Physico-chemical parameters of Karamana river water in Trivandrum district, Kerala, India

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ABSTRACT

The study report discusses about the analysis of various physico-chemical parameters of salinity, TSS, TDS, DO, BOD, turbidity, pH, temperature, alkalinity, hardness and dissolved nutrients of surface water and sediments collected from different points (5 stations) of Karamana River were measured during March and July 2009. The highest temperature (31.0ºC) noticed during pre-monsoon period and no influence of salinity. In the monsoon period, high DO ranges (5.4mg/L) noticed in the water of Karamana River. High BOD observed at Thiruvallam indicated the influence of effluents in these stations. TSS 17mg/L at Manakatukadavu to 40mg/L at Thiruvallam during pre-monsoon and 24mg/L at Manakatukadavu to 60 mg/L at Pallichal during monsoon. TDS in water samples increased from 56mg/L at station 1 to 28mg/L at station 5 during pre-monsoon and from 41mg/L at station 1 to 112mg/L at station 5 the high TDS might be due to the influence of seawater. Total alkalinity observed in the present study is well within the prescribed standards of drinking water (>120mg/L). High hardness 12 mg/L) noticed at Karamana near Siva temple during pre-monsoon period. Total Iron concentrations is high as 1.08 to 2.52mg/L in pre-monsoon and 1.51 to 2.24mg/L during monsoon recorded at station 5 might be due to the high rate of surface runoff in waters. Total phosphate value (2.56-2.19mg/kg) at Pallichal showed the deposition of nutrients during monsoon season. The distribution of heterotrophic population was highly fluctuating during the study and the high counts (417cfu/ml to 524 dfu/ml) during monsoon at Mankattukadavu and Kundamankkadavu.

Keywords: Physico-chemical parameters, Karamana River, Water pollution.

1 Introduction

Karamana River ranks 15th in catchment area and 17th in stream length. This is a small falls in mountainous (head water elevation 1000-3000m amsl) river draining the Western Ghats (Sahyadri hills.) The crest of Western Ghats constitutes the interfluves between the Karamana (west flowing) and the Thamaraparai (east flowing) river basins. The river originates from Chemmunji Mottai, a peak in the Sahyadri hills, at altitude of 1717m amsl. Another prominent mountain peak known as Adirumalaia, with an altitude of 1591 m amsl, forms the source of Attair, a major tributary of Karamana River. Along the course of the Karamana river, the master stream of the system, there is a 71m waterfall at Pachani Thuval, 2km downstream of Chemmunji Mottai The Vazhapazhattiar and the Attair tributaries of the Karamana river, originate from Panditheri Malai (1560rn) and Adrumalai (1594rn) which
join at an altitude of 249m and join with Karamana river at an altitude of 149rn from amsi, at about 2km downstream of the Panchani Thuval waterfall. Further down 5 other tributaries also join Karamana River.

Karamana is one of the major rivers flowing through Thiruvananthapuram district, Kerala State. The River that originates from Western Ghats falls in to the Arabian Sea. The present study is carried out during March and July 2009.

In early days, water was primarily used for domestic needs like drinking, washing, bathing and cooking etc. But due to industrial and urban development, requirement of water for these activities has increased along with domestic purpose. Water of good quality is required for living organisms. The quality of water is described by its physical, chemical and microbial characteristics. But if, some correlations were possible among these parameters, then significant ones would be fairly useful to indicate the quality of water (Dhembare et al., 1997). The deterioration of quality, loss of biodiversity and fast depletion of water resources are the main challenges, which need urgent attention. The immunological study gives the proper direction in decision-making processes for problems like pollution control, fish and other aquatic lives. This represents the organic material available in particulate form on which the animal population of aquatic ecosystem depends directly or indirectly. The studies of physico-chemical parameters are used to detect the effects of pollution on the water quality.

It is well known that water bodies have played a crucial role in the growth and development of society. All settlements across the globe have started along water bodies and rivers. However it is true that the water bodies have undergone degradation in modern times. Urban growth, increased industrial activities, intensive farming and over use of fertilizers in agricultural productions are identified as drivers responsible for degradation. Increasing urbanization coupled with industrialization during past few years have resulted into depleting water ecosystems of major cities.

Water supply systems are important, but at the same time wastewater treatment systems are also equally important. Approximately 80% of water turns to waste water after its utilization. This wastewater should be properly treated before discharging into any water body. In case of river as a receiving body, when waste water is discharged on upstream side of river, downstream community uses the same water from the river for its day to day needs. Hence it is very much important that wastewater should be properly treated before discharging into river and maintaining sanctity of river. The sewage either seeps into the soils or pollutes ground water or it flows through streams and rivers and pollutes surface water.

2. Materials and Method

For quantitative analysis of Karamana River water, various samples were collected from the station Mankattukkadavu (station1), Kundamankadavu (Station 2), Near Siva temple (station3), Thiruvallam (Station 4) and Pallichal (Station 5). The study was carried out in pre-monsoon (March) and South West monsoon (July) period in 2009. Surface water samples and sediment samples were collected from the sampling stations. For the analysis of physic-chemical parameters, the surface water samples collected in new white colored 1L pearl pet bottles using clean buckets and in sterilized glass bottles, for the bacteriological parameter study. The sediments were collected in plastic polythene cover with the help of Van Veen Grab. For bacterial analysis, the samples were kept in an icebox and analysis was carried out within 24 hrs. Preservation and transportation of the water samples to the laboratory were as per standard methods (Trivedy and Goel (1984) and APHA, 1998). The analysis is carried out for
determination of physico-chemical properties of Karamana River water such as: temperature transparency pH, total hardness nitrates, Phosphate etc. The temporal distribution of salinity, TSS, TDS, DO, BOD, turbidity, pH, temperature, alkalinity, hardness and dissolved nutrients of surface water and sediments etc. Physicochemical parameters of these samples were determined by using standard procedure (Rain and Thatcher, 1990; Rao, 1993; Clescerl et al., 1993; Pelczer et al., 1986; Jain and Jain, 2007)

1. pH: The pH is determined by Elico, model LI.120 Digital pH meter which gives direct value of pH.
2. Temperature: The temperature is measured by using mercury filled Celsius thermometer with an accuracy of 0.1ºC.
3. Conductivity: The conductivity is determined by using digital conductivity meter. The Conductivity meter used is Lavibond made Senso Direct Con.200.
4. Turbidity: It can be determined by using turbidity meter.
5. Total Solid: Total solid consists of suspended solid and dissolved solid. This is determined by weight difference method. The 50 ml water sample has been taken in evaporating dish. The total water is evaporated. Whatever total solid matter is present gets accumulated at the bottom of the evaporating dish. After cooling the evaporating dish to room temperature it is again weighed. By weight difference method the total solid present in water is determined.
6. Total Dissolved Solid: The 50 ml of water sample is filtered through ordinary filter paper and water is collected in the evaporating dish of known weight. Further it is heated and water is totally evaporated. Whatever dissolved solid matter is present gets accumulated at the bottom of evaporating dish. The evaporating dish is cooled and weighed. By weight difference method the total dissolved solid is determined.
7. Total Suspended Solid: This can be determined by the weight difference of total solid and total dissolved solid. TSS = TS – TDS
8. Total Hardness: The 50 ml water sample is titrated against 0.01M EDTA (Disodium Salt) solution by using EBT as an indicator. The EDTA of Qualigens is used with 98% purity. This gives the total hardness of water.
9. Permanent Hardness: The 250 ml water sample is boiled to reduce the volume to 100 ml. It is filtered through ordinary filter paper. This results in removal of temporary hardness. The filtrate is diluted to 250 ml with doubly distilled water. Permanent hardness is determined as above. Now it is possible to evaluate the temporary hardness of the water.
10. Alkalinity: The alkalinity of water sample is determined by titrating it against standard acid solution using indicators like phenolphthalein and methyl orange.
11. Chloride content: The chloride content of water sample is determined by titrated the water sample against 0.02M silver nitrate solution using potassium chromate as an indicator.
12. Sulphate content: The sulphate content in the water sample is determined by using nephelometer.
13. Metal Ions: Metal ions are detected by flame photometry and atomic absorption Spectroscopy. The absorption of energy by ground state atoms in the gaseous state forms the basis of atomic absorption spectroscopy. When a quantitative analysis is to be performed, the sample is atomized and the absorption is measured exactly in same condition.
14. Biochemical Oxygen Demand: Dissolved Oxygen is determined by Winkler method both at the start and after incubation at 200°C in a BOD incubator.
15. Dissolved Oxygen: The percentage of DO is determined by using Lavibond made Senso Direct Oxi.200.
3. Result and Discussion

Monitoring water resources will quantify water quality, density impairments and help policy markers make land use decisions that will not only preserve natural areas, but improve the quality of ate. The fate and transport of many anthropogenic pollutants are determined by not only hydrological cycled, but also physic chemical processes. In order to migrate the impacts of human societies have natural waters, it is becoming increasingly important to implement comprehensive monitoring regimes. The monitored values of physicochemical parameters of Karamana River water samples are noted in the following tables (Table1, 3, 3 & 4).

Table 1: Physicochemical parameters of water samples of Karamana River (Pre-monsoon)

| Parameters          | Stn.1 | Stn.2 | Stn.3 | Stn.4 | Stn.5 |
|---------------------|-------|-------|-------|-------|-------|
| Temperature         | 29.7  | 29.9  | 30.2  | 30.8  | 31.0  |
| pH                  | 6.5   | 6.5   | 6.7   | 6.7   | 6.9   |
| Conductivity (mhos) | 92    | 142   | 121   | 232   | 252   |
| DO (mg/L)           | 4.8   | 4.9   | 4.0   | 4.8   | 5.1   |
| OD (mg/L)           | 0.42  | 1.88  | 2.87  | 3.04  | 1.4   |
| TDS (mg/L)          | 56    | 75    | 72    | 149   | 280   |
| TSS (mg/L)          | 17    | 28    | 31    | 40    | 43    |
| Total hardness (mg/L)| 32    | 42    | 71    | 44    | 48    |
| Total Alkalinity    | 26    | 30    | 42    | 72    | 114   |
| SO₄ (mg/L)          | 0.49  | 0.82  | 1.18  | 1.52  | 2.48  |
| NO₃-N (mg/L)        | 0.12  | 1.12  | 1.98  | 1.12  | 1.78  |
| PO₄g/l (mg/L)       | 0.06  | 0.27  | 0.19  | 1.19  | 1.52  |
| Total Iron          | 1.10  | 1.08  | 1.28  | 2.09  | 2.52  |

Table 2: Physicochemical parameters of water samples of Karamana River (Monsoon)

| Parameters          | Stn.1 | Stn.2 | Stn.3 | Stn.4 | Stn.5 |
|---------------------|-------|-------|-------|-------|-------|
| Temperature         | 28.5  | 28.8  | 29.0  | 28.9  | 29.4  |
| pH                  | 6.5   | 6.8   | 6.8   | 6.7   | 6.9   |
| Conductivity (mhos) | 72    | 83    | 90    | 128   | 209   |
| DO (mg/L)           | 4.9   | 5.0   | 4.4   | 4.9   | 5.4   |
| OD (mg/L)           | 0.24  | 1.44  | 2.51  | 2.89  | 1.19  |
| TDS (mg/L)          | 41    | 50    | 58    | 70    | 112   |
| TSS (mg/L)          | 24    | 39    | 42    | 56    | 60    |
| Total hardness (mg/L)| 31    | 34    | 62    | 38    | 51    |
| Total Alkalinity    | 22    | 28    | 36    | 48    | 92    |
| SO₄ (mg/L)          | 0.79  | 0.86  | 0.98  | 1.61  | 2.60  |
| NO₃-N (mg/L)        | 0.24  | 1.68  | 2.81  | 1.46  | 2.61  |
| PO₄g/l (mg/L)       | 0.36  | 0.39  | 1.19  | 1.01  | 1.12  |
| Total Iron          | 1.69  | 1.51  | 1.61  | 1.92  | 2.24  |
**Table 3:** Physicochemical parameters of Sediments samples of Karamana River (Pre-monsoon)

| Parameters                  | Stn.1 | Stn.2 | Stn.3 | Stn.4 | Stn.5 |
|-----------------------------|-------|-------|-------|-------|-------|
| Sand (%)                    | 19.5  | 14.6  | 9.8   | 16.2  | 35.2  |
| Silt (%)                    | 34.2  | 35.5  | 26.2  | 29.6  | 26.2  |
| Clay (%)                    | 39.2  | 41.2  | 48.3  | 38.8  | 27.6  |
| Sed. Organic Carbon (%)     | 0.49  | 0.48  | 0.98  | 0.80  | 0.9   |
| Total N (mg/Kg)             | 24    | 41    | 28    | 37    | 73    |
| Total – P (mg/Kg)           | 0.61  | 0.39  | 0.48  | 1.62  | 2.56  |

**Table 4:** Physicochemical characteristics of sediment sample of Karamana River (Monsoon)

| Parameters                  | Stn.1 | Stn.2 | Stn.3 | Stn.4 | Stn.5 |
|-----------------------------|-------|-------|-------|-------|-------|
| Sand (%)                    | 30.9  | 32.2  | 30.7  | 29.6  | 34.7  |
| Silt (%)                    | 40.7  | 38.2  | 42.4  | 47.6  | 38.1  |
| Clay (%)                    | 24.2  | 23.9  | 22.9  | 19.3  | 20.5  |
| Sed. Organic Carbon (%)     | 0.34  | 0.48  | 0.42  | 0.63  | 0.39  |
| Total N (mg/Kg)             | 27.8  | 34.1  | 32.8  | 38.9  | 78.2  |
| Total – P (mg/Kg)           | 0.59  | 0.63  | 0.97  | 0.52  | 2.19  |

3.1 **Temperature:** Temperature is an important water quality parameter and is relatively easy to measure water bodies will naturally show changes in temperature seasonally. The variations in temperature of Karamana River water in the studied stretch did not show wide spatial difference the range being 28.5 to 31°C. During the pre-monsoon period highest temperature was vertical temperature could be due to open nature of the site and due to the hot climate in the pre-monsoon.

![Water temperature graph](image)

**Figure 1:** Water temperature broadly varied from 29.7°C at station 1 to 31°C at station 5 during per-monsoon and during monsoon it varies from 28.5 °C at station 2 to 30 °C at station.
3.2 pH: In natural waters, the pH scale runs from 0 to 14. A pH value of 7 is neutral; a pH less than 7 is acidic and greater than 7 represents base saturation or alkalinity. The principal component regulating ion pH in natural waters is the carbonate, which comprises \( \text{CO}_2 \), \( \text{H}_2\text{CO}_3 \) and \( \text{HCO}_3^- \) (APHA, 1995). The distribution in pH clearly showed that the waters have no or very slight influence of salinity even at Karamana, Generally, tropical waters tend to have low pH. Lower values in pH are indicative at high acidity, which can be caused by the deposition of acid forming Substances in precipitation. A high organic content will tend to decrease the pH because of the carbonate chemistry. As microorganisms break down organic material, the by product will be \( \text{CO}_2 \) that will dissolve and equilibrate with the water forming carbonic and \( \text{H}_2\text{CO}_3 \). Most metals will become more soluble in water as the pH decreases. The excesses of dissolved metals in solution will negatively affect the health of the aquatic organisms. pH values recorded in the river water is in agreement with the pH values reported for other fresh water systems of Thiruvananthapuram District (Krishnakumar, 1998) and elsewhere in Kerala (Sreejith et al., 1998).

![Figure 2: The pH of water fluctuated between 6.5 to 6.9 at stations 2, 4 and 5 during pre-monsoon and between 6.8 at station 2 and 6.1 at station 5 during monsoon.](image)

3.3 Conductivity: Conductivity in natural waters is the normalized measure of the waters ability to conduct electric current. This is mostly influenced by dissolved salts such as sodium chloride and potassium chloride. The conductivity ranged from 92 mhos to 252 mhos and 72 to 209 mhos respectively at station 1 to 5 stations during Pre-monsoon and monsoon seasons. High conductivity during pre-monsoon might be attributed to saline intrusion from sea at Karamana and slight reduction in the station during monsoon might be due to fresh water input from rain. There was a positive correlation between conductivity and TDS of the water samples.

3.4 Dissolved oxygen: DO is indicative of the health of an aquatic system, the vital metabolism of aerobic organisms, respiration depends purely on the amount of oxygen dissolved in the water. Optimum concentration of dissolved oxygen is essential for maintaining aesthetic qualities water as well as for supporting life. Considerably high DO range (4.8 to 5.11 mg/liter in Pre-monsoon and 5.0 to 5.5 mg/liter in monsoon) noticed in the
present study during monsoon was indicative of the influence of rain flushing the water of Karamana River.

**Figure 3:** Conductivity ranged from 92 µmhos to 252 µmhos to and 72 µmhos to 209 µmhos respectively at station 1 to station 5 during pre-monsoon and monsoon seasons.

High DO near Thiruvallam might be attributed to the open nature of the confluence and resultant high dissolution of atmospheric oxygen in the water similar observation was made by Mini et al. (2003) from certain locations of Vamanapuram River, Kerala, Sharp fall in DO in water could put the biotic communities under serve stress (Virendra et al., 2003)

**Figure 4:** Dissolved Oxygen ranged from 4.0 mg/L at station 3 to 5.1 mg/L at station 5 during pre-monsoon and 4.4 mg/L at station 3 to 5.4 mg/L at station during monsoon

**3.5 BOD:** BOD is used as the index of organic pollution of waste water that can be decomposed by bacteria under anaerobic conditions (Sladeck et al., 1982) BOD showed a narrow fluctuation between 0.42 mg/liter and 0.24mg/liter at station I to 1.4 mg/liter and 3.19 mg/liter at station 5 respectively during pre-monsoon and monsoon seasons. Very low BOD
was observed in one station and high BOD at all the other Stations indicated the influence of ret effluents in those. However there seem ample almost same with the high BOD due to the decomposition of organic matter and decay of vegetation in Indian rivers.

![Figure 5](image)

**Figure 5:** BOD showed a narrow fluctuation between 0.42 mg/L at station 1 to 1.04 mg/L at station 5 during pre-monsoon and between 0.24 mg/L at station 1 and 1.19 mg/L at station 5 during monsoon season.

### 3.6 TDS:
Water with a high total dissolved solids indicated more ionic concentration, which is of inferior palatability and can induce an unfavorable physicochemical reaction in the consumers. Kataria *et al.*, (1996) reported that increase in value of TDS indicated pollution by extraneous sources. The high amount of dissolved, suspended and total solids of samples adversely affects the quality of running water and it is unsuitable for any other purpose irrigation and drinking. Value as high as 623 ppm was noticed from another Tamil Nadu River during September 2003. Total suspended solids, that determine the depth to which photosynthetic organisms grow, or the photic zone of a lake.

![Figure 6](image)

**Figure 6:** Total dissolved solids (TDS) in water samples varied between 56 mg/L at station 1 to 280 mg/L at station 5 during pre-monsoon. In monsoon TDS varied from 41 mg/L at station 1 to 112 mg/L 5.
3.7 Total Suspended Solids: Turbidity or total suspended solids (TSS) is the material in water that affects the transparency or light scattering of the water. The range for natural water is 1 to 2000 NTU. The measurement unit used to describe turbidity is Nephelometric Turbidity Unity (NTU). TSS is typically composed of fine clay or silt particles, plankton, organic compounds, inorganic compounds or other microorganisms. These suspended particles range size from 10nm to 0.1nm. TSS as well as TDS can be influenced by changes in pH. Changes in the pH will cause some of the solutes to precipitate or will affect the solubility of the suspended matter. Suspended solids in the runoff pollutants greatly influence the Turbidity of the receiving water which in turn affects the light penetration resulting in reduced photosynthesis (Patel et al., 1983). TSS ranged from a minimum of 17.0 mg/liter are station 1 to maximum of 43mg/liter at station 5 during Pre-monsoon and 24mg/liter at station 1 to maximum to 60mg/liter at station 5 during monsoon.

![Figure 7: TSS ranged from a minimum of 17 mg/L at station 1 to a maximum of 43 mg/L at station 5 during pre-monsoon and 24 mg/L at station 1 to 60 mg/L station 5.](image)

3.8 Alkalinity: In the study area, total alkalinity valued ranged from 26 mg/liter (stations 1) to 71 mg/liter (stations 5) and 20 mg/liter (station 1) to 49 mg/liter (stations 5). Total alkalinity observed in the present study is well within the prescribed standards of drinking water (> 120mg/liter) alkalinity is imparted more by the presence of Co$_2$ suggesting the decay of organic matter is the prominent activity elevating alkalinity in natural waters. It is also important that alkalinity resulting from naturally occurring ions like co$_3$ and HCO$_3$ are not considered as a health hazard for drinking purposed.

3.9 Nitrate: Nitrate pollution will cause Eutrophication of a stream where algae and aquatic plant growth will consume the oxygen and increase the TSS of water Eutrophication is usually the result of nitrate and phosphate contamination and is a significant reduction of water quality. Nitrate can exist naturally in ground water but can exist naturally in ground water but can increase dramatically on irrigated lands. The nitrate concentration on the present study ranged from as low as 0.12 mg/liter and 0.24mg/liter in Kundaman Kadavu to 1.78 mg/liter and 2.61 mg/liter in Pallichal respectively during Pre monsoon and monsoon season.
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Figure 8: Total Hardness also was the minimum (32 mg/L) at station 1 when station 3 showed the maximum value (71 mg/L) during pre-monsoon and 31 mg/L at station 1 to 51 mg/L at station 5 during monsoon.

The comparatively high value on stations like Pallichal and Thiruvallom could be attributed to anthropogenic sources, viz run off waters, discharge of effluents from retting activity containing nitrogen species and their subsequent oxidation by microbiological activity under aerobic conditions. Nitrate and phosphate are essential for the growth of blue green algae.

Figure 9: Total alkalinity fluctuated between 26 mg/L at station 1 to 114 mg/L at station 5 during pre-monsoon and 22 mg/L at station 1 to 92 mg/L at station 5 during monsoon.

3.10 Sulphate: High concentration of SO$_4^{2-}$ could cause a cathartic action on human beings and can also cause respiratory Problems. In this study, the average sulphate concentration of the river was 0.49 to 2.48 Mg/liter during pre monsoon and 0.79 to 0.20 mg/liter during
monsoon. The increase in concentration and run off waters from agricultural lands might have also contributed to overall sulphate content in the river water.

**Figure 10:** Sulphate content narrowly varied between 0.49 mg/L at station 1 and 2.48 mg/L at station 5 during pre-monsoon and 0.79 mg/L at stations 1 and 2 and 2.60 mg/L at station 5.

**3.11 Phosphate:** The main environmental impact associated with phosphate pollution is Eutrophication. In organic phosphate in surface water fluctuated between 0.06 to 0.36 mg/liter in Kudamankadavu during pre monsoon and 1.08 to 1.01 mg/liter in Thiruvallam during monsoon seasons respectively. This indicated that the phosphate bearing contaminants such as detergents get accumulated at Thiruvallam during both the season. The wide spatial fluctuation in nitrate, phosphate and sulphate values observed in the present study reveals the localized mode of contamination in the river. This is particularly so for orthophosphate since it is attached to setting particles (Hamilton and Mitchell 1997). Similar result of the localized influence in the water quality of Bharathpuzha River has been reported by Babu *et al.* (2003).

**Figure 11:** Nitrate concentration in surface waters varied from 0.12 to 1.78 mg/L during pre-monsoon and 0.24 to 2.61 mg/L during monsoon. The lowest value was recorded from 1 when the highest value was noticed was noticed at station 3.
3.12 Iron: Total iron concentration varied from 1.08 to 2.52 mg/liter in pre monsoon and 1.51 to 2.21 mg/liter in monsoon. The highest concentration being at station 5 considering the standard limit (0.3mg/liter) of dissolved iron prescribed by WHO 1984). In drinking water and investigations done in other fresh water like Sasthamkotta and Cellur (Sreejith et al., 1998) and Vellayani (Krishnakumar, 1998) in Kerala state. Many of the values observed in the present study are high. However the high rate of surface run off might be attributed to the high iron content in waters.

![Graph of Inorganic Phosphate Content](image)

**Figure 12:** Inorganic phosphate in surface waters fluctuated between 0.06 mg/L at station 1 and 1.52 mg/L at station 5 during pre-monsoon and between 0.36 and 1.12 mg/L at same stations during monsoon season.

3.13 Sediment Chemistry: Percentage composition of sediments showed a minimum of 908% sand at station 3 near Karamana and a maximum of 35.2% at Pallichal during pre-monsoon and 29.6% at Thiruvallam and 34.7% at Pallichal during monsoon. Silt content varied from a minimum of 26.2% at station 3 and a maximum of 35.5% at station 2 during pre-monsoon and 38.1% at Pallichal to 47.6% at Thiruvallam during monsoon. Clay contents varied between 27.6% at Pallichal to 48.3% at station 3 near Karamana during pre-monsoon and 19.3% at station 4 and 24.2% at station 1 during monsoon. The current study shows that the sediment deposited which depicts the organic matter input due to obvious weed growth and vegetation respectively in the water and on the river banks and its subsequent degradation in the system. The sand content at stations adjacent to Pallichal was high and this might be due to the deposition of sand from the upstream stations and from the coast. During monsoon clay seemed to be washed by the rain and therefore the dominance of sand and silt in most stations.

The percent organic carbon in sediments varied from 0.48% at station 2 to 0.98% at station 3 near Karamana during pre-monsoon and 0.34% at station 1 to 0.63 % at station 4 during monsoon. Organic debris might have washed have with rain water and attributed to reduction in % organic carbon in monsoon season.
Figure 13: Total iron concentration fluctuated between 1.10 mg/L at station 1 to 2.52 at station 5 during pre-monsoon and 1.69 mg/L at station 2 to 2.24 mg/L at station 5 during monsoon.

The presence of varying sediment types in organic matter distribution has been shown (Ajao and Fagade, 1990) to be highly related to anthropogenic inputs to sedimentary or depositional nature. A study by Paria and Konar (2003) of organic carbon of soil of 13 rivers in West Bengal revealed a range of 0.14 to 1.06%.

Figure 14: Percentage composition of sediments showed 9.8% sand at station 3 and 35.2% at station 5 during pre-monsoon and 29.6% at station 4 and 34.7% at station 5 during monsoon.

However, total nitrogen concentration in sediments showed a slight increase during monsoon possibly due to addition of nitrogenous pollutants through the runoff water. Lowest values (24mg/kg and 27.8mg/kg) were at Manakatukadavu and highest values (73mg/kg and 78.2mg/kg) were at Pallichal during both the seasons. For a basin to be considered

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hypereutrophic, the organic nitrogen concentrations recorded from the sediments indicated the possibility of induced eutrophication.

**Figure 15:** Silt content varied from a minimum of 26.2% at station 3 to a maximum of 35.5% at station 2 during pre-monsoon and 38.1% at station 5 to 47.6% at station 4 during monsoon.

**Figure 16:** Clay content varied from a minimum of 27.6% at station 5 to a maximum of 48.3% at station 3 during pre-monsoon and 19.3% at station 4 to 24.2% at station 1 during monsoon.
Figure 17: The percent organic carbon in sediments varied from 0.9% at station 5 to 0.98% at station 3 during pre-monsoon and 0.34% at station 1 to 0.63% at station 4 during monsoon.

Figure 18: Total nitrogen concentration fluctuated between 24 mg/L at station 1 to 73 mg/L at station 5 during pre-monsoon and 27.8 mg/L at station 1 to 78.2 mg/L at station 5 during monsoon.

Total phosphate content distribution in sediments showed the lowest value at stations 2 and 4 (0.39 in pre-monsoon – 0.52 mg/kg in monsoon) and the highest value (2.56-2.19 mg/kg) at Pallilchal. This shows the deposition of nutrients especially during monsoon season in to the downstream of the river. Available nitrogen and phosphorous in sediments (8.6-31.4 mg/100g and 1.2-8.4 mg/100g respectively was recorded by Paria and Konar (2003) in West Bengal rivers. The sediment containing more than 40 mg/100g of soil of available nitrogen and 5 mg/100g soil of available phosphorous is conducive to growth of fish (Jhingran, 1975; Ghosh 1978). Total nitrogen content in sediments was moderate and this could be attributed to the coir retting activity prevalent in the area.
Figure 19: Total phosphate ranged from 0.39 mg/kg at station 2 to 2.56 mg/kg at station 5 during pre-monsoon and 0.52 mg/kg at station 4 to 2.19 mg/kg at station 5 during monsoon.

4. Conclusion / Suggestions/ Findings

The water temperature in the study was on the rise especially during the pre-monsoon that might support increased weed growth and augment eutrophication possibility. Distribution in pH indicated no influence of salinity till Veli Estuary and the conductivity of the waters was generally low both allowing the algal growth. DO in water at many sites was low possibly due to the organic detritus, weed growth and biomass degradation in the benthic layer. Distribution in pH indicated no influence of salinity till Veli Estuary and the conductivity of the waters was generally low both allowing the algal growth. DO in water at many sites was low possibly due to the organic detritus, weed growth and biomass degradation in the benthic layer. High BOD observed at Karamana and Thriuvallam indicated the influence of ret effluents. However, there seemed ample dilution of pollutants during the monsoon. TSS during monsoon indicated suspended matter being carried downstream while high TDS recorded at Pallichal might be due to the influence of seawater. Anthropogenic sources, viz., discharge of ret effluents and channel precipitation and runoff waters from agricultural lands containing nitrogen species, iron and their subsequent oxidation by microbiological activity under aerobic conditions. This revealed the localized mode of pollution in the river. Sediment composition showed clay as the major constituent depicted the organic matter input due to obvious weed growth and vegetation in water and on the river banks its subsequent degradation in the system. More nitrogen in sediments during monsoon might be due to addition of nitrogenous pollutants through the runoff water, the highest at Pallichal indicating the possibility of induced eutrophication and also high total phosphate in sediments of Pallichal showed the deposition of nutrients especially during monsoon season. Elevated level of water nutrients like nitrate, phosphate, sulphate etc pointing towards development of eutrophication and consequent aria effect like blooming obnoxious algae, depletion of dissolved oxygen of water quality leading to dystrophic condition. Based on the data obtained, visually as the summer progressed, the basins developed masses of vegetation either in the form of algae and submerged macrophytes or weed growth. The result was a basin productivity characterized from a nitrogen and phosphorus perspective as hypereutrophic.
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