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An Assessment on the Impact of Waste Discharge on Water Quality of Priyar River Lets in Certain Selected Sites in the Northern Part of Ernakulum District in Kerala, India

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Abstract

The study assessed the impact of waste discharge on the water quality of Periyar river lets at four different sites selected in the Northern regions of Ernakulam District. Physico-chemical status was examined to determine the quality of river water. The parameters studied includes colour, odour, taste, pH, total hardness, turbidity, calcium, magnesium, alkalinity, chloride, sulphate, nitrate, fluoride, phosphate, total dissolved solids, BOD, COD and electrical conductivity. The results were compared with the BIS standards. The study noticed that the water samples from site1, site2 and site3 exhibited clear pollution tendencies which may be attributed to the higher or lower level of different parameters studied which are not satisfying the requirement for the uses of various purposes.

Keywords: Water quality, periyar river lets, northern part of Ernakulam, waste discharge, physico-chemical.

Introduction

Rivers play a significant role as they serve not only the purpose of water supply for domestic, industrial, agricultural and power generation but also utilized for the disposal of sewage and industrial waste and therefore put under tremendous pressure. In the last few decades, pressure has been increasing and greater emphasis is laid on the deterioration of the quality of Indian Rivers. Most of the rivers have been unmindfully used for the disposal of domestic and industrial effluents far beyond their assimilative capacities and have been rendered grossly polluted[1]. Despite its importance, water is the most poorly managed resource in the world**.** The quality of water is getting vastly deteriorated mainly due to unscientific waste disposal; improper water management and carelessness towards the environment and this had led to the scarcity of potable water affecting human health[2].

People who live near the river area use the water from the river for domestic purposes. Unfortunately, there is no frequent and up to date monitoring and information providing facility on the quality of the industrial effluent discharged into the river and the quality of the water in the river for human use. Such information is important for the authorities to take proper action in preventing pollution of the environment for the good health of the population. Before water can be described as potable, it has to comply with certain physical, chemical and microbiological standards to ensure that the water is palatable and safe for drinking and other domestic purposes[3]. The objective of the present study was to assess the extent of various pollutants received by Periyar river lets in the Northern regions of Ernakulum district, as affected by industrial, domestic sewage and solid wastes discharged therein.

Material and Methods

Study area and sampling sites: Water samples were collected from four different selected sites of Periyar river let in the northern part of Ernakulum district, Kerala, India during the month of March 2013. The four sampling sites and source of water pollution selected for the study are:

Site1: One of the major areas located at Eloor where there is heavy discharge of industrial effluents into the Periyar river let.

Site2: This is the site located at Kalamassery area where heavy solid waste dumping occurs in the river side.

Site3: This site is located at North Paravoor area where river let receives heavy discharge of domestic sewage waste.

Site4: This is the site located at Aluva area and which was selected as the least polluted site owing to the absence of waste discharge in direct vicinity.

Collection of water samples: The water samples were collected in high grade plastic bottles of one liter capacity. Before collection, the plastic bottles were rinsed once with distilled water and then thrice with respective water sample. During collection, care was taken to avoid the trapping of air within the bottle by completely immersing the bottle within the respective water sample until the bottle is completely filled in with the water.

Parameters analyzed: The samples collected were brought to the laboratory and the parameters like colour, odour, taste, turbidity, pH, total hardness (TH), calcium, magnesium, total alkalinity (TA), chloride, sulphate, nitrate, fluoride, phosphate, total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen demand (COD) and electrical conductivity (EC) were analyzed. Standard methods were adopted for the analysis of water samples[4]. Physico-chemical parameters analyzed and measured on water samples were compared with BIS, IS: 10500 standards[5] for drinking water. Each data provided in the table 2 is an average of three samples collected from each site.

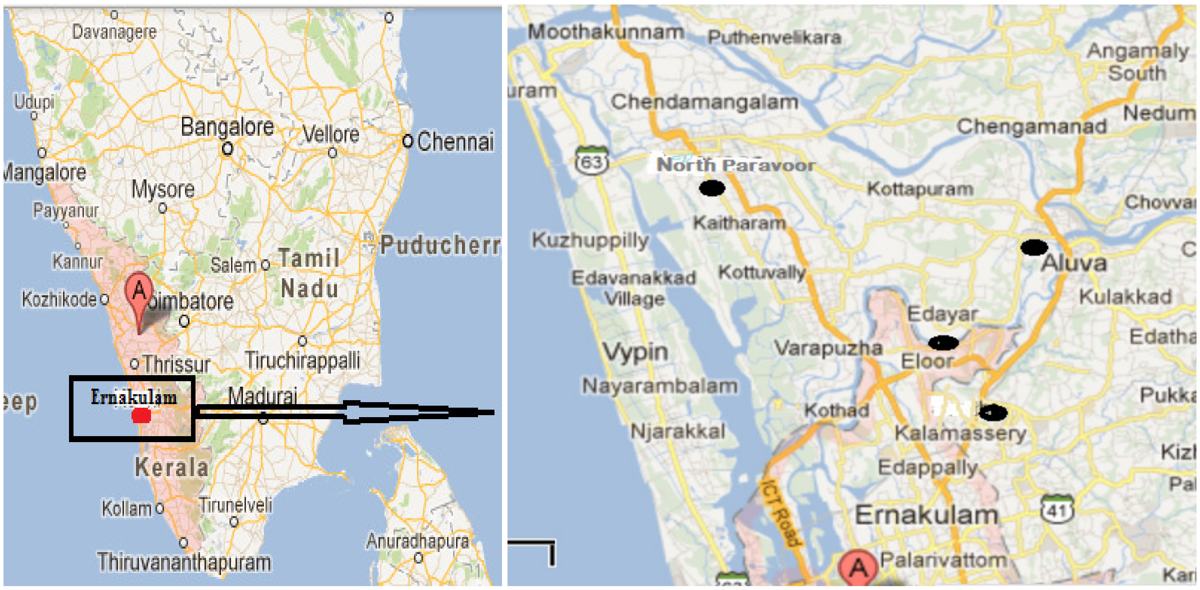

Figure-1
Location Map of the study area and black dots indicate sampling sites

Table-1
Physico-chemical parameters, Analytical methods and Guidelines of BIS

			BIS- 1992 Guidelines	
Sl. No.	**Parameter**	**Method of analysis**	**Desirable Limit**	**Maximum Limit**
1	Colour	Visual comparison	5	25
2	Odour	By smelling	unobjectionable	---
3	Taste	By tasting	Agreeable	--
4	Turbidity	Nephelometric method	5	10
5	pH	Electrometric	6.5-8.5	NR
6	Total Hardness	Titration by H2SO4	300	600
7	Iron	Calorimetrically	0.3	1.0
8	Chlorides	Titration by AgNO3	250	1000
9	Fluoride	UV-VIS Spectrophotometer	1	1.5
10	Calcium	Titration by EDTA	75	200
11	Magnesium	Titration by EDTA	30	100
12	Sulphates	Turbidimetric	200	400
13	Nitrates	UV-VIS Spectrophotometer	45	100
14	EC	Electrometric	--	--
15	Total Alkalinity	Titration by H2SO4	200	600
16	BOD	5 days incubation at 200C followed by titration	--	--
17	DO	Winkler method	--	--
18	TDS	Electrometric	500	2000

Results and Discussion

The detailed results of the various physico-chemical parameters of Periyar river lets analyzed in the present investigation are given in table 2. The colour, taste and odour of the water samples were noted at the sampling site itself. Water samples collected from site 2 was found to be light brown coloured. With respect to the taste and odour, water samples at site 2 and site 3 are not agreeable and are objectionable respectively.

pH: pH of river let water studied ranged from 6.23 to 7.32 and it was 6.34 at site1, 6.23 at site 2, 7.32 at site 3 and 6.82 at site 4. The obtained results indicate, water sample at site3 is slightly alkaline whereas all other samples are acidic in nature. As per BIS standard[5], the desirable range of pH for drinking water is 6.5 to 8.5 and therefore site1 and site2 are not within the safer limit. Water with a pH outside the normal range may cause a nutritional imbalance or may contain a toxic ion which can adversely affect the growth and development of aquatic life[6]. As pH affects the unit processes in water treatment that contribute to the removal of harmful organisms, it could be argued that pH has an indirect effect on health[7].

Turbidity: Desirable and maximum permissible limit of turbidity in drinking water is 5NTU and 10NTU respectively[5] whereas as per WHO standards[8], turbidity of drinking water should not exceed 5 NTU and should ideally be below 1 NTU. In the present study turbidity values varied from 0.26 NTU to 3.2 NTU and are all within the desirable limit as per BIS, however water at site1, 2 and 3 are not ideal as per WHO standard[8]. Comparatively higher values of turbidity at site2 and site3 may be attributed to the comparatively higher suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter[9].

Total hardness: Total hardness of water generally indicates the concentration of calcium and magnesium ions in the water. Desirable and maximum permissible level of hardness in drinking water is 300mg/l and 600mg/l respectively[5]. Total hardness of water samples varied from 46mg/l to 840mg/l. The highest hardness level was recorded at site3, which exceeded the maximum permissible level and this may be attributed to the mixing of sewage effluents into the river water[10]. Hardness causes incrustations in distribution systems and excessive soap consumption[11].

Calcium (Ca) and Magnesium (Mg): Ca and Mg content of water samples at different sites fluctuated in the range of 17.2mg/l to 524mg/l and 6.95mg/l to 43.41mg/l respectively. Desirable and maximum permissible content of Ca and Mg in drinking water are 75mg/l and 200mg/l and 30mg/l and 100mg/l respectively[5].The study shows Ca content at site 4 and Mg content at site and & site 4 are within the desirable limit. At site1 and site 3, the content of Ca has exceeded the maximum permissible limit and found not safe whereas Mg content exceeded the desirable limit but lies within the maximum limit. Water containing high Ca is not suitable for washing, bathing, and in boilers. It causes concretion in the body and may cause intestinal diseases and stone formation[12]. Higher concentration of Mg can cause hardness of water and exerts a cathartic and diuretic action[4].

Total alkalinity: Total alkalinity values in the present study recorded in the range of 14.3mg/l to 232mg/l. The desirable and maximum permissible limit of alkalinity in drinking water is 200mg/l and 600mg/l respectively. Water sample collected from site3 exhibited maximum alkalinity (232mg/l) and is above the desirable limit but within the maximum limit whereas site1 (62.5mg/l), site2 (15.5mg/l) and site4 (14.3mg/l) exhibited desirable values. Highest alkalinity at site3 may be associated with comparatively higher pH value and higher concentrations of chlorides, sulphates, phosphates and other ions present in water, imparted by the sewage effluent discharge.

Chloride: 250mg/l has been established as desirable limit and 1000mg/l as the maximum limit for chloride in drinking water[5]. The study showed that site 3 and site1have chloride content above the maximum limit and was 8862.15mg/l and 1194.82mg/l respectively whereas site2 (841.62mg/l) and site4 (252.79mg/l) has chloride value above the desirable limit but within the maximum limit. The higher content of chloride in site3, site1 and site2 can be attributed to the heavy discharge of sewage waste[13], effluents from chemical industries[14] and leaches from solid waste dumping, sea water intrusion etc[15] respectively. Higher concentration of chloride in water can impart undesirable taste, may cause corrosion in the distribution system and may harm growing plants[16].

Sulphate: Sulphate content of water samples varied from 210mg/l to 2400mg/l. With the exception of site4, all sites have sulphate content exceeding maximum limit. The highest sulphate content was obtained from site1 followed by site 3, site 2 and it was 2400mg/l, 1100mg/l and 790mg/l respectively. An excess of sulphate in river water is taken as an index of pollution[6]. The release of sulphate ions from various wastes discharged into the river water might be the reason for the excessive content. Excessive content of sulphate in water can cause laxative effect and may contribute to the corrosion of distribution systems[17].

Nitrate and Fluoride: Nitrate and Fluoride content of water samples in the present study varied from 1.2mg/l to 8.6mg/l and 0.1mg/l to 0.5mg/l respectively. The study clearly indicates, nitrate and fluoride content of all the water samples are well within the desirable limit[5].

Phosphate: The concentration of phosphate in water samples in the present study varied from 0.02mg/l to 6.7mg/l. The highest phosphate value was observed at site 3 (6.7mg/l) and it has exceeded the maximum permissible limit whereas all others are well within the desirable limit. The release of phosphates from phosphorous detergents discharged along with the sewage waste into the river water might be the reason for the excessive content of phosphate[18] at site3. Excessive concentration of phosphate in water may cause vomiting and diarrhea, stimulate secondary hyperthyroidism and bone loss.

Total dissolved solids (TDS): The desirable and maximum excessive level of TDS in drinking water prescribed by BIS is 500 mg/l and 2000 mg/l respectively. There were great differences in the values of TDS in the present study and it was 3792mg/l at site1, 2992mg/l at site2, 15918mg/l at site3 and 156mg/l at site 4. The water sample collected from the site4 has an acceptable value whereas all others have TDS value much higher than the maximum excessive limit. This increased level of TDS might be impacted by the dissolution of higher concentrations of chlorides, calcium, magnesium, sulphates, organic and other inorganic particles which resulted from the discharge of sewage, industrial and solid waste into the river lets. The excessive TDS in water can cause changes in taste, excessive scaling in water pipes, water heaters, boilers and household appliances[19]. Concentration of TDS that are too high or too low may limit growth and lead to the death of many aquatic life forms[20].

Total suspended solids (TSS): Higher concentration of TSS in river water is an index that it is more polluted. In the present study, the highest TSS value was obtained in water sample collected from site 3 with an average of 31.82 mg/l. This was followed by 28mg/l, 22mg/l and 1.5mg/l at site 2, site 1 and site 4 respectively.

Dissolved oxygen (DO): DO levels in surface water body indicate the ability to support aquatic life. In the present study, DO levels vary from 2.7mg/l to 6.2mg/l. Among the different water samples analyzed, the lowest DO level was noticed in site 3, which was followed by site2 and then by site1 and this was 2.7mg/l, 2.9mg/l and 3.8mg/l respectively. All these values are not desirable. The decreased DO level at different sites may be due to the little turbulence in the river water and increased competition for oxygen within the ecosystem. The high organic and inorganic pollutants received by water bodies through the discharge of industrial, sewage and solid wastes, require a high oxygen demand resulting in oxygen depletion[21]. The desirable level of DO in water samples at site4 may be because of comparatively low organic matter content. Deficiency of DO gives bad odour to water due to anaerobic respiration of organic matter[22].

Biochemical oxygen demand (BOD): BOD is the amount of organic matter in the water and the amount of oxygen required by the micro organisms to stabilize the biologically decomposable organic matter in wastes under aerobic conditions[23]. BOD values of water samples in the present study varied from 9.5mg/l to 342mg/l. The water samples from site1, site 2 and site 3 exhibited higher values of BOD compared to site4. Higher BOD value at site3 (342mg/l), site 2(186mg/l) and site1(72mg/l) clearly indicate pollution and may be attributed to the percolation of waste water loaded with biodegradable compounds[24], which might be the result of untreated sewage, solid and industrial waste discharge respectively into each sites[25].

Chemical oxygen demand (COD): COD is the amount of oxygen required for the oxidation of inorganic matter using a strong chemical oxidant. All the water samples, with the exception at site4, exhibited higher levels of COD. The highest COD level (192mg/l) was recorded in water sample collected from site3 and this was followed by site 2 and site 1. The higher levels of COD in water samples at site1, site2 and site3 clearly indicate that the waste materials discharged into these water bodies are high oxygen demanding materials, which causes depletion of dissolved oxygen in water. The higher BOD and COD levels of above said water samples indicate that water samples are highly polluted. It may be attributed to the high demand on dissolved oxygen by the wastes discharged in to the water bodies[26] and which render them unfit for drinking, irrigation and also decreased the recreation value of water[27].

Electrical Conductivity (EC): EC of water is the ability of water to conduct current. The highest EC value in the present study obtained in water sample collected from site3 (4572µmhos/cm) whereas the lowest value at site4 (278 µmhos/cm). The table-1 shows, all the EC values of water samples, with the exception at site4, are very high and not desirable. The increased EC value at site 3, 1 and 2 in accordance with the observed increase in total dissolved solids may be attributed to the corresponding higher levels of anions and cations in the water (Jonathan, 2010). There is report that a high positive correlation exists between electrical conductance and chloride concentration[28] and similarly a high positive correlation between electrical conductance and total dissolved solids of water[29]. The present observations are also in support of these reports. The higher conductivity alters the chelating properties of water bodies and creates an imbalance of free metal availability for flora and fauna[30].

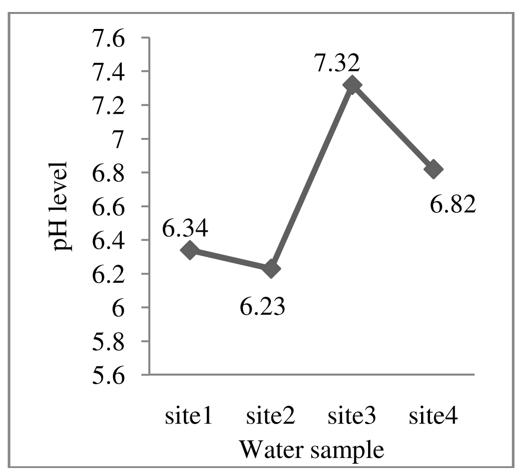

Figure-2
Variation in the value of pH level at different sites

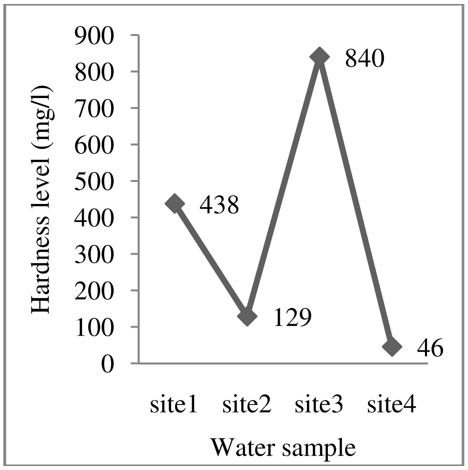

Figure-3
Variation in the value of Hardness level at different sites

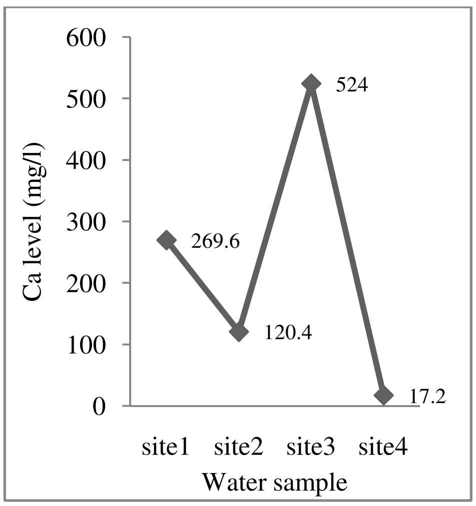

Figure-4
Variation in the value of Ca level at different sites

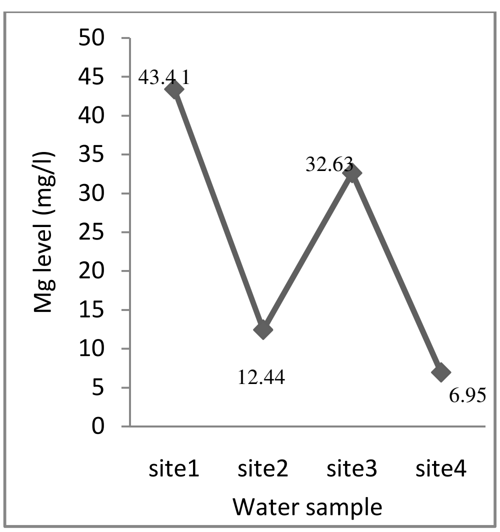

Figure-5
Variation in the value of Mg level at different sites

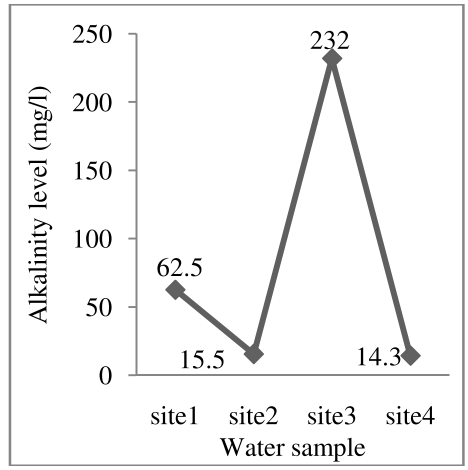

Figure- 6
Variation in the value of Total alkalinity at different sites

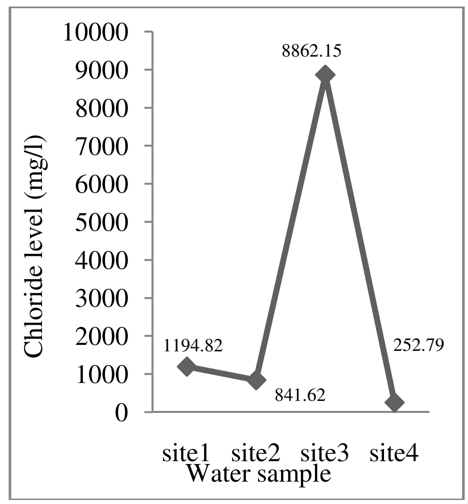

Figure-7
Variation in the value of Chloride level at different sites

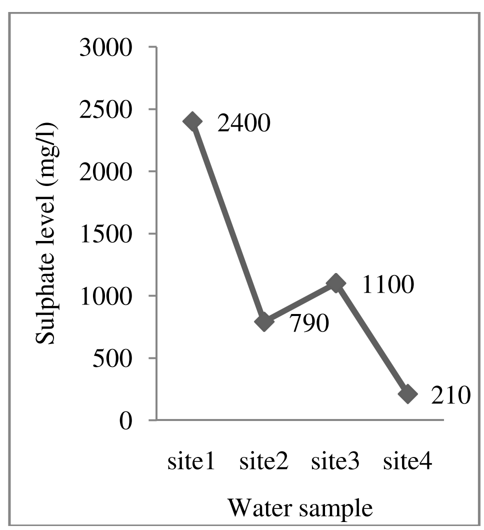

Figure-8
Variation in the value of Sulphate at different sites

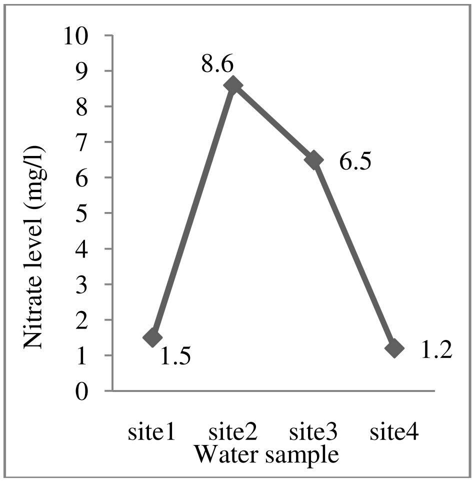

Figure-9
Variation in the value of Nitrate at different sites

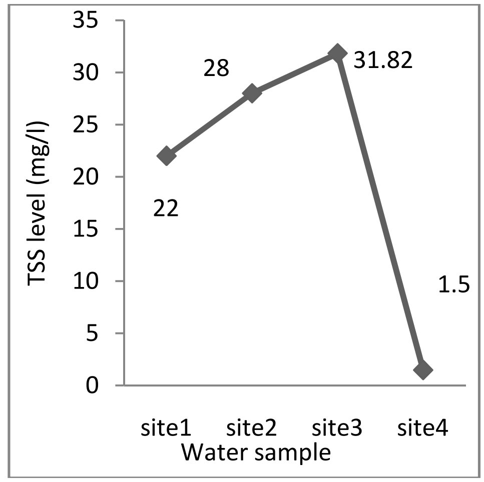

Figure-12
Variation in the value of TSS level at different sites

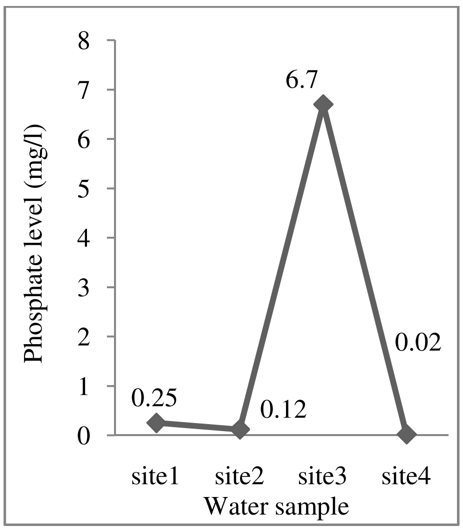

Figure-10
Variation in the value of Phosphate level at different sites

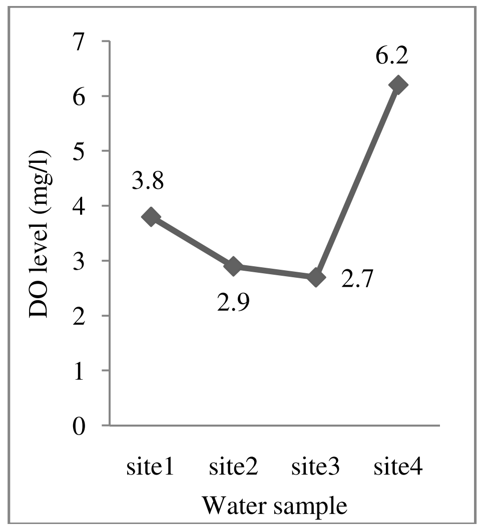

Figure-13
Variation in the value of DO level at different sites

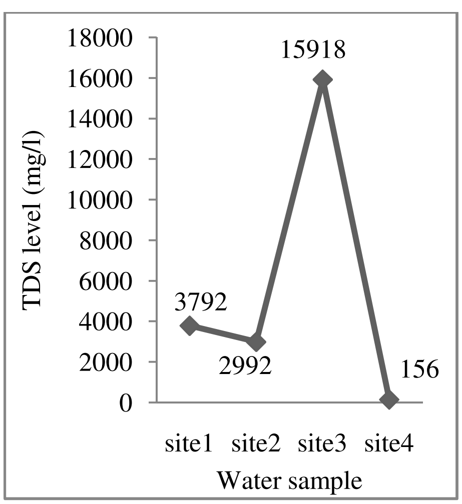

Figure-11
Variation in the value of TDS level at different sites

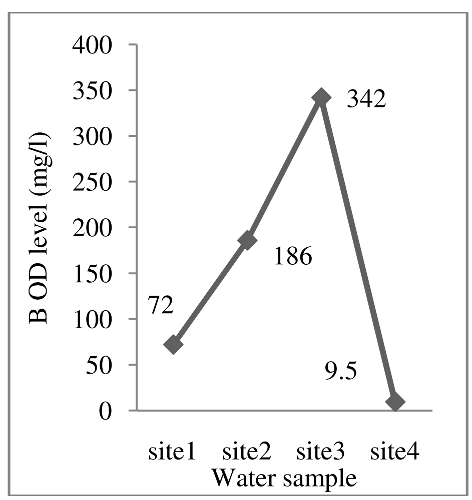

Figure-14
Variation in the value of BOD level at different sites

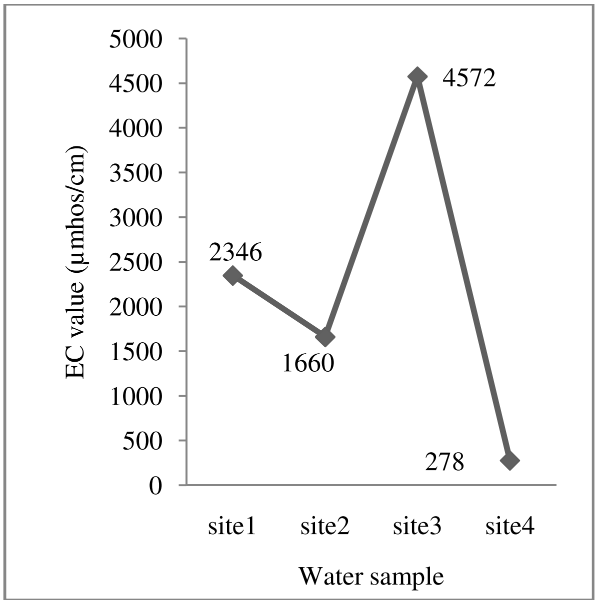

Figure-15
Variation in the value of EC value at different sites

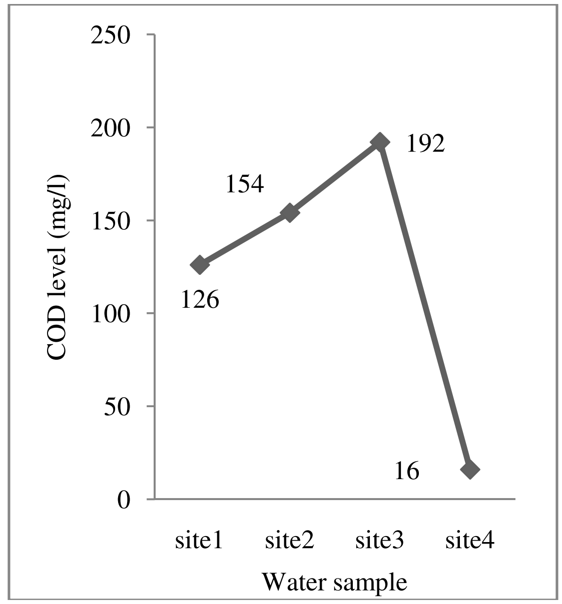

Figure-16
Variation in the value of COD level at different sites

Table-2
Physico-chemical parameters of water samples collected from the selected sites of the Periyar river lets in the Northern part of Ernakulam district

Parameter (mg/L)	Water Sample			
	Site1	**Site2**	**Site3**	**Site4**
Colour	**Colorless**	**Light brown**	**Colorless**	**Colorless**
Odour	**Unobjectionable**	**Objectionable**	**Objectionable**	**Unobjectionable**
Taste	**Agreeable**	**Not agreeable**	**Not agreeable**	**Agreeable**
Turbidity (NTU)	1.4	3.2	2.8	0.26
pH	6.34	6.23	7.32	6.82
TH	438	129	840	46
Calcium	269.6	120.4	524	17.2
Magnesium	43.41	12.44	32.63	6.95
TA	62.5	15.5	232	14.3
Chloride	1194.82	841.62	8862.15	252.79
Sulphate	2400	790	1100	210
Nitrate	1.5	8.60	6.5	1.20
Fluoride	0.5	0.1	0.0	0.0
Phosphate	0.25	0.12	6.7	0.02
TSS	22	28	31.82	1.5
TDS	3792	2992	15918	156
DO	3.8	2.9	2.7	6.2
BOD	72	186	342	9.5
COD	126	154	192	16
EC (µmhos/cm)	2346	1660	4572	278

Each data represents an average of 3 replicates

Conclusion

It was evident from the study that water quality in the Periyar river lets was severely impaired by the waste discharged from different sources at site 1, site 2 and site 3. The decrease in dissolved oxygen, increase in total dissolved solids and a corresponding increase in electrical conductivity, increase in hardness, chloride and sulphate concentrations, increase in BOD and COD proved considerable deterioration of water quality. The study also revealed, even though at site 4, not any discharge of waste material in direct vicinity and observed to be the least polluted when compared, but it was also found to be unfit for human consumption, as the parameters such as chloride, sulphate etc exceeded the desirable limit prescribed by BIS standards. The present study revealed the pollution associated with the physicochemical parameters are induced by the discharge of untreated or partially treated industrial waste, sewage waste and the disposal of solid waste illegally in to the river and near the river network. This clearly indicates that water resources management is incomplete and ineffective in these regions of Ernakulam district and that no effectively implemented methods of integrated management exist. The most crucial problem is the lack of coordination of various actions of different industries, institutions and domestic sectors towards disposal of waste and water management.

The Local bodies and environmental legal authorities should interfere with this situation to produce an internally cohesive institutional framework for waste management. The pollution levels should be reduced by strict enforcement of Environmental Management Act and waste effluent regulations to ensure that the effluent discharged is within the permissible limits. It is thus recommended that waste treatment plants must be established with each industry with proper follow-up. Further, efficient environmental laws and social awareness programme must be undertaken with respect to potential threat of industrial and other waste to the environment.

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