VI. Sediment Quality

6.1 Introduction

Pollutants once dumped into the estuarine environment remain in solution or accumulate into the organisms, but the ultimate recipient of all these pollutants in the aquatic system is the sediment. The nature and volume of discharges alter the physico-chemical characteristic nature of the sediments. Variation in colour and texture of sediments were brought by changes in the grain size and the state of oxidation of organic matter.

Suspended organic matter received by the river through land runoff and sewage settles down and forms part of bottom sediment. Dead aquatic plants and organisms also contribute much to organic content of sediments. The high nitrogen and phosphorus content associated with organic matter is made available to the overlying water column through various physico-chemical processes and utilized by aquatic plants for their growth. Hence, sediments enriched with organic matter act as good reservoirs of nutrients. Moreover, sediments enriched with organic matter with its ability to make chelate compounds play a major role in the retention of toxic heavy metals.

The available trace metals from natural and domestic sources when introduced into the system do not remain in water column. Dissolved metal ions get precipitated or get adsorbed by suspended particulate matter and form part of river
sediment. The presence of high suspended solid loads may play an important part in
the trace metal budget of the estuary by encouraging the retention of the trace metals
in the estuary. Even though, the sediments act as sink, the metals may re-enter into
the water column by various physical, chemical and biological processes. In this
way the river sediment act as buffer and helps to keep the metal concentration above
background level even after the input is removed.

Clay minerals with its comparatively high cation exchange capacity play a
vital role in mobilizing the trace metals, but laboratory experiments carried out on
the adsorption of trace metals on clay minerals have shown that their contribution in
retaining trace metals in sediments is very small (Lee, 1975). Similarly, the process
of metal accumulation in residue is controlled by and related to the amount of fine
grain particles also (Cranston, 1976).

Sediments are indicators of the quality of water overlying them. Data on
sediment quality such as its textural characteristics, chemical composition, organic
matter content are important in assessing the mobility of various toxicants associated
with it. Hence the analysis of sediment is an effective way to assess the magnitude
of pollution caused (Forstner and Wittmann, 1981).

In the present study an attempt has been made to assess the environmental
pollution considering the sediment distribution pattern, organic carbon and heavy
metals in the study area.
6.2 Review of Literature

Enough number of works have been already carried out to study the quality of sediments of important rivers and estuaries world over.

Groot (1966) observed the transport of heavy metals in sediments and process affecting heavy metals in estuarine sediments. The contributions by Brooks et al. (1967) is noteworthy in the field of methodology developments for the study of heavy metal distribution in water, sediment and biota. Groot et al. (1971) have shown that for sediments from the Ems and Rhine estuaries, there is a distinct relationship between the particle size and the concentration of various metals including copper, zinc and lead.

The geochemical association of trace metals in estuarine sediments were investigated by Meade (1972). They noticed the estuarine sediments derived due to the landward transport of marine sediments. Cherian (1973) studied the size distribution of sediments and physical parameters of Cochin harbour. Bryan (1974) reported the adaptation of an estuarine polychelate to sediments containing high concentration of heavy metals. Groot et al. (1976) studied the processes affecting heavy metals in the sediments and the role of organic carbon in the retention of trace metals. Cranston (1976) studied the process of metal accumulation in residues and stated that the process is controlled by the amount of fine grain particles. Jaffe and Walters (1977) in their analysis on Humber estuary sediments had shown a negative relationship between particle size of sediments, organic matter and clay minerals.
Studies on mass transfer of geochemical constituents were carried out in Indian estuaries by Subramanian (1980). Paul and Pillay (1983) investigated the trace metals associated with sediments in Periyar river and Varapuzha estuary. The role of organic matter associated with sediment was explored by Salim (1983). A comparative study of hydrography, organic carbon and sediment texture was conducted and reported by Sarala Devi (1983) in Beypore, Korapuzha, Kali and Mahanadhi estuaries. Laxen (1983) reported that the metals associated with sediments forming part of the particle structure generally sink with the sediment particles. As per the estimations made by Milliman and Meade (1983), the Indian rivers contribute 30% of sediments transported by the world rivers. The elemental analysis in the sediments was carried out in Vembanad lake by Mallik and Suchindan (1984). The interaction of heavy metals with humic substances was studied by Rasport et al. (1984). Heavy metal pollution in sediments was studied by Ouseph (1987) in Cochin estuary. Fernandez et al. (1987) studied the level of zinc in Humber estuary sediments and related its concentration with particle size. Azis and Nair (1987) studied the texture and nutrient concentration of sediments in Ashtamudi estuary and noticed low concentration of heavy metals. Geochemical association of metals in Krishna river sediments were reported by Ramesh et al. (1989). The geochemistry of Mahanadi basin was carried out by Chakarapani (1990). Goel and Chavan (1991) recorded high organic matter in sediments of Kolhapur water system. Nair (1994) carried out sediment analysis in Beypore estuary and obtained a striking parallism between mercury content, organic carbon and clay minerals. Nair (1995)
carried out sediment analysis and heavy metal pollution in Beypore estuary. The chemical analysis of bottom sediments of freshwater ponds of Darbhanga was studied by Shamim et al. (1996).

6.3 Material and Methods

Preliminary Treatment

The sediment samples were homogenised and washed with distilled water to remove the dissolved salts associated with it. The washed samples were oven dried at 60°C to constant weight. The samples were then analysed for various parameters.

Textural Analysis

The texture of the sediment sample was analysed by wetsieving and pipette method (Lewis, 1984). Known weight of the sediment sample was dispersed overnight by adding 10 ml of 10% sodiumhexametaphosphate. Sediment fraction lower than 63 μm was separated by wetsieving. The sieve retents were dried and weighed. The suspension passing through the sieve (#230) was transferred into a 1000 ml stand measuring flask and made up to one litre. The suspension was well stirred and then left undisturbed. 20 ml aliquot was withdrawn from the suspension using a pipette. The aliquot was then transferred into a previously weighed 50 ml beaker. It was dried in hot air oven at 60°C and weighed after cooling in dessicator. The dried aliquot weight was multiplied by a factor 50 and the weight of sodiumhexametaphosphate was then subtracted. Weight of sand, silt and clay fractions were calculated from the above results and converted into percentages.
Organic Carbon

The sediment organic carbon was determined by wet Oxidation Method (Wakeel and Riley, 1957). Organic matter was oxidised by a known quantity of chromic acid and the amount of chromic acid used was then determined by titration with standard ferrousammoniumsulphate solution. Barium salt of diphenylamine sulphuric acid was used as indicator.

Heavy Metals

1 gm of the powdered dry sample was taken in a beaker and added 15 ml hydrochloric acid, 5 ml nitric acid, 3 ml perchloric acid and 25 ml hydrofluoric acid. This was evaporated to dryness. Added 30 ml 1:1 HCl and heated to boil. The solution was transferred to a 100 ml standard measuring flask after cooling and made up to the mark. Trace metals were then analysed using AAS.

6.4 Results

6.4.1 Sediment Composition

Considerable assortment of textural grades of sediments both location-wise and month-wise was observed and are also presented in Table 6a, 6b & 6c and are graphically represented in Fig. 6.1, 6.2 & 6.3.

Textural spectrum of the sediments depict wide variation. In the present investigation, the percentage composition of sand showed considerable spatial and seasonal variations. The average month-wise composition of sand ranged between 54.1% (December) and 74.3% (January). The percentage composition of sand was
Table 6a.  Sand content of the sediment (per cent)

<table>
<thead>
<tr>
<th>Station</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
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<th>May</th>
<th>Jun</th>
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<td>59</td>
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</table>
Fig. 6.1 Sand content of the sediment

- November
- December
- January

- February
- March
- April
- May

- June
- July
- August
Table 6b. Silt content of the sediment (per cent)

<table>
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<tr>
<th>Station</th>
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<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
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</tr>
</tbody>
</table>
Fig. 6.2 Silt content of the sediment

- November
- December
- January

- February
- March
- April
- May

- June
- July
- August
Table 6c. Clay content of the sediment (per cent)

<table>
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<tr>
<th>Station</th>
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<th>Feb</th>
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<td>-</td>
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</tr>
<tr>
<td>V</td>
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<td>-</td>
<td>-</td>
<td>24</td>
<td>11</td>
<td>17.4</td>
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<tr>
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<td>46</td>
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<td>11</td>
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<td>-</td>
<td>16.3</td>
<td>20</td>
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<td>23</td>
<td>1.3</td>
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<td>-</td>
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<td>-</td>
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<td>5.78</td>
<td>10.4</td>
<td>17.8</td>
<td>3.14</td>
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</table>
Fig. 6.3 Clay content of the sediment

- November
- December
- January

- February
- March
- April
- May

- June
- July
- August

Stations
high during monsoon season (65.12%). Station V recorded high percentage of sand (94.7%) and station II recorded low percentage of sand 42.9%. The locationwise composition of sand ranged between 42.9% and 94.7%. The composition of sand was found to be higher at the stations in the riverine zone and it decreased downstream in the study period.

The composition of silt content showed near uniform distribution in the coastal regions (stations I and II). The percentage composition of silt at station I was 32.6% and at station II was 38.4%. But fluctuations were noticed in the composition of silt in the riverine stations. The composition of silt content at stations III to VII ranged from 7.18 to 39.7%. The maximum value of 92% of silt content was noticed at station VI during May and minimum value of 0.07% of silt content was noticed at station III during July. No substantial variation was noticed during different seasons. The monthly average silt content ranged from 13.9% (January) to 35.1% (May). The percentage composition of silt content was slightly higher during monsoon seasons.

In the present study, the composition of clay content followed similar distribution pattern as that of silt composition. The locationwise clay content ranged from 1.50% (station III) to 20.6% (station IV). The clay content recorded higher value at station IV followed by stations VI and II. The percentage composition of clay was low at stations III and VII. The monthwise composition of clay ranged from 0% (January) to 21.2% (February). The percentage composition of clay was higher during premonsoon season.
6.4.2 Organic Carbon

The data obtained for monthwise variations of organic carbon are presented in Table 6d and are graphically represented in Fig. 6.4.

In the present investigation organic carbon ranged from 0.01% (June) to 3.02% (April) at station I, from 0.03% (January) to 2.81% (April) at station II, from 0.01% (November, January) to 1.06% (March) at station III, from 0.01% (December) to 4.625 (March, May) at station IV, from 0.03% (August) to 1.61% (February) at station V, from 0.02% (August) to 3.07% (November) at station VI and from 0.01% (May) to 2.79% (December) at station VII.

In the present study, since organic carbon content was not in high concentration, the Pazhayar river does not contain appreciable amount of organic carbon in sediments. The value of organic carbon decreased upstream from station IV to VII through station VI. Stations IV and VI reached high percentage of organic carbon. The locationwise range was between 0.517% (station III) and 1.523% (station IV). The stations in the coastal region, the head and mouth of the estuary showed lower percentage of organic carbon than the river. Maximum values of organic carbon, were recorded at all the stations during premonsoon season where as minimum values were recorded during monsoon and postmonsoon seasons. A remarkable feature of organic carbon was its considerable covariation with the composition of silt and clay contents in the sediments. The composition of organic carbon showed a positive correlation with hydrogen sulphide.
### Table 6d. Variation of organic carbon in sediments (per cent)

<table>
<thead>
<tr>
<th>Station</th>
<th>Nov</th>
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<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Mean</th>
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<td>0.031</td>
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<td>0.93</td>
<td>3.02</td>
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<td>0.16</td>
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<td>0.01</td>
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<td>2.83</td>
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<td>0.48</td>
<td>0.01</td>
<td>0.68</td>
<td>0.03</td>
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</table>
Fig. 6.4 Organic carbon values in sediments

- November
- December
- January

- February
- March
- April
- May

- June
- July
- August

Stations
6.4.3 Concentration of copper

The monthly variation of copper in sediments at stations I to VII are presented in Table 6e and are graphically represented in Fig. 6.5.

The concentration of copper in sediment ranged from 0.16 mg/l (December, June and July) to 2.85 mg/l (May) at station I, from 0.03 mg/l (December) to 3.19 mg/l (May) at station II, from 0.06 mg/l (December) to 2.3 mg/l (May) at station III, from 0.07 mg/l (December) to 2.60 mg/l (April) at station IV, from 0.01 mg/l (December) to 1.16 mg/l (April) at station V, from 0.07 mg/l (August) to 2.18 mg/l (May) at station VI and from 0.08 mg/l (August) to 0.68 mg/l at station VIII.

In the present study, high values of copper content in sediment were recorded at stations I and II which are near the sea. High values of copper were recorded in the premonsoon season and low values in the monsoon and postmonsoon seasons.

6.4.4 Concentration of iron

The monthly variations of iron content in sediment are presented in Table 6f and are graphically represented in Fig. 6.6.

The concentration of iron in sediment fluctuated between 2.28 mg/l (February) and 32.9 mg/l (November) at station I, between 2.44 mg/l (February) and 28.6 mg/l (June) at station II, between 1.86 mg/l (February) and 20.2 mg/l (July) at station III, between 0.65 mg/l (February) and 18.6 mg/l at station IV, between 1.43 mg/l (April) and 24.3 mg/l (July) at station V, between 2.9 mg/l (May) and 30.2 mg/l
Table 6e.  Variation of copper in sediment (mg/l)

<table>
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<tr>
<th>Station</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
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<td>0.16</td>
<td>3.18</td>
<td>0.19</td>
<td>0.61</td>
<td>0.79</td>
<td>2.85</td>
<td>0.16</td>
<td>0.16</td>
<td>0.38</td>
<td>0.896</td>
</tr>
<tr>
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<td>0.03</td>
<td>0.68</td>
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<td>0.44</td>
<td>1.18</td>
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<td>0.33</td>
<td>0.38</td>
<td>0.42</td>
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<td>0.52</td>
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<td>0.39</td>
<td>1.89</td>
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<td>0.17</td>
<td>0.21</td>
<td>0.610</td>
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<tr>
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<td>0.07</td>
<td>0.68</td>
<td>0.18</td>
<td>0.42</td>
<td>2.60</td>
<td>2.11</td>
<td>0.18</td>
<td>0.15</td>
<td>0.25</td>
<td>0.689</td>
</tr>
<tr>
<td>V</td>
<td>0.64</td>
<td>0.01</td>
<td>0.47</td>
<td>0.27</td>
<td>0.26</td>
<td>1.16</td>
<td>0.96</td>
<td>0.10</td>
<td>0.31</td>
<td>0.11</td>
<td>0.429</td>
</tr>
<tr>
<td>VI</td>
<td>0.30</td>
<td>0.08</td>
<td>0.79</td>
<td>0.27</td>
<td>0.28</td>
<td>1.91</td>
<td>2.18</td>
<td>0.07</td>
<td>0.20</td>
<td>0.07</td>
<td>0.615</td>
</tr>
<tr>
<td>VII</td>
<td>0.25</td>
<td>0.27</td>
<td>0.68</td>
<td>0.38</td>
<td>0.55</td>
<td>0.27</td>
<td>0.39</td>
<td>0.19</td>
<td>0.41</td>
<td>0.08</td>
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<tr>
<td>Mean</td>
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<td>0.097</td>
<td>1.00</td>
<td>0.243</td>
<td>0.421</td>
<td>1.4</td>
<td>1.99</td>
<td>0.191</td>
<td>0.254</td>
<td>0.217</td>
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</tr>
</tbody>
</table>
Fig. 6.5 Concentration of copper in sediment

- November
- December
- January

- February
- March
- April
- May

- June
- July
- August

Stations

Stations

Stations

Copper (mg/l)

Copper (mg/l)

Copper (mg/l)
Table 6f.  Variation of iron in sediment (mg/l)

<table>
<thead>
<tr>
<th>Station</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Mean</th>
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<tbody>
<tr>
<td>I</td>
<td>32.90</td>
<td>5.68</td>
<td>2.85</td>
<td>2.28</td>
<td>20.60</td>
<td>2.81</td>
<td>20.72</td>
<td>22.52</td>
<td>22.52</td>
<td>20.60</td>
<td>15.34</td>
</tr>
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<td>II</td>
<td>3.27</td>
<td>3.55</td>
<td>15.70</td>
<td>2.44</td>
<td>24.50</td>
<td>2.75</td>
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<td>28.60</td>
<td>25.40</td>
<td>26.00</td>
<td>15.37</td>
</tr>
<tr>
<td>III</td>
<td>3.36</td>
<td>3.57</td>
<td>12.08</td>
<td>1.86</td>
<td>10.60</td>
<td>4.08</td>
<td>8.65</td>
<td>18.01</td>
<td>20.20</td>
<td>16.20</td>
<td>9.86</td>
</tr>
<tr>
<td>IV</td>
<td>3.48</td>
<td>3.71</td>
<td>20.50</td>
<td>0.65</td>
<td>9.16</td>
<td>2.51</td>
<td>2.85</td>
<td>11.86</td>
<td>14.00</td>
<td>18.60</td>
<td>8.73</td>
</tr>
<tr>
<td>VI</td>
<td>2.99</td>
<td>3.74</td>
<td>26.10</td>
<td>5.74</td>
<td>30.20</td>
<td>3.48</td>
<td>2.90</td>
<td>26.80</td>
<td>22.00</td>
<td>24.30</td>
<td>14.82</td>
</tr>
<tr>
<td>VII</td>
<td>2.53</td>
<td>4.31</td>
<td>14.62</td>
<td>2.62</td>
<td>18.80</td>
<td>1.28</td>
<td>3.35</td>
<td>22.70</td>
<td>21.50</td>
<td>22.90</td>
<td>11.46</td>
</tr>
</tbody>
</table>
Fig. 6.6 Concentration of iron in sediment

- November
- December
- January

- February
- March
- April
- May

- June
- July
- August

Iron (mg/l)

Stations

1 2 3 4 5 6 7

Iron (mg/l)

Stations

1 2 3 4 5 6 7

Iron (mg/l)

Stations

1 2 3 4 5 6 7

Iron (mg/l)

Stations

1 2 3 4 5 6 7
(March) at station VI and between 1.28 mg/l (April) and 22.9 mg/l (August) at station VII.

In the present study high values of iron content in sediment were recorded at stations I and II followed by station VI. High values of iron content were recorded in the monsoon season and low values in the premonsoon and postmonsoon seasons.

6.4.5 Concentration of zinc

The results obtained for monthly variations of zinc content in sediment are presented in Table 6g and are graphically represented in Fig. 6.7.

The concentration of zinc varied from 0.22 mg/l (December) to 1.10 mg/l (May) at station I, from 0.16 mg/l (February) to 0.92 mg/l (January) at station II, from 0.16 mg/l (August) to 1.07 (January) at station III, from 0.28 mg/l (February) to 1.14 mg/l (December) at station IV, from 0.18 (February) to 0.86 mg/l (March) at station V. from 0.18 mg/l (March) to 1.18 mg/l (April) at station VI and from 0.26 mg/l (December and January) to 1.10 mg/l (April) at station VII.

In the present study, almost uniform distribution pattern of zinc content was noticed. High values of zinc concentration were recorded in the premonsoon season and low values in the monsoon and postmonsoon seasons.

6.4.6 Concentration of manganese

The variations of manganese content during the study period of stations I to VII are presented in Table 6h and are graphically represented in Fig. 6.8.
Table 6g. Variation of zinc in sediment (mg/l)

<table>
<thead>
<tr>
<th>Station</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.49</td>
<td>0.22</td>
<td>0.76</td>
<td>0.24</td>
<td>0.81</td>
<td>0.32</td>
<td>1.10</td>
<td>0.42</td>
<td>0.67</td>
<td>0.78</td>
<td>3.581</td>
</tr>
<tr>
<td>II</td>
<td>0.55</td>
<td>0.38</td>
<td>0.92</td>
<td>0.16</td>
<td>0.80</td>
<td>0.38</td>
<td>0.50</td>
<td>0.68</td>
<td>0.75</td>
<td>0.86</td>
<td>0.598</td>
</tr>
<tr>
<td>III</td>
<td>0.22</td>
<td>0.18</td>
<td>1.07</td>
<td>0.42</td>
<td>0.96</td>
<td>0.21</td>
<td>0.95</td>
<td>0.48</td>
<td>0.20</td>
<td>0.16</td>
<td>0.385</td>
</tr>
<tr>
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<td>1.14</td>
<td>0.88</td>
<td>0.28</td>
<td>0.46</td>
<td>0.39</td>
<td>0.68</td>
<td>0.42</td>
<td>0.48</td>
<td>0.48</td>
<td>0.567</td>
</tr>
<tr>
<td>V</td>
<td>0.55</td>
<td>0.42</td>
<td>0.61</td>
<td>0.18</td>
<td>0.86</td>
<td>0.82</td>
<td>0.86</td>
<td>0.55</td>
<td>0.72</td>
<td>0.55</td>
<td>0.612</td>
</tr>
<tr>
<td>VI</td>
<td>0.49</td>
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<td>0.86</td>
<td>1.33</td>
<td>0.18</td>
<td>1.18</td>
<td>0.86</td>
<td>0.79</td>
<td>0.87</td>
<td>0.82</td>
<td>0.771</td>
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<td>0.45</td>
<td>0.26</td>
<td>0.26</td>
<td>0.75</td>
<td>0.29</td>
<td>1.10</td>
<td>0.92</td>
<td>0.68</td>
<td>0.98</td>
<td>0.90</td>
<td>0.659</td>
</tr>
</tbody>
</table>

| Mean    | 0.458| 0.418| 0.765| 0.48| 0.6228| 0.628| 0.838| 0.574| 0.667| 0.65 |
Fig. 6.7 Concentration of zinc in sediment

- November
- December
- January

- February
- March
- April
- May

- June
- July
- August
Table 6h. Variation of manganese in sediment (mg/l)

<table>
<thead>
<tr>
<th>Station</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
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<td>2.57</td>
<td>6.89</td>
<td>1.02</td>
<td>3.81</td>
<td>3.62</td>
<td>1.65</td>
<td>1.82</td>
<td>2.26</td>
<td>2.12</td>
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<td>2.38</td>
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<td>3.29</td>
<td>2.11</td>
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<td>2.66</td>
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<td>1.30</td>
<td>2.16</td>
<td>1.92</td>
<td>1.707</td>
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<td>1.06</td>
<td>1.23</td>
<td>2.01</td>
<td>2.89</td>
<td>0.97</td>
<td>2.82</td>
<td>1.62</td>
<td>1.30</td>
<td>2.01</td>
<td>1.725</td>
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<td>1.31</td>
<td>1.17</td>
<td>2.20</td>
<td>2.56</td>
<td>1.27</td>
<td>1.32</td>
<td>1.88</td>
<td>2.16</td>
<td>2.09</td>
<td>1.98</td>
<td>1.794</td>
</tr>
<tr>
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<td>1.01</td>
<td>2.74</td>
<td>1.54</td>
<td>1.32</td>
<td>2.83</td>
<td>2.07</td>
<td>2.05</td>
<td>2.49</td>
<td>1.22</td>
<td>1.855</td>
</tr>
<tr>
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<td>2.99</td>
<td>1.19</td>
<td>2.16</td>
<td>1.23</td>
<td>1.24</td>
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<td>1.12</td>
<td>1.16</td>
<td>2.12</td>
<td>1.38</td>
<td>1.655</td>
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<tr>
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<td>2.687</td>
<td>1.697</td>
<td>2.368</td>
<td>2.017</td>
<td>2.111</td>
<td>1.745</td>
<td>2.098</td>
<td>1.858</td>
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</tr>
</tbody>
</table>
Fig. 6.8 Concentration of manganese in sediment

- November
- December
- January

- February
- March
- April
- May

- June
- July
- August
The concentration of manganese varied from 1.02 mg/l (February) to 6.89 mg/l (January) at station I, from 1.22 mg/l (February) to 3.39 mg/l (March) at station II, and from 1.12 mg/l (December) to 2.66 mg/l (March) at station III. The range was between 0.97 mg/l (April) to 2.89 mg/l (March) at station IV, from 1.17 mg/l (December) to 2.56 mg/l (February) at station V, from 1.01 mg/l (December) to 2.83 mg/l (April) at station VI and from 1.12 mg/l (May) to 2.99 mg/l (November) at station VII.

In the present survey, the manganese content showed almost uniform pattern at all stations, except near the bar mouth. Station I recorded the maximum value of manganese content in the sediment.

In the present investigation, higher values of manganese content were recorded in the premonsoon season and low values in the monsoon and postmonsoon seasons.

6.5 Discussion

Mainly three sediment categories are dispersed on the bottom of the river viz., sand, silt and clay. Sediments of the river bed from the upstream to bar mouth depict considerable intermixing of textural grade. Sand, which is the most dominant of the textural grades, irrespective of the course of the river showed its lowest prominence at station II. Stations I and II, situated near the sea recorded a gradual reduction of sand composition indicating textural maturity of alluvial stream. However, the proper estuarine portion is constrained to contain different proportion
of sand, probably representing location specific hydra mechanics operating in the system. Station V was dominated by the composition of sand and stations IV and VI which are situated in the riverine zone recorded comparatively low content of sand. These two stations had high silt and clay content than other stations. This was due to the drainage from the surrounding paddy field which may receive more clay.

The textural characteristics of sediment of Pazhayar river showed that it was sand, silt and clay in stations I and II, silty sand in stations III, V and VII while clay sand in stations IV and VI.

Input of organic matter in rivers and estuaries are mostly controlled by the rate of supply of terrestrial materials, rate of deposition of organic to inorganic constituents, organic productivity, rate of decomposition of organic matter and texture of sediment load transported by the river. Aquatic weeds also play a major role in controlling the organic matter content.

In the present investigation, the composition of organic carbon was found to be high during premonsoon and low during monsoon seasons. The low rainfall, reduced freshwater influx and evaporation due to heat caused stagnation leading to sharp rise in organic content in premonsoon season. At stations I and II during premonsoon season, higher values of organic carbon were recorded compared to other seasons. This may be due to the closure of the barmouth of the estuary during this time, which reduced freshwater influx and thus resulted in the development of a stagnant condition. The monsoon season was marked by heavy rainfall and the
subsequent floods lead to the fall in carbon values. The same type of result was obtained by Nair et al. (1983) in Ashtamudi estuary and Bijoy Nandan (1991) in Kadinamkulam estuary.

In the present study, station II (estuary) recorded higher per cent of organic carbon than station I (bar mouth). Station II is situated near the mouth of the river. The high per cent of organic carbon at station II may due to the retting of coconut husk in this estuary. Retting of coconut husk is one of the principle sources of organic carbon. The process of retting liberates large quantities of organic matter like pectin, phenol, tannin, lignin into the water (Prabhu, 1957). It is brought about by the action of bacteria and fungi (Bhat and Nambudiri, 1971). This is in confirmation with similar type of observations from Ashtamudi estuary by Nair et al. (1983), Kadinamkulam estuary by Bijoy Nandan (1991).

The values of organic carbon showed positive correlation with hydrogen sulphide. This is in conformity with the findings of Bijoy Nandan (1991) in Kadinamkulam estuary and Shibu (1991) in Paravur lake.

In the present study, stations IV and VI were recorded high per cent of organic carbon. Organic carbon was higher in sediments rich in clay particles, and lower in sediments consisting of sand and silt. Stations IV and VI were found to have clay sand sediment texture and so organic carbon content was found to be higher, while stations III, V and VII were found to have silty sand sediment texture in the present investigation and so organic carbon content was found to lower. The
sympathetic relationship of organic matter with that of silt could be due to the cosedimentation of organic matter with silt sized particles as their settling velocities are similar. One of the main reasons attributed to this was the increase in surface area of fine particles to contain more dispersed organic matter (Sues and Muller, 1980).

The metals introduced into the system do not remain in water column, they form part of river sediment. The total concentration and reactivity of metals in sediments is a function of organic matter, mineralogy and textural characteristics related to quality of sediments (Willey and Filzerald, 1980). Rea and Pigula (1977) demonstrated the importance of texture on the antherogenic precipitation of elements. Many researchers were unclear whether metal distributions result from the greater influence of grain size or organic matter content. However Sholkovitz (1976) found significant metal association with organic matter. Similarly clay minerals have ability to absorb or release heavy metal ions (Farrah et al., 1980). Electrostatic attraction between the negative sites on the clay and the metal ions are important in the sorption process. Though a general pattern of clay affinity for metals were presented by Farrah et al. (1980), the sequence may vary for different metals.

In the present study the spatial distribution of heavy metals copper, iron, zinc and manganese showed considerable fluctuations from upstream to bar mouth. The annual mean value of concentration of iron in the sediment was found to be higher than the other three metals. This was in good agreement with the findings of Azis and Nair (1987) in Ashtamudi estuary and Shamim et al. (1996) at Darbhanga river.
In the present study, the concentration of iron content was found to be higher in the near shore stations I and II. This was due to the incorporation of iron in the sediments in the form of ferric oxide hydrosol stabilized by the organic colloids and also due to the flocculation and settling of iron in the saline water near the coastal region (Caseno and Garrels, 1950). Similarly station VI recorded high values of iron content in sediment. This was attributed to the clay content at this station. Farrah et al. (1980) reported that clay sediment has more affinity for metals.

In the present survey, the concentration of copper in sediment was found to be higher at station I. Nair et al. (1987) in Beypore estuary reported that the absolute concentration of metals are found to be higher in nearby marine sediments. Copper has direct bearing with sediment texture and organic carbon content. Organic carbon showed negative correlation with copper composition. The stations IV and VI which are richer in fine clay sediment, recorded lower copper content in sediments. This is due to the high organic carbon present in these stations. Shamim et al. (1996) reported that increase in organic content in the soil decreases copper availability. This is in conformity with the present investigation.

In the present study, station VI recorded high values of zinc content in the sediment. This was attributed to fine nature of clay sediment and enrichment of organic carbon. Similar pattern was observed by Jaffe and Walters (1977) in their analysis on Humber estuary sediment.
In the present investigation the manganese content in the sediment showed almost uniform pattern except at station I. Manganese content was found to be high at this station. Station I was situated near the sea. So submergence of marine sediment may cause the increase in manganese content. In other stations, depending on the sandy texture of the sediments slight variations in manganese content were noticed.

In the present investigation the spatial relationship of the four metals were complicated. Of the four metals, the composition of iron and copper were found to be high at stations I and II, manganese at station I and zinc at station VI. Iron, copper, manganese and zinc showed uniform distribution in the upstream, but fluctuations were observed in the lower stream. This could be due to the variant level of mixing and textural dissimilarity of sediments in the lower stream. Temporal and spatial variability of trace metals in estuarine sediments result from the cyclic changes in the fresh and sea water, conditions of temperature, pH, salinity, suspended sediment and oxygen concentration. Their non-conservative interaction during mixing exerts a major influence on heterogeneous chemical reactions in estuaries (Morris et al., 1981). This may be the reason for appreciable concentration of iron, copper, zinc and manganese at stations I and II near the sea.

In the present investigation the concentrations of metals copper, zinc and manganese were found to be high during premonsoon season. This was due to very low rainfall, reduced freshwater, evaporation due to heat which resulted in the development of a stagnant condition leading to sharp rise in the heavy metal concentration.