μg/l) during December-January. Surface depletion of dissolved zinc during August-October may be due to uptake of zinc by organisms (Syama Sunder, et.al; 1994). The seasonal variation of zinc is similar to that of silicates in the same period of observations in Krishna river (Srinivasa Murti, 1989). It is probable that diatoms may play an important role in its biochemical cycling. At station 3 considerably high concentrations are recorded throughout the years which may be due to excessive input, but the distributional trend at station 2 and 3 are similar than station 1. The variation of zinc at station 4 showed that relatively low concentrations exist suggesting the transportation of zinc to the particulate form as reported by Carpenter, et.al; (1975). Further, it is reported that the complexation of zinc in estuarine environment has pointed to the importance of organic substances (Muller and Kester, 1990).

In the present study, the concentration of zinc at different station gradually decreases during different seasons. At station 'A' 71 ppm, in winter (January) 64.5 ppm, in summer (May) and 36.5 ppm in monsoon; at station 'B' 74 ppm in winter, 54.1 ppm in summer and 39.9 ppm in monsoon; while at station 'C' 53 ppm in winter, 59 ppm in summer and 35.9 ppm in monsoon was observed.

In the present study almost low values were recorded in all three seasons. It might be due to less concentration of nickel in the industrial as well as domestic sewage water. These values of nickel were below the permissible level.

Low values of nickel were recorded throughout the year at all the stations. The results shows that at station 1 (1.2 μg/ l) concentration was observed in July and almost non-detectable range is noticed in post-monsoon season except in January (1.09 μg/l). On the whole 2 peaks, one in July and other in January are recorded with considerable depletion during October-December (Syama Sunder, et.al; 1994). This typical behaviour of nickel coinciding with the distribution of silicate reflects its involvement in the biological cycles (Srinivasa Murti, 1989).

The low concentrations of nickel present in the dissolved form may be due to limestone environment as reported elsewhere (Turekian, 1970) which was further lowered because of its involvement in the biogeochemical cycles and also due to adsorption on to the iron and zinc hydroxides as suggested by Jenne (1968, 1977). Our study showed that, lowest values were recorded in winter and summer seasons. Slight higher values were recorded in monsoon, it might be due to industrial wastes, electroplating waste, batteries and paint waste water carried by rain water. It may be due to lack of nickel deposits occur as sulphides or as oxides (Laterites) in these area.

Lead has been widely used industrially, in food and beverage processing and in medicine. Lead poisoning is a well known hazard in our society. Lead and its compounds may enter and contaminated the global environment at any stage during mining, smelting, processing and use. The single source of lead in air is from vehicle exhaust, municipal waste incinerators and acid battery manufacture and lead bearing paints and plaster. Most of lead poisoning occurs by the oral route (Kataria, 1994). Concentration of dissolved lead shows the maximum value of 5 $\mu g/l$ at Vijayawada in the month of December. The high concentrations found are unlikely to have been caused by sample handling as there was no evidence of gross concentration (Syama Sundar, 1994). It is revealed that, the distribution of lead at all stations is irregular and it may be attributed to the atmospheric inputs at different stations (De, 1989). In the present study concentration of lead shows the maximum value (0.00082 ppm) at station 'A' and 'B' in winter and summer seasons.

A comparison of trace metal concentrations is made with the reported average values of global river water (Burton and Liss, 1974; Martin and Meybeck, 1970) and theoretical values in Godavari river water (Satyanarayana, et.al; 1991). The levels of these trace metals in Krishna river are within the limits of average global river water concentrations taking into account different processes that affect the trace metals and their pathways through river and esturine environment (Syama Sundar, et.al; 1994).

The concentrations of heavy metals in Betwa river was observed in silt sediments, points of industrial confluence and sewage disposal, respectively (Kataria, 1994). The results were observed as Cu varied from 1.2 to 17.3, 0.078 to 2.92, 0.041 to 3.2 mg/l, Zn ranged from 11.4 to 18.2, 0.80 to 3.10, 0.02 to 2.8 mg/l, Pb varied from 1.6 to 15.2, 0.006 to 6.3; 0.007 to 1.30 mg/l, Cd present below the detection limit and not found on observations in some sampling stations and varied from 1.0 to 5.8, 0.01 to 0.06, 0.01 to 0.02 mg/l. Mn observed and ranged from 0.8 to 1.2, 0.04 to 0.50, 0.66 t 0.082 ppm at consecutive points.

The discharge of effluents containing heavy metals into the river may be the reason for higher concentration of metals. In sewage sludge heavy metals may be bound to small particles consisting mostly of organic matter. The destructive and harmful effects of heavy metal pollution is substantiated species of diversity and low abundance of fauna and flora. The toxicity of heavy metals in the study of aquatic fauna and flora increase with pH lowering due to accumulation of untreated sewage, that is sources of heavy metals to aquatic ecosystem. The alarming sign of heavy metal contamination in river water was observed. Even at infinite low levels, heavy metals get adsorbed in the bottom sediments affecting benthos, and hence they are regarded as potential pollutants in aquatic ecosystems. Environmental persistence, having toxicity at low concentrations and their ability to incorporate in food chain. Biological transfer of heavy metals through food chain is of significant interest since these are more concentrated within the tissue. Tissue levels of heavy metals may often relate to longevity and growth rate of the organisms rather than its position in food web.

The concentration of trace metals, namely Zn, Pb, Cd, Sb, Cu, Co, Fe and Ni in the water of river Beas have been studied for 470 Km. stretch from Manali to Pongdam alongwith physico-chemical parameters, like pH, conductance, dissolved oxygen (DO), chlorides, sulphate, nitrate, total hardness, alkalinity, TDS and TSS. The heavy metal manganese and iron fairly exceeding permissible limits of drinking standards. It is interesting to note that DO was declined to 5.53 ppm at Pongdam (Singh, et.al; 1996). The presence of heavy metals like Zn, Pb, Mn, Cd, Sb, Cu, Co, Fe and Ni in the upstream of Manali has been question in concern. These heavy metals further increase in the downstream of Kullu. The concentration of these heavy metals were further reduced at D/S of Largi river, at this point river receives a tributary of Beas which diluted river to a great extent.

The values of metals reflecting discharge from Pandoh-Nadaun drains the drable land of Suket and Kangra valleys with maximum agricultural activities. The higher contamination of trace metals have been found D/S of Mandi may be due to untreated or partial treated sewage or domestic waste discharge into the river. The main sources of these heavy metals in the Beas river may be agricultural activities runoff in the Beas valley and geology of the mountaneous region revealed occurence of minerals in the Himalaya. Agriculturist of this area are being used plant protection material (Insecticides) which are zinc phosphate, copper oxichloride, carbonate component of zinc. organochlorines (BHC) and aldrin. Heavy metals Fe and Mn are exceeding permissible limits of drinking water standard at certain places, indicating environmental deterioration in the river to be polluted in respect of certain heavy metals (Singh, et.al; 1996).

In the present study, pollution is mainly due to receiving a heavy load of untreated sewage from Sangli city, industrial effluent from Madhavnagar area through Sherinalla, from automobile workshop, electroplating units, agriculture runoff, laboratories and hospitals through Haripurnalla entering into river Krishna at sampling station 'A'.

Dissolved trace metals exhibited different behaviours with constant or increasing concentrations upstream, especially in the Cobb valley. Low concentration found in upper Takaka river suggest that, limestone, weathering makes a minor contribution to concentrations of trace metals. The Cobb river exhibited much higher concentrations implying that, the differing compositions of rock types and soils within the separate catchments exercise important control on trace metals (Kim and Hunter, 1997). The concentrations of Zn, Cu, Ni, Cd, Cr, Pb, Mn and Fe is found to be present in higher concentration as compared with WHO standard for drinking waters (Agrawal and Gopal,. 1996). In the present study the concentration of Zn, Ni, Pb and Al is found to be lower except Zn.

Levels of the heavy metals were highest during the summer season. Results also shows that, all metals existed below the maximum allowable limit recommended by ISI and WHO (Devi Smriti and Tiwari, 1997). In the present study, maximum values of heavy metals was recorded in winter season, but the concentration of zinc was very high and concentration of other metals such as Ni, Pb and Al were below permissible level. Heavy metals are known to adversely affect the aquatic environment, hence Zn, As and Cr in the polluted water and sediments in rivers Ganga (Kanpur to Varanasi), Yamuna (Allahabad), Ramganga (Moradabad to Bareilly) and Gomati (Kooraghat to Jaunpur) have been studied. It is revealed that, the pollutional load of river Ganga and Gomati were maximum in respect of zinc, arsenic and chromium (Singh and Mahaver, 1997). Present study showed heavy pollutional load in river Krishna at station A and B during winter, summer and monsoon seasons. The concentration of Zn at all stations was very high as compared with WHO standard for drinking waters.

Jhingran and Joshi (1987) reported slightly less zinc and chromium in filtered water in Yamuna as compared to present observation in Ganga and its tributaries. However, their concentration was quite low in Ganga and its tributaries as compared to river Tungabhadra (Joseph,1989). High concentration of zinc was observed by Saikia, et.al. (1988) in Ganga.

Aston, et.al; (1974) emphasised the disadvantage of metals in water as a reliable indicators of pollution. Discharge of effluent from city sewage, textile waste, industrial waste, distillery waste and sugar and rubber factory wastes are mainly responsible for contamination of river Ganga and its tributaries. Pollution load is mostly associated with the type of effluents released at various sampling stations. In general, zinc and arsenic were maximum at station 12 and 13 on river Gomti (Lucknow) closely followed by station 6 on river Ganga (Varanasi). But, chromium was highest at station 4 in river Ganga (Allahabad). Concentration of metal was high in June, 1994 as compared to December, 1993. Concentration of metallic elements (Iron, Lead, Manganese, Aluminium, Zinc, Copper) in Kerwan dam water flow was studied for a period of six months between January to June, 1997. Among these metallic elements iron and lead were found more than permissible level. The probability of presence of these elements is expressed due to geological data, decay and deposition of vegetation in and around the area. The biggest source of atmospheric pollution is due to vehicle exhaust, acid battery manufacturing industries, lead bearing paints and municipal wastes (Shrivastava and Jain, 1998).

Joseph (1989) reported high values of zinc (74-324 ppm) and chromium (1.3 - 15.9 ppm) in sediments of river Tungabhadra. Its values were quite low in all the rivers and chromium was high at station 4. It may be due to high chromium contents in the effluents of industrial waste of Naini, Allahabad. In general, metals were higher in sediments as compared to waters of all the rivers.

In the present study high concentration of Zn was observed in sediments at three stations in winter, summer and monsoon seasons, it may be due to high zinc contents in the domestic sewage and industrial effluent, whereas in water sample from these stations there was no trace of any metal.

The concentration of total metals in the surface sediments (0-50 mm). The highest concentration of zinc, lead, chromium, copper and nickel were observed in sediments near major input source in Corio Bay and Hobsons Bay, and also in shoreline samples in the eastern bay near inputs from both Patterson river and Kananook creek. It was only at these sites that concentrations exceeded sediment guideline values (Long, et. al; 1995) for these contaminants. Mercury concentrations were highest in Hobsons Bay at near 0.5 $\mu g\ g^{-1}$. In the present study, concentration of heavy metals, such as Zn, Ni, Pb and Al in sediment samples of three different stations were varied in quantity. The concentration of zinc was maximum at all three stations during winter (January), summer (May) and monsoon (July, 2000). Concentration of other metals were below ISI standard (1983).

The accumulation of heavy metals in the river sediments due to discharge of industrial effluents and sewage has serious implications for the biota and human beings. Depending upon a number of factors, the trace metals may remain immobilised or become available for uptake of biota and then accumulate through the food chain. The heavy metals uptake of biota and their tissue concentration as well as the metabolic effects of different trace metals. Finally, critical analysis of both chemical and biological (physiological) characteristics indicate that, at present the impact of the metals may not be serious but in future their concentrations may increase due to continuous entry of effluents from industries and bring drastic changes in river water quality and biological spectrum. The continuous monitoring of these environments is essential for checking the levels of various metals entering through different types of effluents/ pollutants.

Toxicity and Bioaccumulation :

All heavy metals, when present in excessive quantities have been found to be toxic for animal life. In fact, the toxicity of all the essential trace elements follow the following general trend, under supply leads to deficiency and over supply leads to toxicity and even eventual death to the organisms. The adverse effects of heavy metal toxicity in biological system may result from the following reasons :

a. interaction of the metal with protein leading to denaturation.
b. interaction with DNA leading to mutation
c. effect on cell membranes
d. effect on regulatory enzymes
e. retardation of growth
f. decrease in longevity
g. detrimental changes in reproductive cycle leading to mortality of the offsprings.

Higher levels of even the essential metals may leads to toxicity. The toxicity due to the metals and their compounds is mainly determined by the delivery of the metals to the cell to attain a critical concentration level at the site of action and the cellular biochemical defence mechanisms. The toxicity of a metal is mainly determined by its solubility, stability, physical form at the site of its action, biological reactivity and the presence or otherwise of a homeostatic mechanism. Among the metals Cr, Ni and Cd are potentially carcinogenic and Cd, Cu, Pb, Hg, Mo, Ni and Se in excessive amounts are found to be potentially teratogenic (i.e. embryotoxic, including anatomical birth defects) (Dara, 1995).

Lead has numerous commercial applications due to its physical properties and relative chemical inertness. Unfortunately, lead is highly toxic in inorganic or organic compounds. All heavy metal pollutants affect the aquatic organism but Hg, Cd, Cu and Pb are more toxic (Wisely and Blic, 1967, Portmann, 1972).

Lead is considered as a general protoplasmic poison which is cumulative, slow-acting and subtle. The major biochemical effect of lead (Pb) is its interference with heme synthesis and leading to hematological damage. Lead inhibits several important enzymes involved in the overall process of heme synthesis. Higher levels of Pb in the blood can cause kidney dysfunction, it is toxic to the central and peripheral nervous system (Dara, 1995).

Many toxic effects attributed to zinc may have been due to other associating metals such as Cd, Pb, Sb and As. Zinc is less toxic to fishes as compared to Hg, Cd, Cr and As. They accumulate zinc in gills, gut, hepatopancreas, gonads etc. Nickel is toxic at higher concentrations. Nickel is found to be toxic for most plants and fungi. Growth of woody plants was hindered by high nickel concentrations in the soil. Nickel is believed to inhibit various enzymes such as cytochrome oxidase, isocitrate dehydrogenase and malic dehydrogenase. Nickel dusts are reported to be carcinogenic.

Aluminium is more soluble in aquatic ecosystem and hence, potentially more toxic to aquatic biota at acidic pH. It is widely accepted that Al was a major factor affecting the success of aquatic organisms and communities in acidic habitats. The respiratory effects of Al in fishes were noticed. Al is a gill toxicant to adult fish causing both ionoregulatory and respiratory effects, depending on water pH and on Al concentration (Gensemer, 1999).

Heavy metals can be burried in land fills or washed into sediments. After getting entry into aquatic bodies,. These metals may precipitate or adsorb on solid surfaces, remain soluble or suspended in water or may be taken up by fauna and flora (Leland, 1977; Oehme, 1978; Reimers, et.al; 1975). Heavy metals are non-degradable unlike many organic pollutants and subsequently endanger human and animal health (Vallee and Ulmer, 1972).

Heavy metals have a significant biological role in metallo-enzymes and are required as trace elements by all living organisms (Wood, et.al; 1975). However, they proved to be hazardous even when the concentration of these metals is slightly increased above the trace quantity needed for nutritional requirement and physiological interactions. Mercurial compounds and combination of heavy metals have been found to be very toxic to phytoplankton and inhibited their growth (Nuzzi, 1972) and primary productivity of phytoplankton (Jayaraj and Deshpande, 1987) respectively, even at very low concentration.

The heavy metal concentrations in zooplankton also varied seasonally with Cu (150 $\mu g\ g^{-1}$), Zn (27.00 $\mu g\ g^{-1}$) and concentration being high during the premonsoon, and Hg (3068.0 $\mu g\ g^{-1}$) during the monsoon and low during the premonsoon seasons. The concentration of Cd (19.5 $\mu g\ g^{-1}$) in zooplankton was higher during the premonsoon season. A strong and significant positive correlation between the metal concentration in water and zooplankton (for Cd, $r = 0.972$; and for Zn $r = 0.857$; $p < 0.0001$) was observed (Govindswamy, et.al; 1998).

Experiments conducted on the uptake and depuration of Cd and Zn in selected tissues of the fresh water prawn *Macrobrachium malcolmsonii* showed that, in all tissues a dose and time dependent uptake of Cd was noted. However, prawn regulated tissue concentrations of Zn upto threshold level of dissolved metal exposure. The rate and level of depuration varied for the two metals. As and Cd concentrations found in the tissue reflect the external concentrations, these prawns may consider ideal tools for monitoring environmental Cd levels (Vijayaraman, et.al; 1999).

Five commercially important fishes of Saudi Arabia from Jizan Red coast have been analysed during July, 1991 for certain heavy metals (Cu, Hg, Cd, Cr, Pb and Zn) in different organs of fish tissues, viz. liver, kidney, gut, gills and muscle. All the heavy metals analyzed were found to be accumulated more in liver and kidney. Least concentrations of different metals were found in muscle tissue (Al-Mohanna, 1994). Lowe, et.al; (1985) found varying concentrations of copper ranging from 0.76 to 19.76 mg/g in fish from various parts of the U.S.A. El-Faer et.al; (1992) observed 0.0004 mg/ 100 g to 0.48 mg/100 g in different fishes collected from Arabian Gulf region.

The mean concentrations of zinc for fish from the upper Benue river were in the range of 34.2 ± 6.2 to 40.4 ± 7.2 mg/kg, the highest value being in the trunk fish, *Mormyrus macrophthalmus* (Eromosele et.al; 1995). Zinc concentrations are relatively high when compared with the mean concentrations for fish from parts of England and Wales which were not greater than 6.28 mg/kg wet weight (Portmann, 1972) and from the Niger Delta area of Nigeria in the range of 1.03 to 17.85 mg/kg, wet weight (Kakulu, et.al; 1978). In particular, *Gobius niger* and *Sargus annularis* had level of zinc upto 58 ± 2.0 and 70 ±2.5 mg/ kg dry weight respectively. For fish from the upper Benue river, species variation in zinc concentrations was not apparent and the highest mean concentration of 40.4 ± 7.2 mg/kg was slightly below the Food Standards Committee (FSC) general limit of 50 mg/kg for zinc in foods (Egan, et.al; 1981).

The mean concentrations of calcium for fish from the two lakes are within the same range, the highest value being 63.8 ± 5.7 mg/kg. Similarly, the mean concentrations of zinc for fish from the lakes are comparable but appear to be lower values in all the tissues of three species of bivalve molluscs from Krishna river in present study. The highest mean concentration of zinc was 48.7 ± 19.9 mg/kg in catfish from lake Njuwa. The mean concentration of iron and copper in fish from the lake are not greater than 2.4 ±2.0 and 0.3 ± 0.4 mg/kg respectively, and are comparable to the corresponding value for the Benue river. The lead levels were in the range of 14 ± 7.3 to 49.7 ± 29.6 mg/ kg, the upper concentration value being for *Citharinus citharus* from lake Njuwa. This was considerably very low concentration of zinc in all seasons as observed from Krishna river. Of particular note are the levels of lead in *Tilapia zilli* from lakes Geriyo and Njuwa, which are less values of Pb in all the tissues of 3 species of bivalve molluscs from Krishna river was observed. The levels of lead in the lake fish may have been accentuated by the immobility of water in the latter, resulting in the higher concentration of metals in solution and in the sediments (Eromosele, et.al; 1995).

After 30 days of exposure, the concentrations of mercury recorded in gill were 2.96, 3.01 and 3.58 ppm; in hepatopancreas, 2.61, 2.86 and 3.14 ppm and in muscle 0.39, 0.40 and 43 ppm, respectively, in the three exposure concentrations. Cadmium concentration recorded were 134.5, 158.8 and 173.9 ppm in the hepatopancreas, 133.6, 146.8 and 168.9 ppm in the gill and 11.5, 12 and 12.5 ppm in muscle, respectively. Zn concentrations recorded were 540.6, 551.2 and 558 ppm in the hepatopancreas, 148.4, 490.8 and 510.6 ppm in the gill and 53.3, 54.2 and 54.4 ppm in the muscle respectively (Narayanan, et.al; 1999). In the present study, the maximum concentration of zinc in winter, summer and monsoon seasons recorded in tissues of *Lamellidens corrianus.* Maximum values were 0.65 ppm, 0.76 ppm and 0.875 ppm in gills, while minimum values were 0.09 ppm, 0.13 ppm and 0.171 ppm in foot respectively. In *Lamellidens marginalis* maximum value of Zn were 0.60 ppm, 0.525 ppm and 0.455 ppm in gills while minimum values were of Zn 0.08 ppm, 0.048 ppm and 0.17 ppm in hepatopancreas respectively. In *Indonaia caeruleus* maximum value of Zn 0.67 ppm, 0.68 ppm and 0.700 ppm while minimum values were 0.12 ppm, 0.127 ppm and 0.135 ppm in gonads respectively.

Concentrations of Cd, Ni, and Pb in the sediments, and in the different body tissues of a snail, *Brotia costula* (Gastropoda : Thiaridae), a mussel, *Lamellidens marginalis* (Bivalvia : Unionidae) and two species of shrimps, *Macrobrachium lamarrei* and *M. dayanum* (Decapoda : Palaemonidae) collected from four fresh water ecosystems in Barak valley Assam, India were studied comparatively. Among the soft tissues, the digestive gland in *Brotia costula*; gill in *Lamellidens marginalis* and hepatopancreas in *Macrobrachium lamarrei* and *M. dayanum* appear to be important sites for metals accumulation (except cadmium in the latter) .

Among the four taxa, *Lamellidens marginalis* accumulated maximum Ni and Pb (Gupta, 1998). The hepatopancreas in decapod crustaceans has shown to be involved in the storage and excretion of excess metals (Alikhan, et.al; 1990), Bardeggia and Alikhan, 1991, Mwangi and Alikhan, 1993); whereas these deposited in phosphatic granules in the digestive gland of molluscs (Mason and Nott, 1981). In the present study, maximum concentration of Ni, Pb and Al was recorded in gonads, while minimum concentration of these metals were recorded in siphon in winter, summer and monsoon seasons.

The gills of *Lamellidens marginalis* to be instrumental in accumulation and possible sequestration of excess Cd, Ni and Pb. The gill in bivalves is a very important organ, as it is not only involved in exchange of gases, but also in the capture of food particles by entangling them in mucous and directing them via the labial palps to the mouth. Similar importance of gills in metal bioaccumulation has also been shown in the shrimp, *M. lamarrei* where they incorporate metals through chelation by mucous or surface adsorption; or both (Murti and Shukla, 1984).

Regulatory ability could exist for Cd, Ni and Pb as well. Furthermore, the phenomenon of moulting in crustaceans presents an additional problem as some of the metal lost in cast moults could be derived originally from the soft tissues (Phillips, 1980). In contrast, the *Lamelliadens marginalis* accumulate Ni and Pb to high concentrations inspite of the low ambient concentrations of these metals in their environment. Hence the potential use of *Lamelliadens marginalis* in biological monitoring of trace metals ought to the explored in more detail. This finding is in accordance with the fact that bivalve molluscs have been extensively used as indicators of trace elements in marine and estuarine environments (Phillips, 1980, Ritz, et.al; 1982).

Mitra and Choudhury (1993) investigated trace metal contents in a gastropods, *Nerita articulata*; in a bivalve, *Balanus balanoides* (Mitra, et. al; 1995) and *Senthilnathan* and Balasubramanian (1997) in Prawn, *Penaeus indicus*. As copper is present in haemocyanin pigment of crustacean, so this may be the reason for the high concentration of copper (7.0 to 3.10 μg/ g dw) in prawns. The high concentration of Zn and Fe in biota reflect either a physiological need for Zn and Fe or the ability of these invertebrates to concentrate higher level of metals.

Heavy metal concentration in soft tissues of oyster, *Crassostrea cuculata* showed that zinc was higher than other metal analysed. Gill and mantle exhibited higher concentration of metals than the aductor muscles. Concentration of all metals enhanced in all the body parts during the monsoon months (Mitra and Choudhury, 1994).

Concentrations of Zn, Cu, Mn, Fe, Cd and Pb were measured in the soft tissues and shells of snails *Lymnaea* (Radix) *peregra* and *Lymnaea stagnalis* occuring in Liwiec and Muchawka rivers in waters of different purity. It has been shown that, an inflow of sewage treatment plant water to the river Liwiec caused an increase of metal concentration both, in soft tissues and shells of the two snail species. Snails occuring in environment with a higher inflow of metals had a low share of soft tissue in their bodies when compared to those inhabiting unpolluted environment. Out of the two snail species studied *L. peregra* accumulated higher concentrations of metals than *L. stagnalis* (Krolak Elzbieta, 1998).

In response to metal pollution many aquatic animals including freshwater mussels produce metal binding metallothionein proteins that appear to function in detoxification (Roesijadi, 1992; Couillard, et.al; 1993; Mason and Jenkins, 1995). Sulfur rich metallothionein-like granules (s-granules) containing high concentration of Cu, Pb and Zn are patchily distributed in the mantle of *Hydridella depressa* (Vesk and Byrne, 1999).

The bivalve tissues like mantle gills, foot, siphon, hepatopancreas and gonads of *Lamellidens corrianus, L. marginalis* and *Indonaia caeruleus* showed typical pattern of accumulation. Concentration of zinc was maximum in gills, while minimum in foot in different seasons. Similarly concentration of nickel, lead and aluminium was maximum in gonads whereas, it was minimum in siphon in different seasons in all the bivalve species studied.