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STUDIES ON THE POLLUTION LEVELS IN ARIYANKUPPAM BACKWATER, PUDUCHERRY REGION

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Abstract: A systematic investigation in the pollution level at Ariyankuppam backwater from March 2011 to February 2012 was carried out. The untreated domestic wastes from various parts of the Ariyankuppam town are directly discharged into the river which leads to an increased level of pollution. The present studies emphasis on the magnitude of pollution by monitoring key water quality parameters such as dissolved oxygen, temperature, pH, salinity, B.O.D, C.O.D and Chlorophyll content. Monthly water samples were collected from three different sampling stations, which give the information about the rate of pollution and its influence on the aquatic environment .Water temperature recorded for the entire study period showed a wide variation and ranged between 24° C to 29.5° C. The range of salinity varied between 260 to 3055 ppm. The pH level shows more alkaline during the month of December due to rain and less alkaline during the month of March. Some of the characteristics like DO, BOD, and nutrient loading are causes for eutrophication process in this backwater, found to be eutrophic throughout the year.

1.0 Introduction

The Union territory of Puducherry is located on the eastern coastal region of Peninsular India. Initially agriculture and fishing formed the major source of income for this region. In the recent years due to economic growth the trend has shifted to rampant industrialization and urbanization thereby putting pressure on natural resources and also causing environmental degradation. A standing example for this uncontrolled pollution is the Ariyankuppam river which is highly polluted mainly due to untreated discharge of industrial effluents, domestic waste water and agricultural drainage which dilutes and enters during rainy season (Giridhar, 2001).The Ariyankuppam river also serves as a tidal inlet, a serious health hazard to marine biotas and human are experienced due to these pollutants (Beiras *et al*., 2003; Capuzzo *et al*., 1985; Rama Devi *et al*., 1996; Tran *et al*., 2002; Williams, 1996). Some of the salt water fish tends to come inside the tidal inlet for breeding during this period the fishes gets severely affected by these pollutants and also large cases of fish mortality were witnessed. It is also reported that the fish growth is decreasing in the coastal waters of the Puducherry region. Consumption of fish thriving in polluted coastal waters also will deteriorate the human health (Gowri and Ramachandran, 2001). Therefore it is required to assess and study the level of pollution in the Ariyankuppam river, in order to make further recommendations for controlling the quality of wastewater disposal. The source pollution into the Ariyankuppam river can be stated as: Pollutants from fixed point sources from wastewater from municipal and domestic effluents, organic, inorganic, and storm water runoff. Pollutants from non-point sources as Nutrients through fertilizers, toxic pesticides, and other chemicals, mainly from agriculture runoff; organic pollution from human settlements located along the periphery of the backwater (Reddy and Char 2006). Nevertheless, it is observed that human activities are the major factor in determining the quality of the surface and groundwater through atmospheric pollution, effluent discharges, use of agricultural chemicals, and land use (Sillanpää et al. 2004). Eutrophication is most often the result of an elevated supply of nutrients, particularly nitrogen and phosphorus, to surface waters that results in enhanced production of primary producers, particularly phytoplankton and aquatic plants. The abundance of organic compounds, toxic chemicals, radionuclides, nitrites, and nitrates in potable water may cause adverse effects on human health such as cancer, other human body malfunctions, and chronic illnesses (Ikem et al. 2002). Although aquatic ecosystems are equipped with a variety of physicochemical and biological mechanisms to eliminate or reduce adverse effects of toxic substances, toxicants may evoke changes in development, growth, reproduction, and behavior and may even cause death of freshwater organisms (Rand et al. 2003). The primary objective of this study is to assess and study the nature, intensity and extent of physical, chemical and biological pollutants of the Ariyankuppam river at three identified locations which are severally affected by enormous quantity of industrial and domestic wastewater disposal. This study will recommend a method for proper wastewater disposal and protecting the health of coastal ecosystem.

2.0 Study Area

River Sankaraparani, drains into the Bay of Bengal on the southern side of Pondicherry region. Also known as river Gingee or Varahanadhi, it has its source at the hills of Malayanur in the South Arcot District of Tamil Nadu. The River splits off into two branches namely Chunnambar in the south and Ariankuppam River in the north. This river is not a perennial river and it flows only during rainy season and floods. (Source: Drainage Map of Pondicherry, Pondicherry Town Planning Authority)Ariankuppam River and Estuary is situated in Pondicherry, between Latitude 11°55’N and 12°30’N and Longitude 70°05’E and 80°05'E (Fig.1.). This is a fan medium river basin with drainage of about 100Sq.kms. Ariankuppam River, which originates from the River Sankaraparani, at Nallareddy Palayam (about 10 kms from the sea shore) usually gets cut off from River Sankaraparani, during non-monsoon period and the water is more or less stagnant during other seasons. Pondicherry is about 293 sq. km. in aerial extent with a total population of about 0.6 million. Due to tremendous increase of population in this area, the generation of wastewater has also increased. The waste generated from areas near to Ariankuppam River is let out into the river directly, deteriorating the water quality of the river.

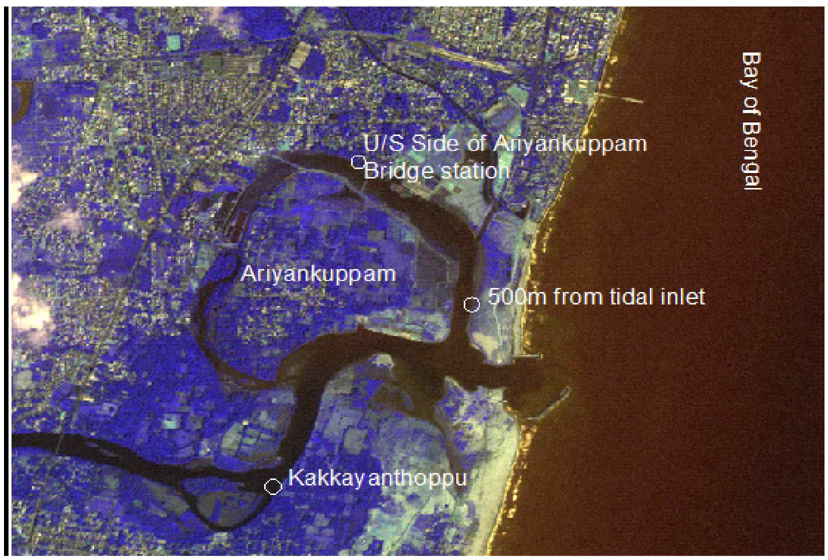

Fig.1. Location Map of Ariyankuppam backwater, Puducherry Region

3.0 Materials and methods

Considering the sources of inflow to the Ariankuppam River, three different sampling sites were selected. The first location, is Kakkaiyanthoppu were maximum settlement near the river is found, which is the main source of domestic effluents which directly gets discharged into the river, the second location is around 500m from the tidel inlet of the river where fish storage godown are present, and the third station was selected near the upstream side of the old ariayankuppam bridge were water gets stagnated due to the construction of new bridge which obstruct the natural flushing of water from the tidal inlet The water sample were collected in polyethylene bottles of 2-l capacity. These samples were transported to laboratory in an ice box to avoid unpredictable changes in physicochemical and biological characteristics. Sampling and analysis were carried out according to standard methods prescribed by World Health Organization. The temperature of the water was measured by using thermometer, the pH was determined by using pH meter, the salinity of water was determined by Salinometer, Dissolved oxygen in water was determined by the Winkler's iodometric method and biochemical oxygen demand determined by 5-day biochemical oxygen demand (BOD) was determined by Reflux method using Pottassium dichromate. Alkalinity was determined by titrometric methods. Phosphates in water were determined by the molybdophosphoric acid method and nitrate determined by brucine method APHA (1985).The total Chlorophyll content was estimated using spectroscopic method(Alimot et al 2000).

4.0 Results and discussions

4.1 Dissolved oxygen

Dissolved oxygen (DO) present in the Ariyankuppam river varied from 2.3 to 7.50 mg/L (Fig.2.) The DO ranged between 2.3 to 5.60 mg/l (Table .1) near the upstream side of the Ariyankuppam bridge, between 2.60 to 7.50 mg/L (Table. 2.) near Kakkayanthoppu area and 2.20 to 5.80 mg/L(Table. 3.) at 500m from the tidal inlet of the Ariyankuppam river (Fig 1). In general during summer, with the increase in water temperature, there was reduction in dissolved oxygen, whereas in winter season, due to decrease in temperature, the level of dissolved oxygen of water body increased. These results are in conformity with Srivastava et al. (2003) and Masood and Krshnamurthy (1990) and showed a positive correlation between temperatures, duration of sunlight, and soluble gases like dissolved oxygen. The depletion of dissolved oxygen by the organic matter that accumulates in the river during dry season resulted in the low level of dissolved oxygen of 2.3 mg/L. The decrease in oxygen may be due to the high loading of organic substances in the inflow from the Urban area settlement near the river upstream and due to obstruction by the construction of new bridge which narrowed the outflow and caused stagnation. The reduction in DO was experienced near the tidal inlet were natural flushing is obstructed due to siltation at the mouth , oil spillage from small boats and presence of fish godown which directly discharge their waste into the river there by contributing enormous amount of organic matters which obstruct the direct sunlight. The natural flushing at Kakkayanthoppu station was not affected by siltation, but due to thick urban settlement and enormous discharge of domestic waste directly into the backwater leads to decrease in DO content. This lack of oxygen is a good indication of the trophic state of the river, which is overloaded with inorganic and organic matter and transforming into a eutrophic water body. The primary production and input of degradable organic substances create a demand for oxygen. The dissolved oxygen profile at Ariyankuppam river indicates unstable oxycline conditions in different months. It is known fact that if dissolved oxygen level is more, then there is definite decrease in BOD.

4.2 Biochemical oxygen demand

In the present investigation, the biochemical oxygen demand in Ariyankuppam river varied from 24.32 to 152.32 mg/L(Fig.3.).The BOD ranged between 60.14 to 152.32 mg/L (Table .1.), 30.48 to 136.52 mg/L(Table.2.), and 24.32 to 144.28 mg/L(Table.3.) for upstream side of Ariyankuppam bridge,Kakkayanthoppu and 500m from tidal inlet stations, respectively. The maximum BOD was recorded in June and continued till September 2010 and minimum was recorded in the months of December continued till March 2010. Biochemical oxygen demand was observed to be maximum in the month of March 2010 near the upstream side of the Ariyankuppam bridge (152.32mg/L) were due to the high rate of evaporation and high temperature together with the high organic load, low level of DO and reduced movement in the water body. The maximum BOD (144.28 mg/L) at the station 500m from the tidal inlet was found during the Month of March and continued till May2010 due to clogging of the mouth and high nutrient concentration by source such as waste from fish godown and domestic waste from Urban settlement. The Kakkayanthoppu station has a maximum demand in BOD (136.52mg/L) during the month of May 201 0 and continued till July mainly due to domestic effluent. The minimum biochemical oxygen demand was recorded at the three station in the month of December 2010) may be due to the onset of monsoon and natural flushing of water. In general, the biochemical oxygen demand levels indicate low concentrations of biodegradable organic matter, high oxygen consumption by heterotrophic organisms, and a high rate of remineralization of organic matter. As in the case of shallow tropical water body in northeast Mexico (Zavala et al. 2000), the lakes and rivers in towns and cities increaesingly serve as sinks for domestic sewage, municipal, and industrial wastes. Most of the lakes and rivers in India are seriously polluted with high BOD levels. Similarly, many rivers in India have levels of DO as low as 0–2 mg/l and BOD levels as high as 50–200 mg/l.

4.3 Chemical oxygen Demand

COD is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water via chemical oxidation. The COD values ranged between 187 to 742 mg/L at the study area of the Ariyankuppam backwater (Fig.4). The value of COD at Ariyankuppam upstream side bridge station was between 187 and 320 mg/L(Table .1.), the Kakkyanthoppu sample station was between 430 and 742 mg/L(Table .2.) and at 500m from tidal inlet was between 220 and 680. mg/L(Table .3.) The COD value for all the three sample stations which appear to be higher than the acceptable limit (250 mg/ L) during March and continued till November 2011 (Figure). The high COD values show the presence of maximum concentration of organic matter, which ultimately causes bad effect on marine organisms (Lester and Harrison, 1990). Though the COD values exceed the permissible limit in most of the sampling locations, there is a significant decrease in COD concentration observed during December and continued decreasing till the first week of January. A large quantity of fresh water input as a result of monsoonal storm in last week of September and heavy rain during the month of December might have enhanced dilution of coastal waters to some extent, and thus decrease in COD values during September till January.

4.4 pH

pH is the negative logarithm of the hydrogen ion concentration in the sample. The pH value at the study area of the Ariyankuppam backwater ranged between 7.32 to 8.95(Fig.5.). The pH level ranged between 7.48 to7.32 mg/L(Table.1.) at the upstream side of Ariyankuppam bridge station , 7.66to8.95mg/L(Table.2.) at the Kakkayanthoppu station, and 7.2 to 8.22 mg/L(Table.3.),at station 500m from the tidal inlet respectively. For upstream side of Ariyankuppam bridge station the nature of water found to be moderate Alkaline for the entire year. For Kakkyanthoppu station, the pH value the water was found to be more Alkalined in the month of August 2010 and continued till Jan2011, At station 500m from tidal inlet ,the pH value the water was found to be more Alkaline in the month of September and continued till December, while the water sample was found to be less Alkaline during the month of March. High alkalinity values are indicative of the eutrophic nature of the Kakkayanthoppu station might be due to the presence of excess of CO2 produced as a result of decomposition processes coupled with mixing of sewage and Domesticl effluents. The higher value at the station 500m from the tidal inlet may be due to clogging of the tidal mouth by sediments which makes the water to get stagnated and enormous dumping of sewage waste and effluent from fish Godown. Whenever there is increase in dissolved oxygen levels, there is definite increase in alkalinity Singh (2000), as shown in in Table 1and Fig. 5.

4.5 Water temperature

The water temperature recorded for the entire study period showed a wide variation between 24°C to 29.5°C (Fig. 6). The temperature recorded at the upstream side of Ariyankuppam bridge station ranged between 25.4°C to 29.5°C (Table 1). Higher temperature at this station was recorded during the month of March and continued till the month of June may be due to higher rate of evaporation and stagnation of water and high organic loading. The temperature recorded at the Kakkayanthoppu station ranged between24.3°C to 28.6°C (Table.2.), higher temperature recorded in this station was during the month of April may be due to enormous organic loading by the urban settlement. The temperature recorded at the station 500m from tidal inlet ranged between24.0°C to 28.9°C (Table.3.), shows a sharp increase in temperature during the month of April may be due to clogging at the mouth of the tidal inlet and organic loading by urban settlement and dumping of waste from fish godown. Sharp fall in temperature was observed during the month of December which is due to rain in the study area. Increase in temperature there is a reduction in the level of dissolved oxygen due to the high rate of evaporation and enhanced by high organic load and reduced movement in the water body Srivastava et al. (2003) and Masood and Krshnamurthy (1990).

4.6 Salinity

The observed salinity values at the Ariyankuppam backwater ranged from 260 to 3146 ppm respectively (Fig.7). The lowest value of salinity were observed at the upstream side of the Ariyankuppam bridge in the last week of November and continued till third week of December and highest salinity values were observed in the same station from the month of Feb and continued till May, respectively (table 1). The increase in salinity from February to May was noticed in this station, which could be attributed to low freshwater influx during post-monsoon and summer, whereas dilution of coastal water by addition of fresh water from the backwaters during NE monsoo period cold be the reason for lower salinity values observed during October to January. The value of salinity observed at Kakkayanthoppu station ranged between 520 to 3100 ppm (Table.2.). The salinity in this region remained almost constant during summer and continued till September. It started decreasing from the month of October reaching a minimum in November. The value of salinity recorded at the station 500m from tidal inlet ranged between 962 to 3219 ppm (Table.3.). The lower salinity was recorded during the month of November may be due to fresh water discharge, the higher salinity was observed from the February and continued till May. The freshwater discharge from rivers causes a decline in the salinity of the surface water (La Fond 1954) during the monsoon and in the subsequent months, the restoration occurs as the salinity continuously increase up to May/June, as recorded in the present study. The significant decrease in salinity values during October/November is not only contributed by the local precipitation during NE monsoon also due to precipitation from further regions which inundates the river. A similar behaviour of salinity in the coastal water from other regions has also been reported by Varma andReddy (1959) and Subramanyan and Sen Gupta (1965).

4.7 Biological pollutants

The municipal sewage wastes containing millions of coliforms are directly disposed into the Ariyankuppam river, which degrades the aquatic environments. Chlorophyll a is a measure of the green pigments (Chl a) present in all photosynthesizing algae in the aquatic environment. The scale for the criteria is good <15µg/L, fair 15–30µg/L, poor >30µg/L. It is observed that the Chl a concentrations exceed the permissible limit in the Kakkyanthoppu station (14.2mg/L)(Table.2.), at upstream side of bridge station (18mg/L)(Table.1.) and at 500m station from tidal inlet (16mg/L)(Table.2.) during September and October. Chl *a* reached notably high levels at all sample locations before monsoonal storm prevailed over these areas (Fig.8.), may be due to organic loading which enhances in Algae growth. The sewage-contaminated river belt exhibit higher concentrations posing significant health hazards to aquatic organisms and humans. Although many of these microbial pathogens survive only for hours to several days in seawater, they remain viable for longer periods in backwater dwelling fish and salt water fish which come to the tidal inlet for breeding (Kennish, 1994).

Month	Do	BOD	COD	pH	Salinity	Temperature	Chl *a* mg/L
March 2011	2.3	152.32	320	7.32	3055	29.3	3.75
April	2.63	138.94	318	7.38	3162	29.5	3.40
May	3.4	118.18	315	7.42	3146	29.4	3.21
June	3.2	120.63	298	7.40	2800	29.0	2.78
July	3.4	126.97	310	7.38	2567	28.0	2.57
August	3.67	136.75	287	7.42	2932	27.0	2.14
Sept	3.92	112.83	272	7.43	2865	27.4	12.32
Oct	3.87	121.32	287	7.38	2500	27.8	18.00
Nov	4.97	89.34	254	7.45	260	26.3	1.76
Dec	5.60	60.14	187	7.48	1069	25.4	1.62
Jan 2012	4.88	72.67	194	7.44	1878	25.6	3.77
Feb	4.32	88.52	220	7.46	3000	26.8	2.66

Table 1: **L**evels of various chemical and biological pollutants of the Upstream Side of Ariankuppam river (March 2011 – Feb 2012)

Month	Do	BOD	COD	pH	salinity	Temperature	Chl *a* mg/L
March 2011	2.60	135.16	742	7.66	2894	28.3	6.4
April	2.74	128.65	657	7.82	2772	28.6	5.3
May	2.72	136.52	700	7.80	2654	28.0	4.6
June	2.98	125.16	680	7.87	2683	27.5	4.3
July	2.95	133.54	710	7.83	2852	27.0	4.7
August	3.26	96.53	680	8.18	2863	26.4	4.3
Sept	3.49	83.56	630	8.37	2752	26.8	12.0
Oct	5.83	76.51	590	8.64	1532	26.3	14.2
Nov	6.92	52.13	570	8.75	520	25.4	1.8
Dec	7.50	30.48	430	8.95	1290	24.3	2.41
Jan 2012	6.71	48.97	450	8.89	2022	24.8	1.26
Feb	5.34	57.19	460	7.99	3100	25.8	6.19

Table 2: **L**evels of various chemical and biological pollutants of the Upstream Side of Kakayyanthoppu station (March 2011 – Feb 2012)

Month	Do	BOD	COD	pH	salinity	Temperature	Chl *a*
March 2011	2.20	144.28	560	7.21	3219	28.3	2.56
April	2.38	140.37	580	7.46	2432	28.9	2.38
May	2.66	128.33	600	7.53	2367	28.6	2.17
June	3.63	98.97	680	7.48	2588	28.0	2.13
July	3.84	88.69	650	7.83	2432	26.7	2.09
August	4.12	66.73	630	7.89	2512	26.4	2.00
Sept	4.25	50.32	640	8.00	2489	25.8	12.34
Oct	4.74	43.43	500	8.07	1781	25.4	16.00
Nov	5.31	37.84	430	8.16	962	24.6	1.98
Dec	5.80	24.32	220	8.22	1345	24.0	2.1
Jan 2012	5.40	42.34	228	8.19	1776	24.8	1.0
Feb	4.76	69.54	260	7.99	3100	26.2	1.52

Table 3: Levels of various chemical and biological pollutants of the station 500m from tidal inlet (March 2010 – Feb 2012)

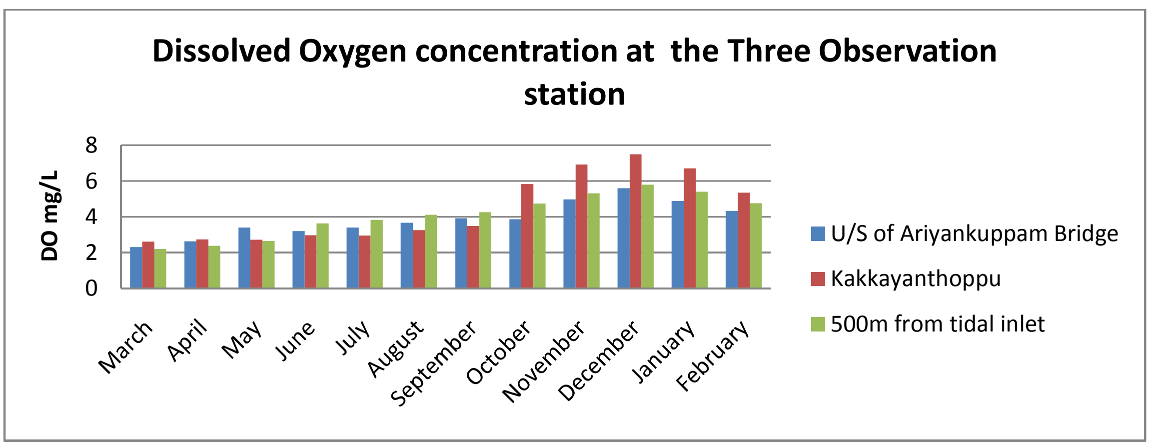

Fig. 2: Comparison of Dissolved Oxygen concentration at the three observation stations

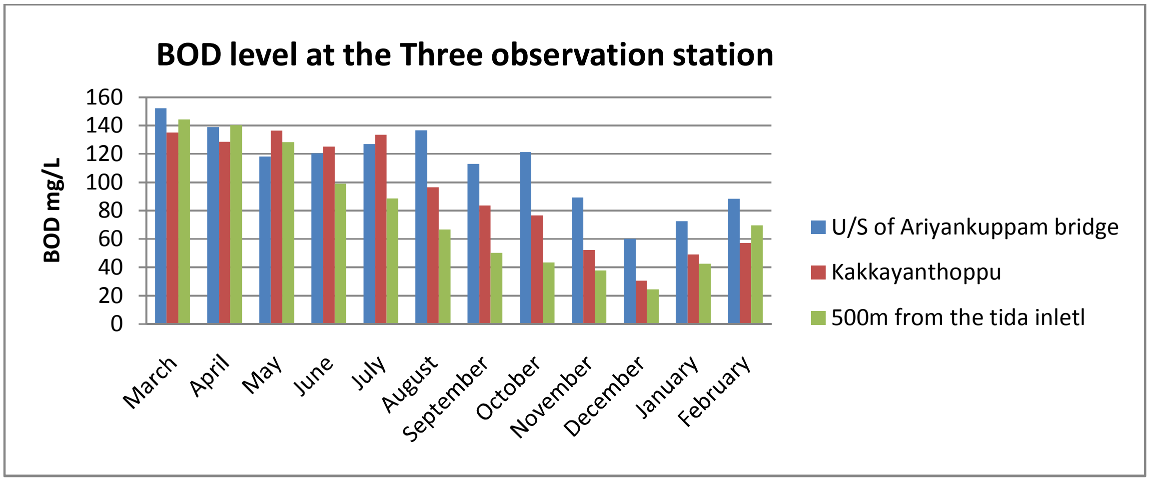

Fig. 3: Comparison of BOD level at the three observation stations

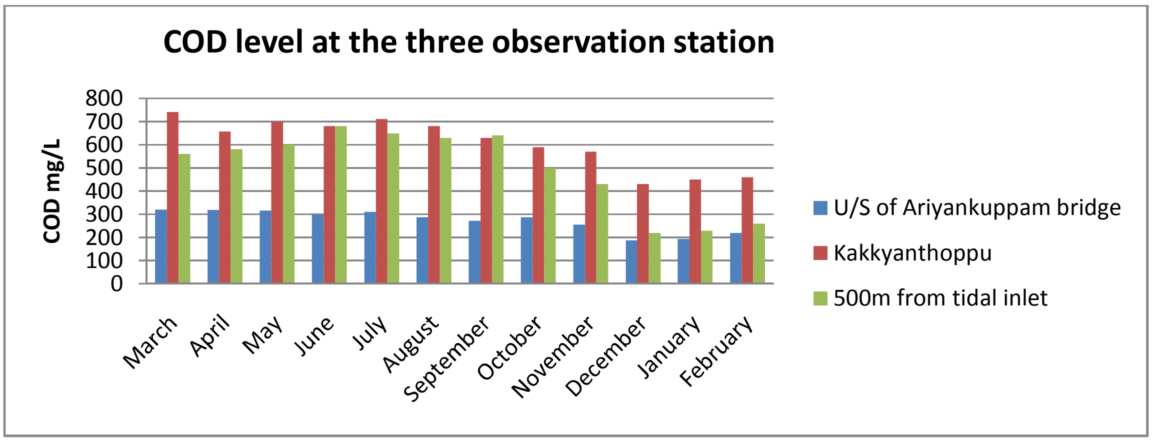

Fig. 4: Comparison of COD level at the three observation stations

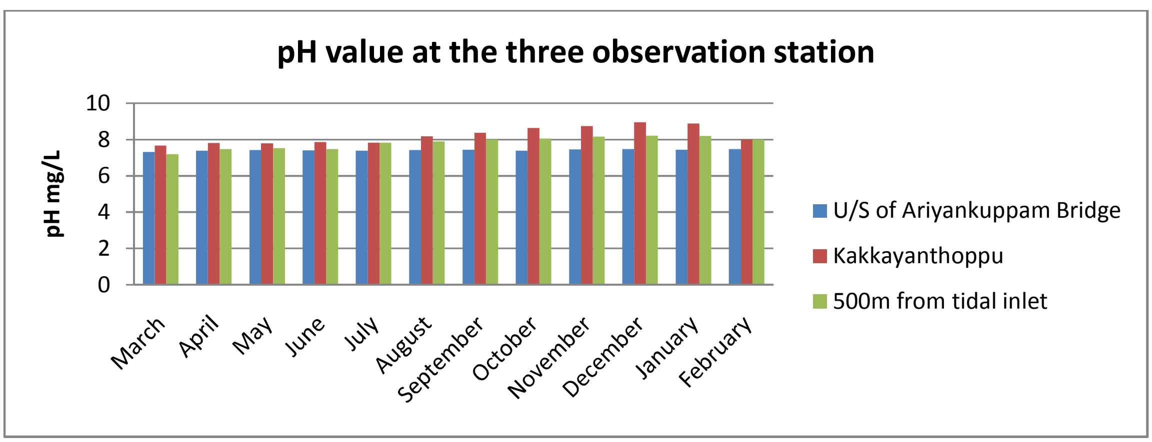

Fig. 5: Comparison of pH value at the three observation stations

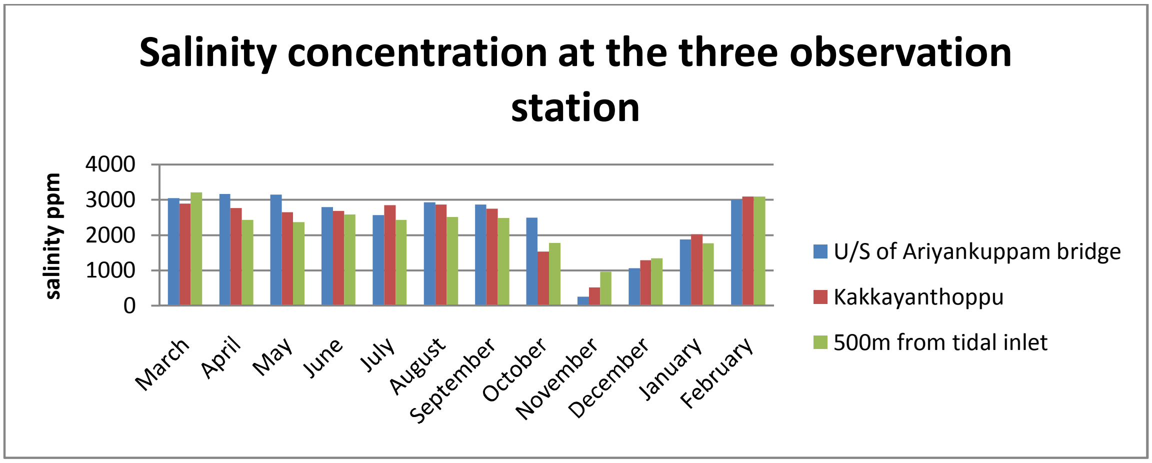

Fig. 6: Comparison of Salinity concentration at the three observation stations

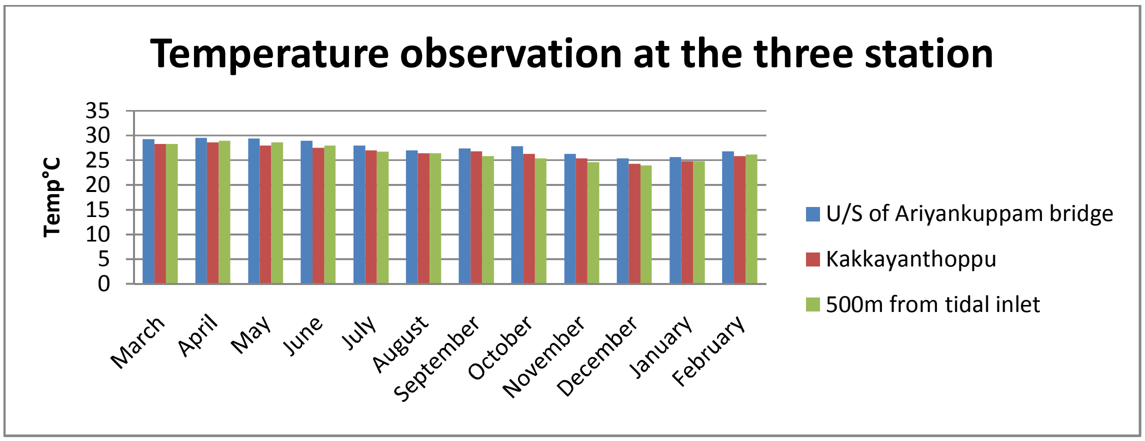

Fig. 7: Comparison of Temperature at the three observation stations

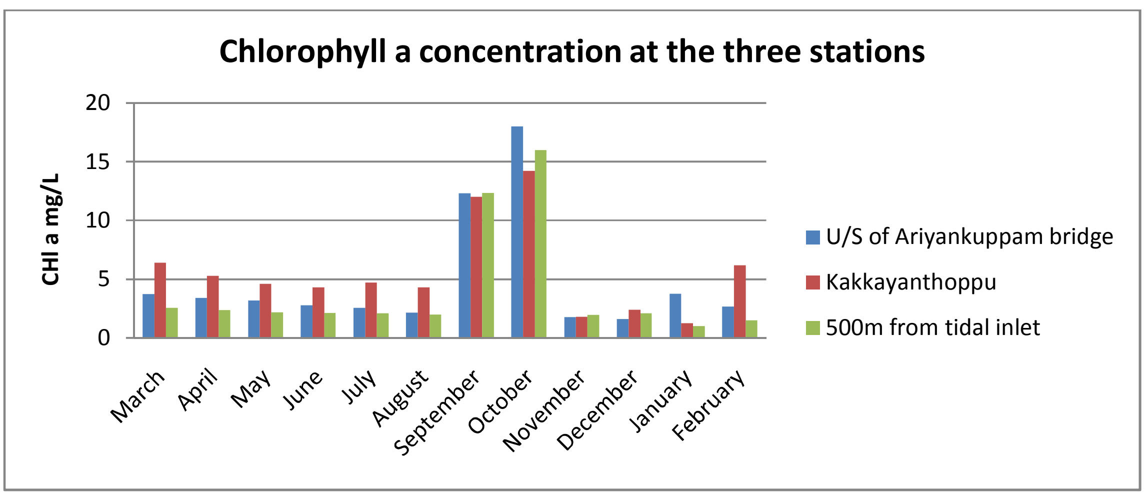

Fig. 8: Comparison of Chlorophyll a concentration at the three observation stations

5.0 Conclusions

The levels of various chemical and biological parameters in the Ariyankuppam back water of the Puducherry city have been assessed and studied for the periods from March 2011 to Feb 2012.. During March, the observations showed a , low dissolved oxygen and high biochemical and chemical oxygen demand in the water sample of upstream side of Ariyankuppam Bridge,Kakkayanthoppu and 500m from tidal inlet stations. From the analysis of the parameters it was found that, the concentrations of pollution level are found to be significantly higher than the permissible limit of international standards at several locations of the study area. As a result of fresh water input in October to the river from further area, the concentrations of some of these parameters became low in study area. Similarly, the analysis of water samples showed that the salinity concentration in the observation stations areas are found to be more than the standard value and identified as highly vulnerable zones because of receiving large quantities of municipal and industrial wastes of the Ariyankuppam town of the Puducherry region. Owing to shallow nature of these areas, disposed waste materials and pollutants are highly persistence in the backwaters, due to lack of treatment facilities to reduce the content of suspended solids, oxygen-demanding substances, dissolved inorganic compounds, and pathogens in these areas. New techniques and dispersion models are thus necessary to be introduced to reduce the levels of pollution in the study area. In the recent years more importance is given for the construction of submarine diffusers to transport and disperse such a huge quantity of waste materials to the deep open ocean areas. Because of the great depth and distance from land, the open ocean areas are found to be ideal for waste dumping than coastal region. Open oceans have also considerable capacity to dilute, transport, and disperse wastes and associated pollutants because of their large volume and free exchange of water. Hence, oceans are less vulnerable to the impact of waste disposal than coastal waters.

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