SUMMARY
AND
CONCLUSIONS

Since the time of human civilization, man settled near and around natural water bodies. The rivers proved more useful and helpful to the human settlements. In the first place, they provided the source of drinking water. Secondly, they made the transport easy and thirdly, they accepted large amount of unwanted waste and took them away from the point of input. Perhaps, the third use of rivers was the most important from the point of view of settlements. This distinguished rivers from the closed water bodies like lakes. It was quite obvious in the subsequent eras that the rivers became prime means of waste clearance. And now-a-days, rivers and estuaries are thought as the places of waste disposal throughout the world, with increasing environmental awareness among scientists as well as public. It has been realised that the estuaries are heavily loaded with organic and inorganic wastes. With the advance in science and technology more industries have cropped up. The industrial effluents (wastes) pollute the estuaries to a great extent. Eventhough the estuarine water is not a potable, the consequences of pollution are seen in the food chains. The results are epidemics like 'Ninamata' and 'Itai-itai' in Japan. There are few studies on the effect of water pollution on mangroves and estuarine ecosystem. Secondly, the pollution status of each estuary in India ingeneral, and in Maharashtra, in particular is not known. In the earlier studies from our laboratory, heavy metal pollution

was suspected in estuarine water and therefore, the present study is undertaken.

The study area is Bhatye estuary which is located towards the south boundary of Ratnagiri city, a district place. Six sites (BP, BS, BR, KR, JV and NM) are chosen, distributed along both the banks. In addition, seawater (site SW) from south bank was also collected. Out of these seven sites, five have the mangrove vegetation. Water, soil and plant samples were collected from the study sites during 1987-88. The water is subjected to analysis of temperature, pH, EC, chlorides salinity, heavy metals and zinc. The soil is subjected to analysis of pH, EC, chlorides and salinity. Plants are analysed for moisture percentage, EC, TAN, chlorophylls, polyphenols, proline, heavy metals and zinc. Further, the primary productivity of estuarine water is also studied. The standard routine methods of analysis are used.

The results of study are presented in 25 tables and 12 figures. Photographic plates are used to document plant species and the mangrove vegetation.

i) Temperature

The range of temperature for water and air is from 26 to 36^{o}C and 26 to 35^{o}C respectively. The range of temperature by earlier workers (Laxmanan et. al., 1982; Kadam & Bhosale, 1986; Kadam, 1987) is nearly the same as noted in the present study. The change in temperature occurs due to the season as well as incoming freshwater.

ii) pH

The pH values range from 5.57 to 9.39 for water and from 6.32 to 8.35 for soil. A very acidic and a very basic pH extremes recorded in the present study for estuarine water, are thought because of human activities and disturbances caused to estuarine ecosystem. In case of soil, basic pH is more frequent towards the mouth of the estuary. It may be due to the mixing of sea water and flooding of the soils.

iii) Electrical Conductivity

The range of EC is from 2.25 to 103.4 mS/cm for water and 0.89 to 18.5 mS/cm for soil. The present values for EC are higher than the earlier reported by Sah et. al. (1986) and Blasco (1975). The EC of soil is not parallel with salinity although EC is usually correlated with salt content of the solution.

iv) Chlorides and Salinity

The range of chloride values is from 1.18 to 24.27 g/l for water and 0.12 to 3.57 g/100 g for soil. The present values for soil and water are confirmatory to the earlier reports. The salinity trend is same as chlorides because, it is calculated from chlorinity. The salinity range for water is in between 2.16 to 43.83 ‰. The dilution effect is evident from salinity observed at different sites. The soil salinity varies from 0.051 to 5.489 g/100 g soil.

v) Heavy metals and Zinc

Low levels of cadmium are observed in water, during July and October, whereas high values are found in September, February and May. In case of lead comparatively low levels are recorded only at NM. The higher concentration of lead is found at BS in September. The range of mercury in the present study is from 1.1 to 28 ppm for estuarine water. For sea water it is 29 ppm. Amongst the heavy metals mercury shows considerable amount in water at NM. The trend shown by zinc is different than the heavy metals. It is found that the concentration of zinc changes due to tidal currents.

vi) Effect of heavy metals and zinc on mangroves

In view of study of the effect of heavy metals and zinc, common mangrove species like S. alba, A. corniculatum, A. ilicifolius, A. marina and C. tagal are considered from the sites, studied. For this purpose different physiological parameters like moisture percentage, EC, TAN, proline, polyphenols and chlorophylls are detected from the plant material.

Accumulation of heavy metals and zinc in the plants varies with species and the concentration available in the surrounding medium. The uptake of heavy metals ingeneral shows its highest values in plants in the subsequent month of its high level in the water. A. ilicifolius appears to be a tolerant species to heavy metals. Zinc, a trace element, shows variable amount on the mangroves, studied. The salt excreting type of mangroves like A. corniculatum show the highest level of zinc. In short,

'luxury uptake' of zinc is observed. Thus, the mangrove species are tolerant to heavy metals and zinc.

The moisture content shows no significant changes. Electrical conductivity is variable in the mangrove species, studied. No definite trend with regards to heavy metals is noted.

Titratable acid number is the acidity status of the plant tissue and concerned with the active growth metabolism of the plants. The TAN values are low in summer months when the salinity of cell sap is high. All the plants presented at KR show comparatively low levels of TAN. It is high in the month of February except for C. tagal. It is to be noted here that February is the month when heavy metals give low values. There is no distinct correlation between TAN and the heavy metals and zinc at higher concentrations.

Proline plays an important role in halophytes. Proline levels observed in present mangroves range from 4 to 202 mg/100 g dwt. Proline does not exhibit direct correlation with heavy metal concentration in the plants.

It is well known that mangroves are rich in polyphenols. The range of polyphenols, in the present study is from 0.05 to 7.00 g/100 g fwt. It seems that low levels of heavy metals have correlation with polyphenols except for S. alba.

Another parameter studied from the plants is chlorophylls. . The results of study show that KR is the site where S. alba shows considerable decrease in chlorophylls. High levels of chlorophylls are recorded

in March and April. In case of A. corniculatum and A. marina high levels of chlorophylls parallel with the high levels of cadmium in March. In case of other mangrove species studied, high level of chlorophylls are obtained in the subsequent month of the high level of cadmium in the plant.

The effect of a specific heavy metal on a particular physiological parameter is difficult to spell out, especially, when they are present in combination in the medium. It seems that the effect of heavy metals is dependent upon ionic species, interaction between them and the plant species concerned.

vii) Phytoplankton productivity and effect of heavy metals and zinc

The phytoplankton productivity is the rate at which radiant energy is captured or carbon dioxide is assimilated. This is Gross Primary Productivity (GPP). From this, Net Primary Productivity (NPP) is determined by substracting respiration rate. There are about 74 phytoplankton species occurring in Bhatye estuary. They broadly include diatoms, dinoflagellates green algae, and blue-green algae. The change in environmental conditions affect the phytoplankton dynamics. In the present study, monthly variation in phytoplankton productivity is studied from December 1987 to July 1988. Values for GPP range from 0.25 to 4.15 $gC/m^3/d$. For NPP the range is from 0.11 to 3.42 $gC/m^3/d$, highest being at BP in January. At the same site, GPP and community respiration (CR) is equal in June. Therefore, no NPP is detected. High rates of respiration observed, in present study may be attributed to the active growth of phyto plankton as well as high levels of mercury in water. As compared to

sea water, NPP of estuarine water is higher. The study indicates that mercury, amongst the metals studied for phytoplankton, is the most toxic. Toxic effects of zinc inspite of its high levels are not identified.

Thus, it is concluded that :

i) there is no major difference in water and air temperature of west coast of India;

ii) water pH is affected by human activities in and around the estuaries;

iii) chlorinity and salinity depend upon the site of collection as well as the pollution status of the site, apart from the seasonal aspects;

iv) the levels of heavy metals and zinc in the mangrove leaves exceed the reported severally toxic levels and hence, are taken as alarming;

v) as there are no visible symptoms of zinc toxicity, high level of zinc is taken as 'luxury uptake';

vi) low levels of heavy metals have correlation with high TAN values;

vii) proline does not exhibit direct correlation with the heavy metals in plants;

viii) low levels of polyphenols are in correspondance with low levels of heavy metals in plants;

ix) so far as chlorophylls are concerned, the effect of cadmium is seen in two ways - a) immediate and b) later;

x) effect of heavy metals on mangroves is dependent upon ionic species, interaction between them and the plant species concerned;

xi) the study indicates that amongst the heavy metals investigated mercury is the most toxic metal for phytoplankton;

xii) it is to be kept in mind that even though there are no visible morphological symptoms in the plants, the plants may contain toxic levels of hazardous metals.