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Monitoring of Water Quality Parameters in Uppanar River of Cuddalore District, Tamil Nadu State, India

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ABSTRACT

The Uppanar River is situated in the Cuddalore district of Tamil Nadu, India. The study was conducted to find out the physico-chemical characteristics of the river. 11 physico - chemical variables were analyzed in the water samples collected every month for 3 years during November 2009 - December 2012. Continuous monitoring of the water quality is very important in order to protect the river and it reveals the pollution status of the river. Various parameters like temperature, pH, redox potential, salinity, alkalinity, dissolved oxygen, reactive silicates, total phosphates, nitrate-nitrogen, nitrite-nitrogen and ammonia-nitrogen gave an outline of water quality of the Uppanar River. The results indicated that the water quality of the Uppanar River was moderately polluted might be due to the continuous discharge of municipal and industrial effluents.

Keywords: Physicochemical characteristics; Uppanar River; permissible limits

1. INTRODUCTION

Water is the elixir of life, an essential natural resource for the survival and sustainability of life on earth. Though the water available in the universe is estimated to contain about 1.36 billion km^3, only 3% of the water existing as fresh water in rivers, stream springs and aquifers, is available for human use (Chinedu et al., 2011; Usharani et al., 2010). Among the fresh water only 5% are available for beneficial use. The total water resource available in India is 1850 km^3, which is roughly 4% of the world's fresh water resource (EPA-PWD, 2001). Water is a vital resource for agriculture, manufacturing and other human activities to lead life. Fresh water resources are deteriorating day-by-day at a faster rate which is a frightening global problem at present (Mahananda et al., 2010). Almost 70% of India's surface water resources have been contaminated by biological, organic and inorganic pollutants (Agarwal and Saxena, 2011; Joseph and Jacob, 2010).

The addition of various kinds of pollutants and nutrients through the agency sewage, industrial effluents, agricultural runoff etc, into the river bodies brings about a series of changes in the physicochemical characteristics of water (Mullai et al., 2011, 2012; Singh et al., 2010). Once the surface water is contaminated, its quality cannot be restored by stopping the pollutants from its source. Hence, continuous monitoring of the water quality becomes crucial in order to protect it (Yisa and Jimoh,

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2010). In Indian estuaries and seas the physico-chemical characteristics have been determined by many researchers (Damotharan et al., 2010; Khare et al., 2011; Mahananda et al., 2010; Manikannan et al., 2011; Sankar et al., 2010; Shraddha et al., 2011). In the present study, the influence of effluent discharge on physico-chemical characteristics in the Uppanar River was investigated from November 2009 to December 2012.

2. METHODOLOGY

2.1 Study area

The Uppanar river is situated at Cuddalore (N 11° 43'E; N 79° 46'E) (Figure 1), 180 Km South of Chennai and 25 Km South of Pondicherry. This river flows between Cuddalore town and most part of Chidambaram Taluk and confluences with the Bay of Bengal through a mouth of Gadilam River. It runs behind the SIPCOT (State Industrial Promotion Corporation of Tamil Nadu Limited) industrial complex covering an area of about 700 acres with 70 industries (Mullai et al., 2013). It is specifically established for chemical, petrochemical, fertilizers, pharmaceutical, dyes, soup, detergent, packing materials resins, pesticides, drugs, antibiotics etc., manufacturing industries. Most of the industries are wet process industries and they consume large quantity of water for their manufacturing process. The effluents of these industries are released untreated into the estuary. In addition to the industrial wastes, the estuary receives also the municipal wastes and domestic sewage from Cuddalore old town.

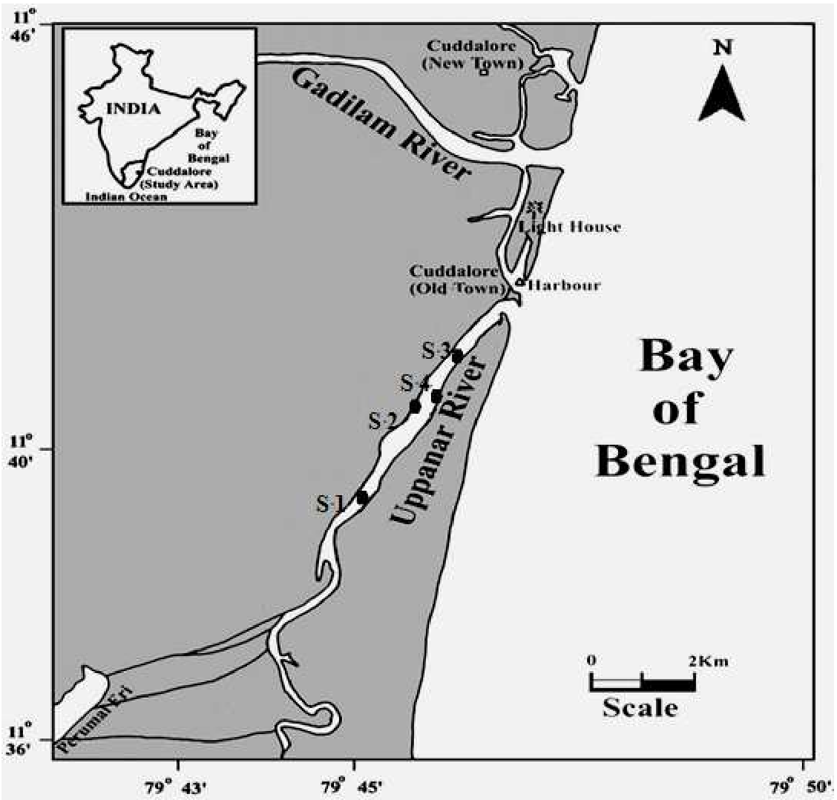

Figure 1 Study area of the River Uppanar, southeast coast of India

2.2 Sampling stations

The four sampling stations, namely S1 – between SIPCOT and Uppanar Estuary (N 11º42’11.4” E 079º46’18.6”), S2 – at the start of the SIPCOT industrial complex (N 11º39’28.0” E 079º44’59.7”) , S3 – near the port office of the Uppanar Estuary (N 11º42’11.8” E 079º46’18.3”) , and S4 – near the site of plantation (N 11º43’51.4” E 079º46’18.8”) were selected along Uppanar River, as shown in Figure 1.

2.3 Sampling and analysis

Surface water samples were collected in acid washed polythene bottles from 4 stations for every 30 days at the selected locations along Uppanar River. Water samples were analyzed for water temperature, redox potential, hydrogen ion concentration (pH), dissolved oxygen, salinity, alkalinity, relative silicate (Strickland and Parsons, 1972), total phosphorus (Murphy and Riley, 1962), nitrate - nitrogen, nitrite - nitrogen, and ammonia - nitrogen according to the standard procedure of APHA (1995).

3. RESULTS AND DISCUSSION

3.1 Temperature

Temperature is one of the important physical factors as it regulates the rate of photosynthesis and also affects the chemical and biological reactions in water. The temperature variation may influence the physico-chemical characteristics, distribution and abundance of flora and fauna (Manikannan et al., 2011; Soundarapandian et al., 2009). Water temperature recorded was more or less similar at all the stations but fluctuated during the sampling period (Figure 2). The maximum temperature recorded was 32.1°C during May 2010 and 2011 at station I; March 2011 at station IV and minimum temperature was 24.2°C during October 2012 at station I. At many sampling time points, temperature was recorded above 25°C, exceeding the WHO (1984) permissible limits. The maximum temperature could be attributed to high solar radiation, evaporation, freshwater influx and cooling and mixing up with ebb whereas the minimum temperature was due to sea breeze and precipitation (Damotharan et al., 2010; Sankar et al., 2010). This variation in water temperature might be because of an increase in rate of chemical reaction and nature of biological activities, since temperature governs the assimilative capacity of the aquatic system (Adefemi and Awokunmi, 2010; EPA, 1976).

3.2 pH

pH is an important parameter in evaluating the acid - base balance of water. The hydrogen ion concentration (pH) ranged from 6 to 9.8 at all the 4 stations (Figure 3). The lowest pH 6 recorded at station III during February 2012 might be due to the dilution of alkaline substances or dissolution of atmospheric carbon dioxide, also due to the influence of effluent from the industries (Kumar et al., 2010), whereas the highest pH 9.8 indicating the alkaline nature of water during December 2009 at Station II might be due to high temperature that reduces the solubility of CO_2, the influence of fresh water influx, dilution of sea water, low temperature and organic matter decomposition. The observed results exceeded the permissible limit of ICMR, 1975 (6.5 - 8.5) at some sampling stations. Similar trend in pH was reported by Gasim et al. (2007) from Bebar river, Malaysia, Prabu et al. (2008) from Pichavaram mangroves, Damotharan et al. (2010) from Point Calimere coastal waters, Sundaramanickam et al. (2008) from Parangipettai and Cuddalore coast of India and Yadav and Srivastava (2011) from river Ganga. A change in water pH affects the aquatic life indirectly by altering water chemistry which in turn alters the dissolved oxygen level in the water, photosynthesis of aquatic plants, metabolic rates of aquatic organisms.

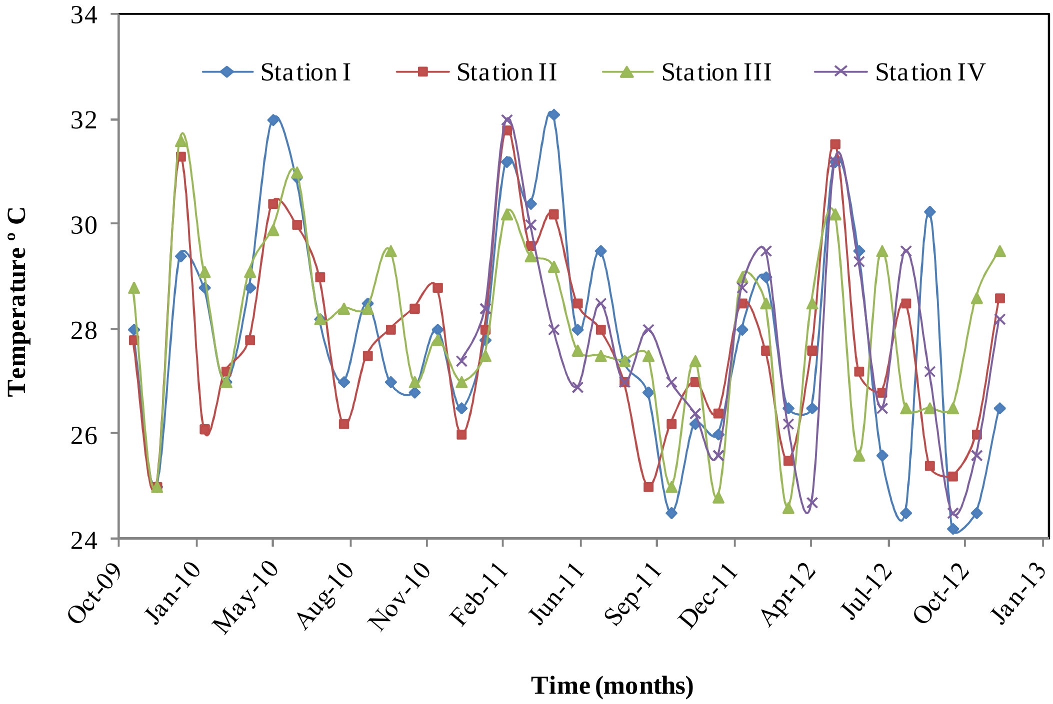

Figure 2 Monthly variations of temperature in the study area during the study period

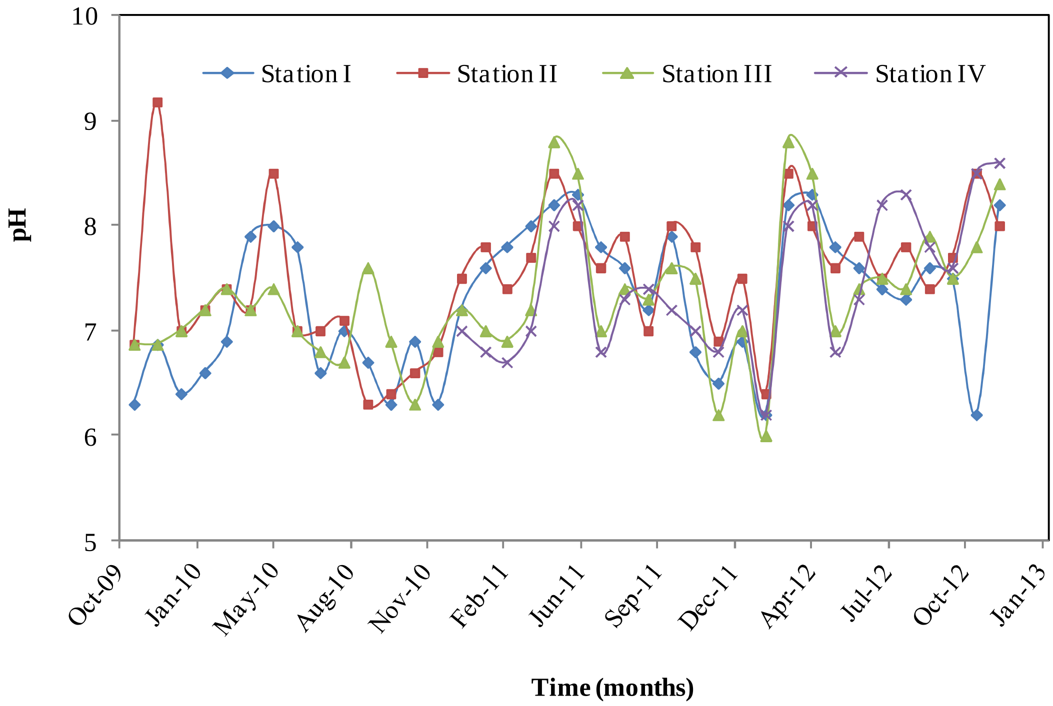

Figure 3 Monthly variations of pH in the study area during the study period

3.3 Redox potential

Redox potential measurement is an excellent indicator of TDS, which is a measure of salinity that affects the taste of potable water. The redox potential of water samples at station I, station II, station III, and station IV showed wide variations from 4.2 mv to 49 mv (Figure 4). The lowest Eh was seen at station II during June 2010 whereas highest Eh was recorded at station I during September 2011. The highest redox potential might be due to its proximity to sea and high influx of surface run off (Adefemi and Awokunmi, 2010; Chinedu et al., 2011; Shraddha et al., 2011; Yadav and Srivastava, 2011). This indicated that the river water had different quality at different locations and also between different aquifers (Gasim et al., 2007).

3.4 Salinity

Salinity is the measure of the salt content of water. Salinity of the Uppanar river ranged from 0 ppt to 29.1 ppt during the study period (Figure 5). The maximum salinity was recorded during November 2009 at station II and minimum was during March 2010 at station I. The lower salinity was due to heavy rainfall and large quantity of fresh water inflow (Manikannan et al., 2011; Soundarapandian et al., 2009). The high value of salinity could be due to low amount of rainfall, higher rate of evaporation and also due to intrusions into the river (Chinedu et al., 2011; Damotharan et al., 2010; Sankar et al., 2010).

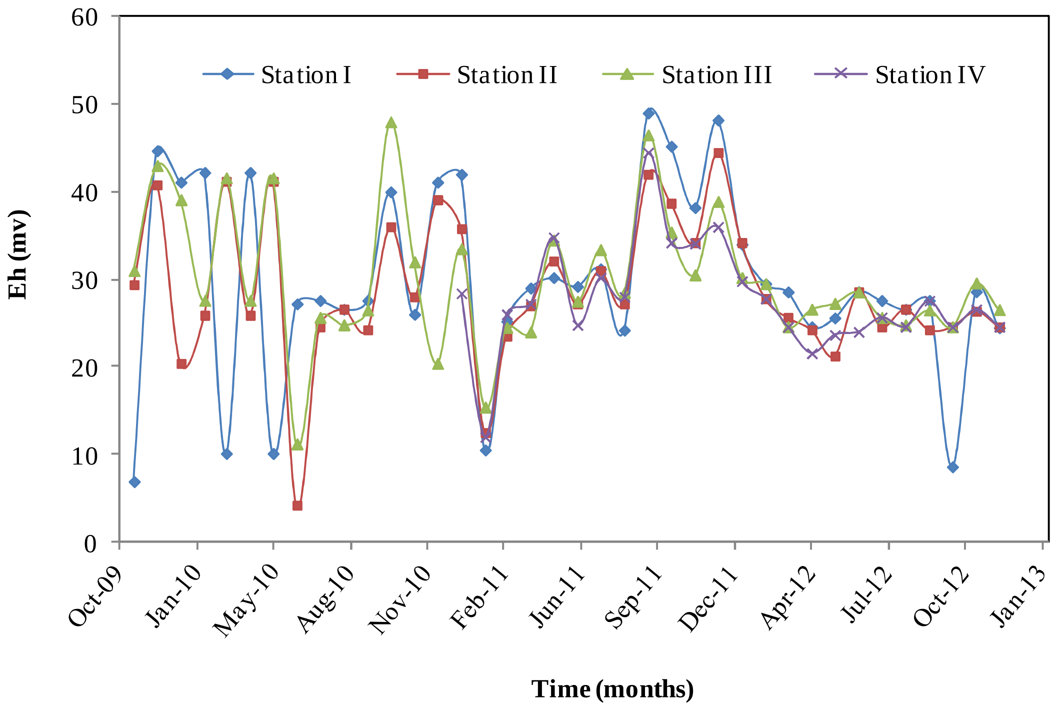

Figure 4 Monthly variations of redox potential in the study area during the study period

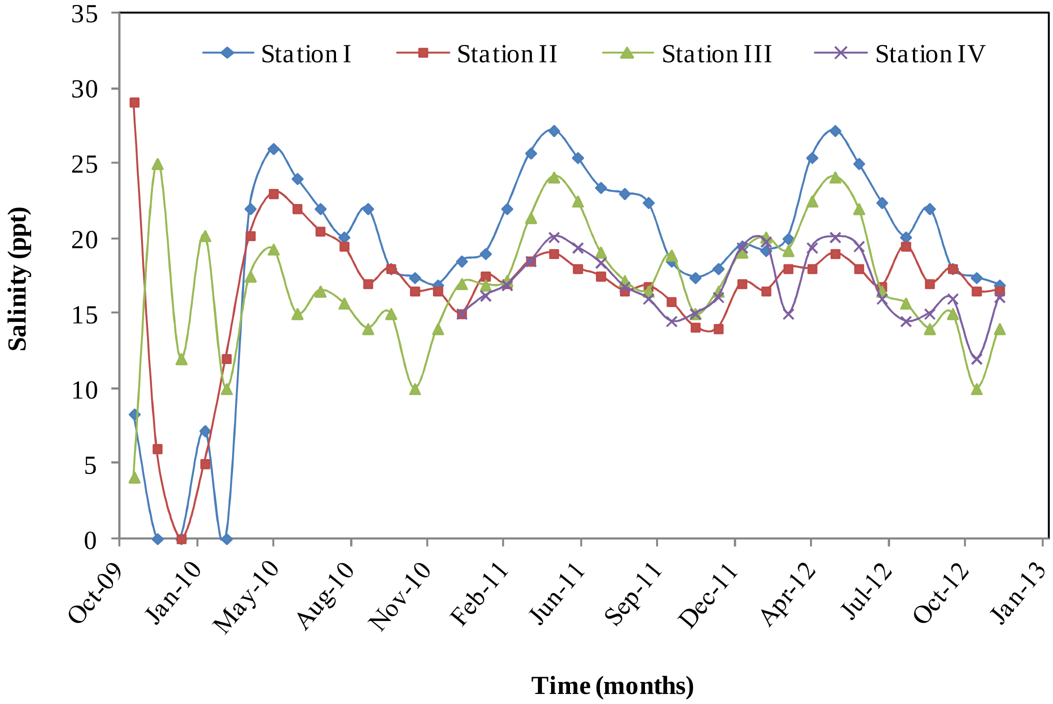

Figure 5 Monthly variations of salinity in the study area during the study period

3.5 Alkalinity

Alkaline nature of water provides an idea of natural salts present in the water. In this study, the maximum alkalinity of 80 mg/L was recorded during November 2010 and 2012 at station II, and during December 2009 at station III. The minimum alkalinity of 20 mg/L at station III was observed during November 2009 and May 2010 (Figure 6). Alkalinity values were within the permissible limits ICMR, 1975 (120 ppm). This is in accordance with the findings of Chandra et al. (2011), Khare et al. (2011), Mahananda et al. (2010) and Umamaheswari et al. (2009).

3.6 Dissolved oxygen (DO)

Dissolved oxygen in natural and waste water depends on the physical, chemical and biological activities in the water body. The maximum DO concentration of 3.8 mg/L was recorded at station I during December 2010 and 2012; and the minimum DO of 1.2 mg/L was at station III during June 2010 and August 2010 and 2012 (Figure 7). DO contents in all samples exceeded the permissible limit of IS: 10500, 1991 (6 mg/L). These fluctuations in DO concentration could be due to anthropogenic activity in and around the Uppanar River and also due to turbulence flow patterns. The lower DO value might be due to the high rate of oxygen consumption by oxidisible matter and higher level of nutrient load. As that of the present work, lower DO values were observed by Chandra et al. (2011), Mahananda et al. (2010), Yadav and Srivastava (2011), but fluctuation in DO concentration was seen in the work of Singh et al. (2010), Sundaramanickam et al. (2008) and Umamaheswari et al. (2009).

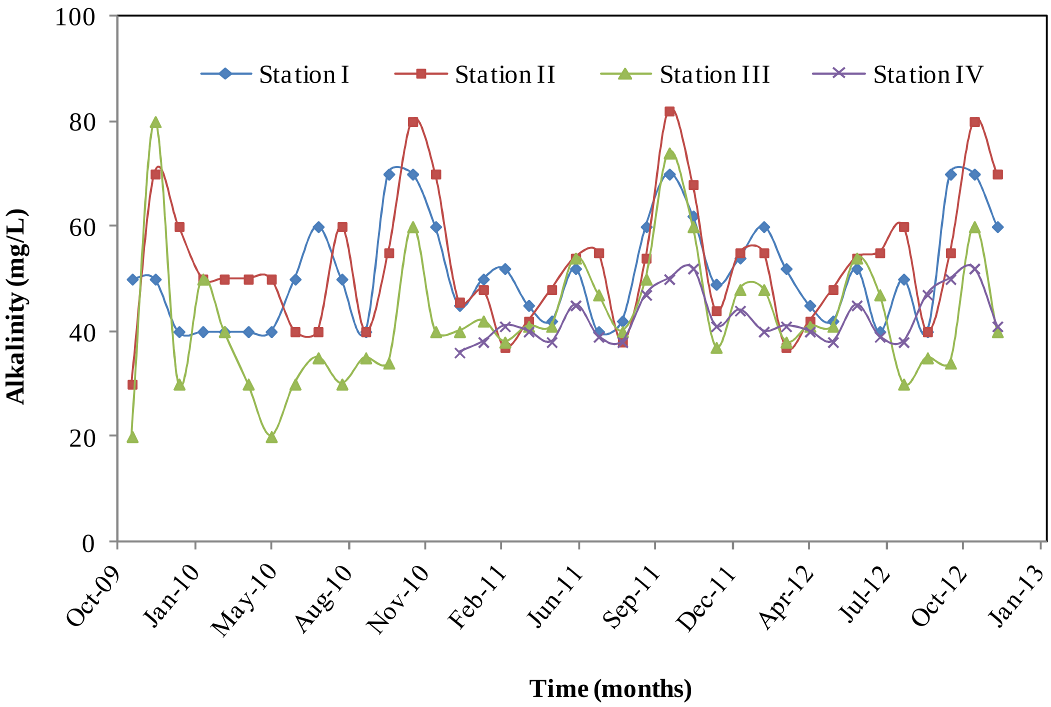

Figure 6 Monthly variations of alkalinity in the study area during the study period

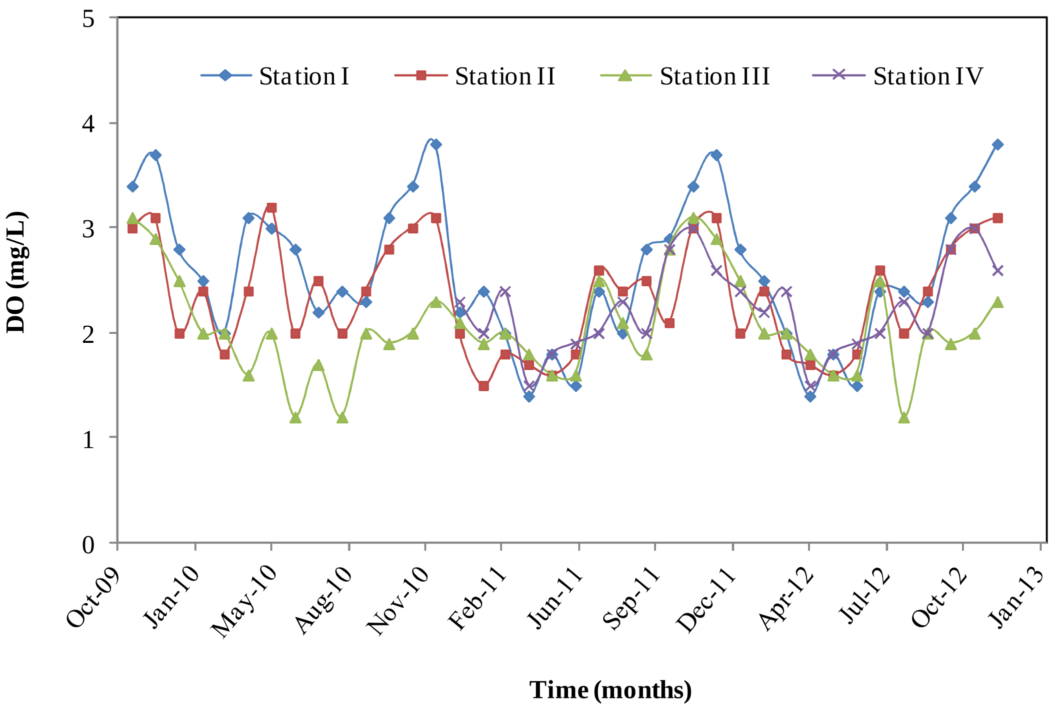

Figure 7 Monthly variations of DO in the study area during the study period

3.7 Reactive silicate (Primary productivity)

Silicon plays an important role in the productivity of aquatic ecosystem. Silicon found in the form of reactive silicates ranged between 0.84 and 48.59 mg/L during September 2010 and 2012. From the obtained values we can infer that the fluctuation in silicate concentration could be seen at all four stations during the study period (Figure 8). The higher silicates values were due to heavy inflow of freshwater from land drainage carrying silicate leached out from rocks and also from the bottom sediment (Damotharan et al., 2010; Sankar et al., 2010). This finding corroborates well with the results of Nayak et al. (2004) and Sundaramanickam et al. (2008) in their work on physico-chemical analysis of the river water.

3.8 Total phosphate

A range of 0.41 - 49 mg/L of total phosphate was recorded at station II during January and June 2010 and at station I during July 2011 and 2012 respectively (Figure 9). Phosphate values in many samples exceeded the standard limit of (0.1 mg/L) US Public Health Standards (De, 2002).The high amount of total phosphate during July - September 2010 and 2011 at all the four stations might be due to pollution dispersion from the surrounding area and this gradual increase of total phosphate concentration was due to the effect of excess of land drainage, runoff from agricultural areas, human use and sewage discharges into the Uppanar River. The possible sources of phosphate to rivers were firm rock deposit, runoff from surface catchments and interaction between the water and sediment from dead plant and animal remains at the bottom of rivers (Adeyemo et al., 2008). But the higher amount of phosphate represents high pollution loads and causes eutrophication of the aquatic body. Similar trend of increase in total phosphate concentration were documented by Sithik et al. (2009), Usharani et al. (2010) whereas Sundaramanickam et al. (2008), Shraddha et al. (2011), Yadav and Srivastava (2011) reported less variation in total phosphate concentration.

3.9 Nitrate – Nitrogen

Nitrate is a form of nitrogen and a vital nutrient for growth, reproduction, and the survival of organisms. The maximum of 26.04 µg/L of nitrate was observed during March and May 2010, October 2011 at station II whereas the minimum nitrate concentration of 1.21 µg/L was observed during September 2010, June 2011 and 2012 at station II (Figure 10). Nitrates were found to be within the permissible limits of 10 mg/L (IS: 10500, 1991; WHO, 1984). The highest nitrates value was mainly due to the organic materials receiving from the catchment area during rainfall, fresh water inflow and litter fall decomposition. Another possible way of nitrates entry was through oxidation of ammonia form of nitrogen to nitrite formation (Joseph and Jacob, 2010; Mahananda et al., 2010; Manikannan et al., 2011). The low values might be due to its utilization by phytoplankton as evidenced by high photosynthetic activity (Sithik et al., 2009; Sankar et al., 2010; Umamaheswari et al., 2009).

3.10 Nitrite – Nitrogen

The nitrite concentration varied between 0.053 µg/L and 0.88 µg/L during September 2010 and 2012 at station II and during August 2010 and 2012 at station III. Throughout the study period, the nitrite levels recorded at all stations (Figure 11) were within the permissible limit of WHO, 1984. The higher nitrite concentration might be due to increased planktonic organisms excretion, oxidation and reduction of ammonia and nitrate respectively, and also due to bacterial decomposition of planktonic detritus. In addition to this, increase in nitrate concentration at the surface water layer might also be due to denitrification and by air-sea interaction of exchange of chemical elements (Damotharan et al., 2010; Manikannan et al., 2011; Sundaramanickam et al., 2008). The low nitrite concentration was might be due to lesser amount of freshwater inflow and high salinity (Sankar et al., 2010; Shraddha et al., 2011).

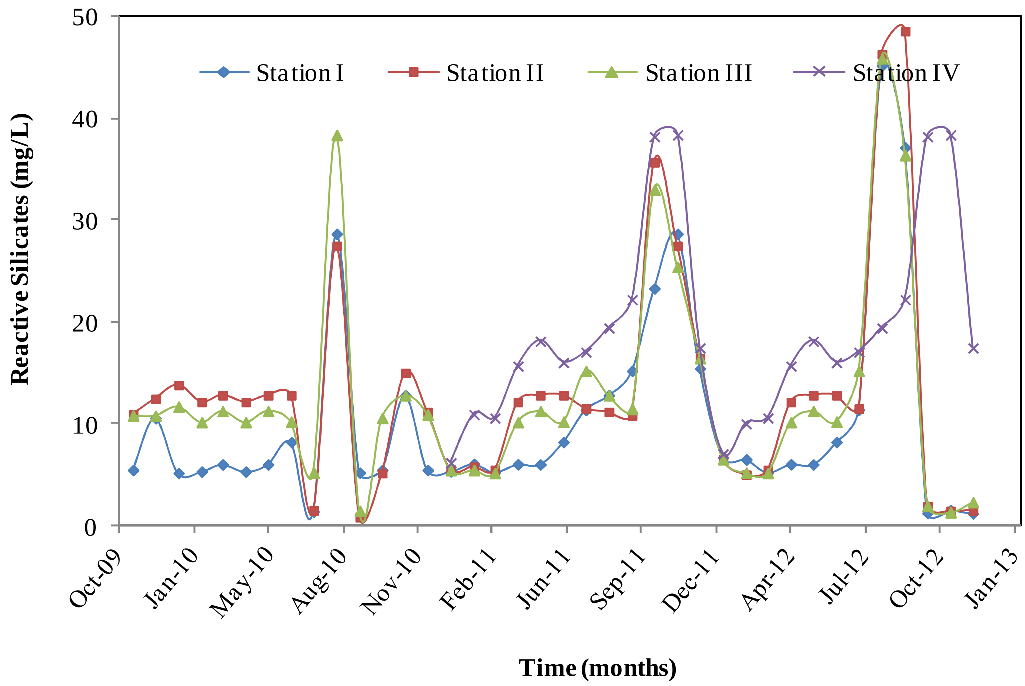

Figure 8 Monthly variations of reactive silicates in the study area during the study period

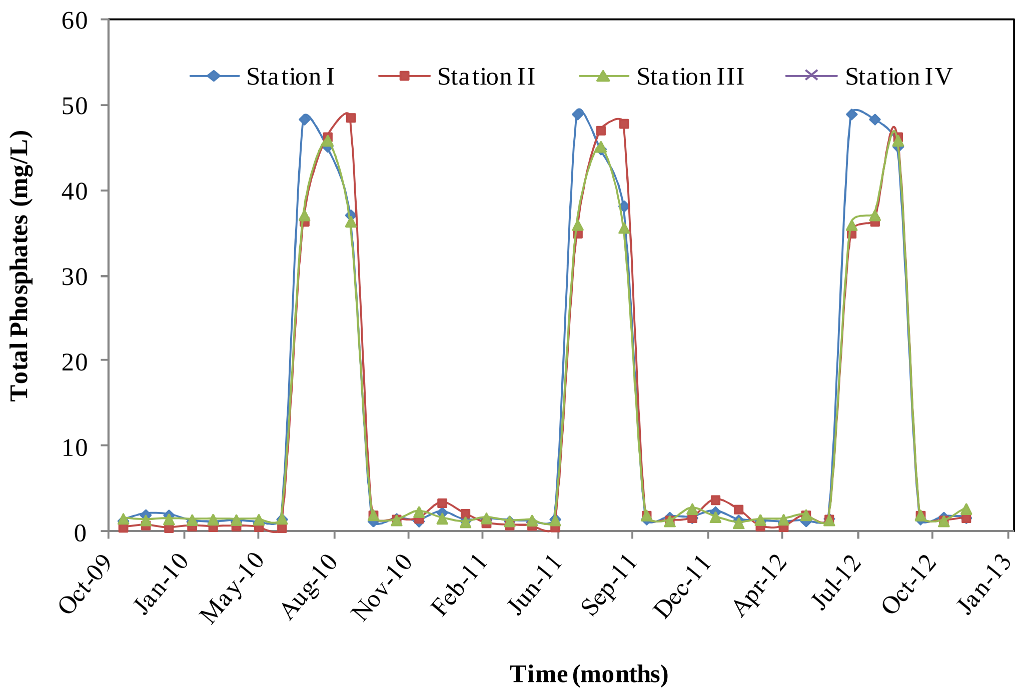

Figure 9 Monthly variations of total phosphate in the study area during the study period

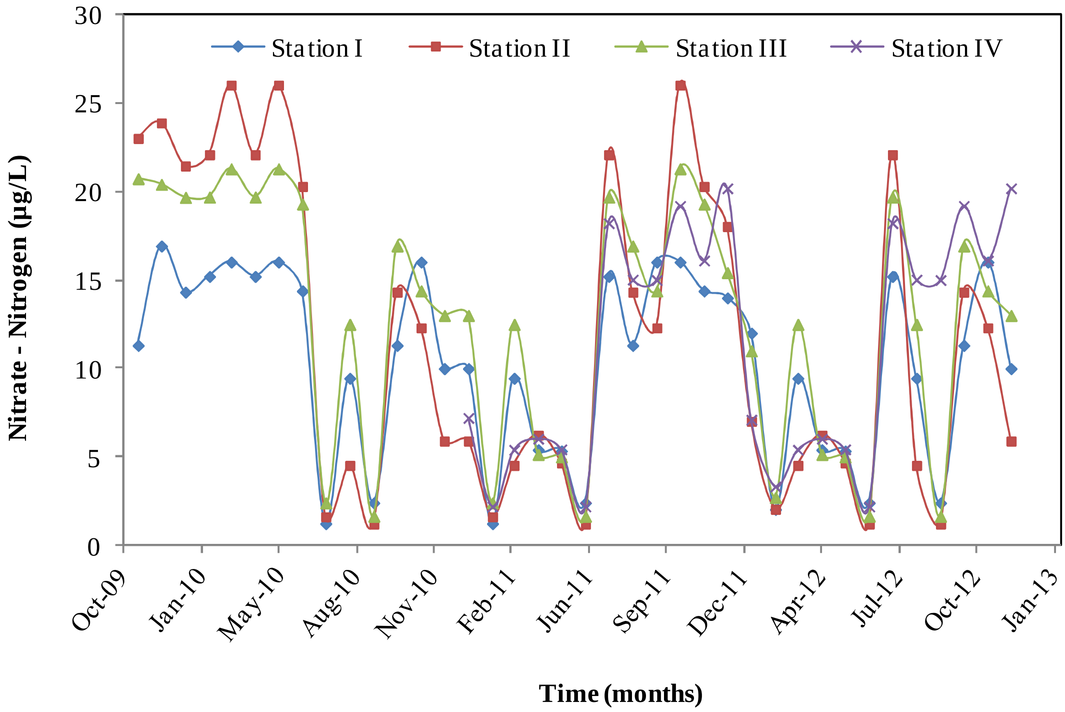

Figure 10 Monthly variations of nitrate nitrogen in the study area during the study period

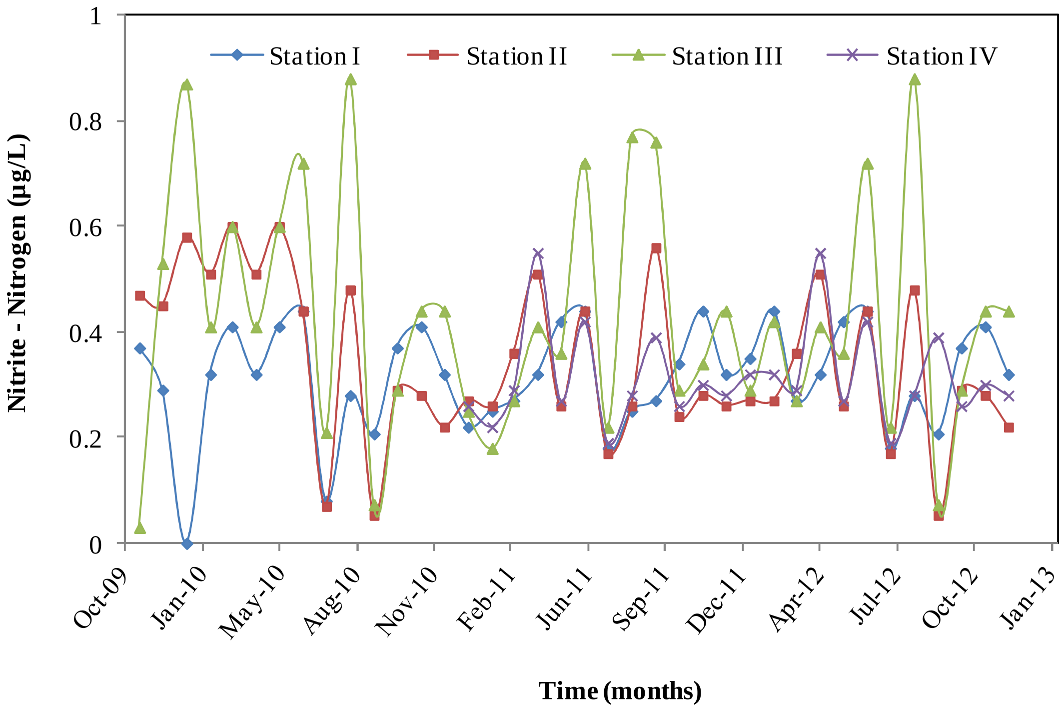

Figure 11 Monthly variations of nitrite nitrogen in the study area during the study period

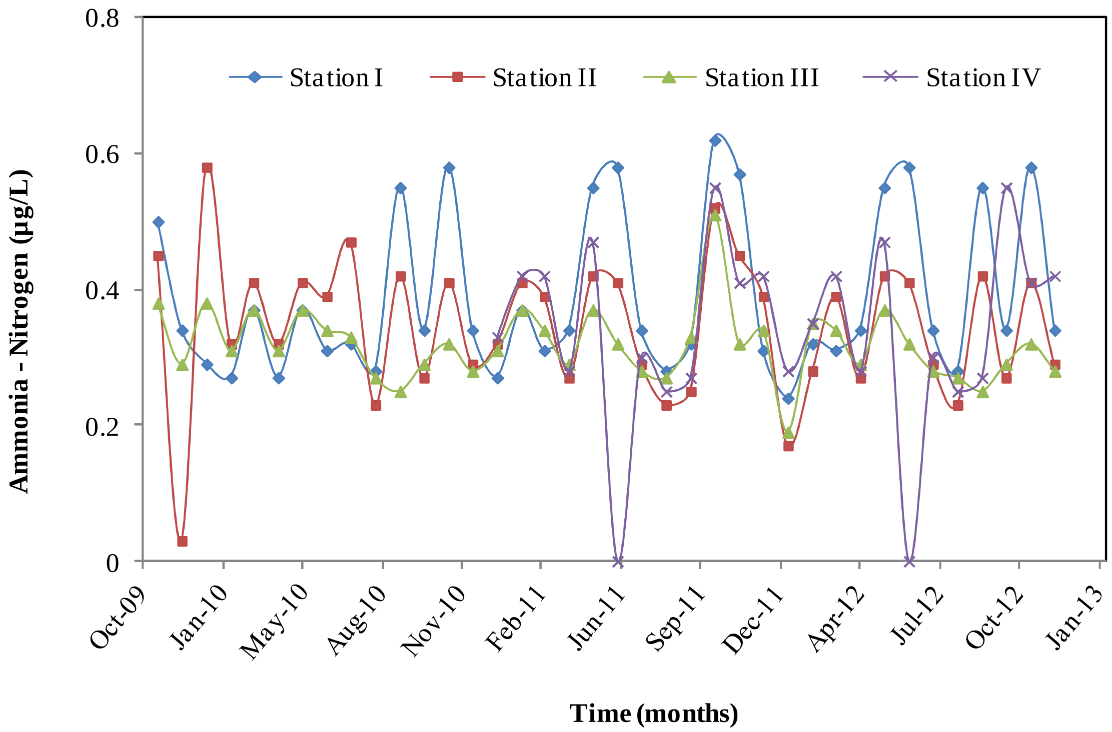

Figure 12 Monthly variations of ammoina nitrogen in the study area during the study period

3.11 Ammonia – Nitrogen

The ammonia - nitrogen concentration observed during the study period ranged between 0.23 - 0.62 µg/L. The maximum concentration was found at station II during August 2010, 2011 and 2012 whereas the minimum concentration was found at station I during October 2011 (Figure 12). There was not much variation in the concentration during the study period that was almost within the permissible limit of WHO, 1984. Sithik et al. (2009) and Sundaramanickam et al. (2008) reported higher ammonia concentration which may be due to death and decomposition of phytoplankton, and also due to the excretion of ammonia by phyto planktonic organism (Damotharan et al., 2010).

From the findings of the present study, it is known that the Uppanar River was moderately polluted. The National Water Policy of 2002 enacted by the Government of India aimed at meeting the challenges that have emerged in the development and management of water resources including water pollution. If the Government enforces the existing water policy strictly, the rivers can be restored. It is suggested to undertake mangrove plantation programme along the coast on estuarine habitats with *Avicennia marina* and *Rhizophora mucronata*. It will help the remediation of river pollution due to anthropogenic influences such as industrial development, municipal waste disposal, agricultural waste and domestic run-off.

CONCLUSIONS

As the physico-chemical characteristics of a few of the river water samples exceeded the maximum permissible limit, it could be concluded that the Uppanar River was polluted moderately. Further increase in the pollution concentration poses a serious threat to the aquatic organisms and especially water quality of Uppanar River. The results would form a useful tool for the eradication of pollution.

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