International Journal of Water Resources and Environmental Engineering Vol. 5(1), pp. 35-48, January 2013
Available online at http://www.academicjournals.org/IJWREE
DOI: 10.5897/IJWREE12.084
ISSN 1991-637X ©2013 Academic Journals

Full Length Research Paper

Assessment of water quality in Noyyal River through water quality index

Mariraj Mohan S.[1] and Vanalakshmi P.[2]

[1]Civil Engineering Department, Alagappa Chettiar College of Engineering and Technology, Karaikudi, Tamilnadu, India.
[2]Civil Engineering Department, Kalasalingam University, Srivilliputhur, Virudhunagar, India.

Accepted 23 October, 2012

Assessment of water quality in Noyyal River from 20/12/2010 to 27/12/2011 was carried out in this study. Water samples were collected from the Noyyal River at a stretch of 3800 m. The sampling locations have been fixed at every 50 m. The parameters were estimated such as dissolved oxygen (DO), pH, Temperature, chemical oxygen demand (COD), total dissolved solids (TDS), Sulphate, Chloride, total hardness etc. This study had two phases. In the first phase, the estimation of water quality parameters was carried out and in the second phase water quality index have been determined based on the existing standards. The effects of municipal sewage on river water quality have also been investigated. The depletion of DO concentration due to the simultaneous effect of water pollution, thus leads to more uncertainty about the survival of DO dependent aquatic species. From the study, it revealed that TDS, sulphate, chloride, and hardness were estimated to be high concentration at sampling location 10 (S_{10}). Among the sample locations, in most of the places, high concentration of TDS, Hardness, sulphate and chloride and low level of DO were observed. Our findings highlighted the deterioration of water quality in the river and are due to human activities. This analysis reveals that the surface water needs some degree of treatment before consumption.

Key words: Noyyal River, dissolved oxygen (DO), water quality index, water quality parameters.

INTRODUCTION

"Pollution is the introduction of contaminants into a natural environment that causes instability, disorder, harm or discomfort to the ecosystem that is, physical systems or living organisms" (Merriam Webster online dictionary, 'http://www.merriam-webster.com/dictionary/pollution', 2010). The term pollutant in a broad term refers to a wide range of compounds, from a superabundance of nutrients giving rise to the enrichment of ecosystems to toxic compounds that may be carcinogenic, mutagenic, or teratogenic. Pollutants can be divided into two major groups, namely, those that affect the physical environment and those that are directly toxic to organisms, including human beings.

Rapid industrialization in the twentieth century had led to the generation of vast amounts of gas, liquid, and solid waste that were introduced into the environment without much thought by the manufacturers of that waste. This has affected the ecosystem and has caused health problems for the first habitants residing near the factories. Economical status of the country directly corresponded to the industrial growth. This is also reflected in the increase in rate of pollution (Rainwater harvesting, 'http://www.rainwater harvesting.org/crisis/river-noyyal.html', 2007).

Overview of textile industry

Textile industry in India is one of the oldest and largest organized sectors. There are over 700 large textile mills concentrated in Ahmedabad, Bombay, Coimbatore, Kanpur and Delhi. Textile processing industries nowadays are widespread sectors in developing countries. Among

*Corresponding author. E-mail: mari_sundar@haoo.com. Tel: +919865186845.

the various processes in the textile industry, dyeing process consumes large volume water for dyeing, fixing and washing. Thus, the wastewater generated from the textile processing industries contains suspended solids, high amount of dissolved solids, un-reacted dyestuffs (color) and other auxiliary chemicals that are used in the various stages of dyeing and other processing. The presence of even a small amount of dye in water (for example, 10 to 20 mg/L) is highly visible and affects the water transparency and the gas solubility of water bodies. Among several classes of textile dyestuffs, the reactive dyes contribute about 50% of the total market share and the most common group used as chromophore is the azo, followed by anthraquinone. Textile industries are found in most countries and their numbers have increased. These industries have shown a significant increase in the use of synthetic complex organic dyes as the coloring material. The annual world production of textiles is about 30 million tons requiring 700,000 tonnes of different dyes which causes considerable environmental pollution problems. During the last few decades, substantial global shifts have occurred in textile production and export.

Toxic effects of dyes

The effluent discharged with high temperature will increase the temperature of the receiving body, thereby reducing the solubility of oxygen in water. High alkalinity of the waste water causes increases in the pH value of the receiving stream. If the pH value exceeds 9 or falls below 5 on the pH scale, it will have an adverse effect on the aquatic biota. The soluble colors and dyes present in the wastewater will persist in the stream and interfere with the penetration of sunlight essential for photosynthesis. The colloidal organic matter in the wastewater will increase its turbidity along with dyes. Oily scum formed on the surface of the water will interfere with the mechanism of oxygen transfer at the air-water interface.

Keeping the above discussion in mind the objectives of this study has been formulated as follows:

(i) To analyses the water quality parameters.
(ii) To evaluate the variations of water quality parameters with respect to existing pollution.
(iii) To compute water quality index based on the existing standards.

METHODOLOGY

Study area

Coimbatore is the one of the major cities in Tamil Nadu and it is well known for industrial activities. The textile industries in and around Coimbatore, disposes the waste into the Noyyal River. The quantity of the wastewater discharged into the river is also getting increased. As a result, the quality of the river gets deteriorated. Hence the Noyyal River has been chosen as the study area. The Noyyal River rises from the Vellingiri hills in the Western Ghats in Tamil Nadu, southeastern India and drains into the Kaveri River. The river basin is 180 km long and 25 km wide and covers a total area of 3,500 km². Cultivated land in the basin amounts to 1,800 km² while the population density is 120 people per km² in the countryside, and 1000 people per km² in the cities (Lenin and Saseetharan, 2008). The area is known for its scanty rainfall and the development of the Noyyal River Tanks System holding any overflow from the rains plus the water in the Northeast and Southwest monsoon season been ecologically important. The 173 km long tributary of the Kaveri River filled 32 tanks. These interconnecting tanks held the water flowing from the Noyyal. One of the major and critical issues is the pollution of the rivers Noyyal and Nallaru originates and flowing in the Kongu region. It is a big menace troubling the people and the Kongunadu region as a whole, and also it is a disgrace to not just people all over India but all over the world constantly visiting Tirupur for industrial activity (Rainwater harvesting, 'http://www.rainwater harvesting.org/crisis/river-noyyal.html' 2007).

As like the many other hazardous changes due to the lifestyle changes and change in culture, the Noyyal is also down the way to death. The deterioration in various water quality characteristics clearly indicates the possibilities of pollution due to industrial activities such as coffee vegetables oils, leather tanning, textiles and foundries in and around Coimbatore city. The population of Coimbatore has also a strong impact on the Noyyal River with regard to pollution and due to this Noyyal River acts as a carrier for the pollution. During the non-flow period of the river, water can be stagnated and the pollution may enter into the ground water. So the ground water quality also gets depleted (Lenin and Saseetharan, 2008).

Sampling program, location and analysis

Schematic representation of sampling sites is as shown in Figure 1. In this study, it has been chosen that the confined stretch of the Noyyal River which passes through Perur, since the over exploitation of the river occurred over there. The samples were collected at different locations with a stretch of 3800 m. The distance between each sampling location is taken as 50 m, but the distance between 6th and 7th is 1 km, between 8th and 9th is 500 m and also between 9th and 10th sampling site is 2 km. The irregularities between the sampling locations are due to the bushes and sluggish in the river as shown in Figure 1. This condition is practically not possible to collect water samples.

The samples were collected during the period of December 2010 to February 2011. 11 sets of samples were collected in 10 locations designated as S_1 to S_{10}, which gives the total number of 110 samples. The time interval maintained for the collection of samples is one week.

The samples were collected by grab sampling (Islam and Alam, 2007). Each sample was analyzed for eight parameters such as dissolved oxygen (DO), total dissolved solids (TDS), chemical oxygen demand (COD), Sulphate, Temperature, pH, Chloride, and Hardness etc. All water quality parameters were estimated by standard methods (13). When compared to all the sites, at S_4, S_5 and S_{10} site activities like fishing, bathing, washing were observed. In the prescribed sampling location S_2, at the bank of the river, temple is located; the discharge of Pooja items has been observed at the river bank.

Water quality index

In this study, it was attempted to evaluate the quality of Noyyal River. It can be done using water quality index.

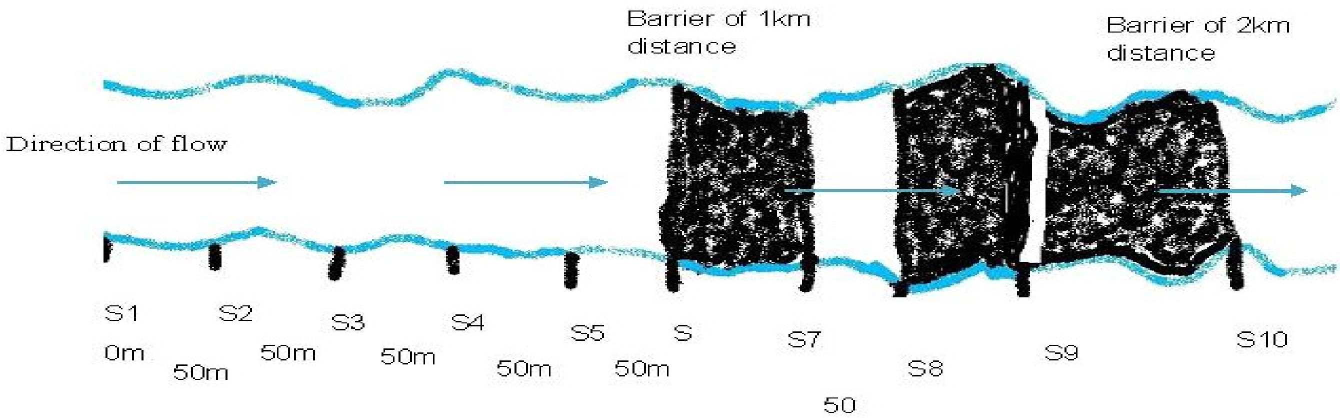

Figure 1. Overview of sampling location.

Water quality index (WQI) is defined as a rating reflecting the composite influence of different water quality parameters. WQI is calculated from the point of view of the suitability of ground water for human consumption Equation (1) (Ramakrishnaiah and Sadashivaiah, 2009).

$$\mathrm{Wi} = \frac{\mathrm{wi}}{\sum_{i=1}^{n} \mathrm{wi}} \quad (1)$$

Where, W_i is the relative weight, w_i is the weight of each parameter and n is the number of water quality parameters.

$$qi = (Ci / Si) \times 100 \quad (2)$$

Where, q_i is the quality rating scale, C_i is the concentration of each parameter in each sample water in mg/L and S_i is the Indian drinking water standard for each chemical parameter in mg/L according to the guidelines of the IS 10500:1991.

$$SI_i = W_i \cdot q_i \quad (3)$$

$$WQI = \sum SI_i \quad (4)$$

SI_i is the subindex of i^{th} parameter; qi is the rating based on concentration of i^{th} parameter and n is the number of parameters. The computed WQI values are classified into five types, "excellent water, good water, poor water, very poor water and unsuitable for drinking".

Weighting has been given, based on the effects which will occur due to the variation of particular parameter. Iron is low in surface water. Hence it is given least weight age, TDS is the major importance in assessing the water quality so given top value

RESULT AND DISCUSSION

The samples were collected during the period of December 2010 to February 2011. Parameters such as DO, TDS, COD, Sulphate, temperature, pH, Chloride, Hardness, iron, fluoride, calcium, magnesium, phosphate, nitrate, nitrite, manganese, sodium have been determined. Out of seventeen parameters eight have been considered as important water quality parameters such as DO, TDS, COD, Sulphate, temperature, pH, Chloride, and Hardness for the classification of surface water. The values of water quality parameters are shown from the Tables 1 to 11.

Due to practical considerations water quality parameters such as iron, fluoride, calcium, magnesium, phosphate, nitrate, nitrite, manganese and sodium could not be measured from 17/01/2011 to 27/02/2011. When going through the results other than eight, all other parameters are within its permissible limits. So analysis were restricted to those eight parameters, the variation is quite more and all are greater than its permissible limits.

Variation of dissolved oxygen

The variation of DO over a period of time is shown in the Figure 2. The DO recorded from 20 /12/2010 to 10 /01/2011 is between 1.3 to 5 mg/L. The lowest DO level recorded was due to high organic load of sewage discharge into the river.

On 17/01/2011, S_1 to S_3 sampling locations recorded as increasing DO levels. In the sampling locations S_1 to S_3, at that period sampling there was no discharge of waste witnessed. In addition to this, the increase in turbulence of the river might have increase DO concentration from S_1 to S_3. It is decreased at sampling location to four (S_4) due to the exploitation such as washing, bathing etc. At S_5 DO concentration gets increased comparing to S_4. The DO was ranging between 6.4 to 10.8 mg/L. The lowest DO level recorded at sampling location S_4 due to high organic load of sewage discharge at that point (Basanta and Chitta, 2009; Sajidu and Henry, 2007).

On 23/01/2011, S_1 to S_3 sampling locations are observed to have a predominant level of DO. As discussed previously, there was no exploitation activity observed from S1 to S_3, which could be the reason for having a predominant level of DO concentration. On 23/01/2011 the DO varies from 7.2 to 10.4 mg/L.

Table 1. Water quality parameters on 20/12/2010.

Sampling locations	Water quality parameter																
	DO (mg/L)	COD (mg/L)	pH	T (°C)	TDS (mg/L)	Hardness (mg/L)	Cl^- (mg/L)	SO_4^{2-} (mg/L)	Fe (mg/L)	F (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	PO_4^{2-} (mg/L)	NO_3 (mg/L)	NO_2 (mg/L)	Mn (mg/L)	Na (mg/L)
S_1	4	240	7.55	17.5	352	130	80	40	0.24	0.4	34	11	3	22	0.44	0	50
S_2	4	20	7.49	18	348	126	80	38	0.24	0.4	34	10	2.5	20	0.2	0	48
S_3	4.4	40	7.48	18	346	126	78	40	0.24	0.4	34	10	2.5	22	0.2	0	48
S_4	5.8	1500	7.52	18.5	356	130	82	40	0.24	0.4	34	11	2.5	20	0.2	0	50
S_5	3.8	80	7.54	18.5	358	140	82	36	0.24	0.4	37	12	2.4	22	0	0	46
S_6	5	60	7.51	18.5	358	140	72	38	0.1	0.4	37	12	2.4	22	0.4	0	46
S_7	5	20	7.51	17	358	140	72	38	0.1	0.4	37	12	2.4	22	0.02	0	46
S_8	5.6	40	7.51	17.5	358	140	72	38	0.1	0.4	37	12	2.2	22	0.2	0	46
S_9	6.4	100	7.53	18.5	360	144	76	36	0.1	0.4	38	12	1.8	22	0.01	0	47
S_{10}	4.2	20	7.74	18.5	1575	540	290	246	0	0.6	144	43	1.5	46	0.2	0	250

Table 2. Water quality parameters on 27/12/2010.

Sampling locations	Water quality parameter																
	DO (mg/L)	COD (mg/L)	pH	T (°C)	TDS (mg/L)	Hardness (mg/L)	Cl^- (mg/L)	SO_4^{2-} (mg/L)	Fe (mg/L)	F (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	PO_4^{2-} (mg/L)	NO_3 (mg/L)	NO_2 (mg/L)	Mn (mg/L)	Na (mg/L)
S_1	2.8	1500	7.53	18	354	130	80	40	0.24	0.4	34	11	3	22	0.2	0	50
S_2	3	120	7.47	18.5	368	130	86	40	0.1	0.4	34	11	2.5	20	0.2	0	53
S_3	3	140	7.46	18.5	364	128	80	40	0.24	0.4	34	10	2.5	22	0.2	0	56
S_4	2.8	180	7.50	18.5	368	130	82	40	0.2	0.4	34	11	2.5	20	0.4	0	54
S_5	3.2	400	7.51	18	378	140	82	36	0.24	0.4	37	12	2.4	22	0	0	52
S_6	2.6	460	7.49	18.5	375	140	76	42	0.24	0.4	37	12	2.4	24	0.4	0	54
S_7	3.2	540	7.48	18.5	359	140	72	38	0.1	0.4	37	12	2.4	22	0.02	0	46
S_8	3	20	7.46	18	358	140	72	38	0.1	0.4	37	12	2.2	22	0.2	0	48
S_9	3	260	7.52	18	362	144	76	36	0.1	0.4	38	12	1.8	22	0.01	0	47
S_{10}	3	320	8.52	18.5	1214	490	230	190	0.34	0.6	131	39	4	40	0.6	0	160

On 01/02/2011, it was recorded that the lowest DO concentration occurred at S_7. On that particular day, dumping of used mats, pillows, garlands at the site was observed. In addition to that, mortal fish were floating on the river at sampling location S_7. This can be interpreted that lack of DO level at S_7 is due to dumping of inert materials. On that date of sampling the DO was varied from 1.2 to 8.8 mg/L.

On 07/02/2011, the DO concentration was recorded from 3.2 to 7.6 mg/L. The average DO concentration of this week was found to be 6.24

Table 3. Water quality parameters on 03/01/2011.

Sampling locations	Water quality parameter																
	DO (mg/L)	COD (mg/L)	pH	T (°C)	TDS (mg/L)	Hardness (mg/L)	Cl^- (mg/L)	SO_4^{2-} (mg/L)	Fe (mg/L)	F (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	PO_4^{2-} (mg/L)	NO_3 (mg/L)	NO_2 (mg/L)	Mn (mg/L)	Na (mg/L)
S_1	4	200	7.55	24	363	130	80	44	0.24	0.4	34	11	3	22	0.44	0	54
S_2	5	660	7.49	25	368	140	80	50	0.24	0.4	37	12	2.5	20	0.2	0	50
S_3	6	300	7.48	25	365	132	80	46	0.24	0.4	35	11	2.5	22	0.2	0	52
S_4	4.2	60	7.52	26	375	136	82	40	0.24	0.4	36	11	2.5	20	0.4	0	54
S_5	3.2	100	7.54	26	377	138	82	36	0.24	0.4	37	11	2.4	22	0	0	55
S_6	3.6	160	7.51	26	376	140	80	40	0.24	0.4	37	12	2.4	23	0.4	0	52
S_7	4.4	500	7.48	25	370	140	80	40	0.1	0.4	37	12	2.4	22	0.02	0	50
S_8	3.6	940	7.46	25	367	140	82	40	0.1	0.4	37	12	2.2	22	0.2	0	50
S_9	6	20	7.53	26	373	144	80	38	0.1	0.4	38	12	2	24	0.02	0	52
S_{10}	3.6	980	8.42	26	1463	540	280	240	0	0.6	142	42	1.5	44	0.2	0	220

Table 4. Water quality parameters on 10/01/2011.

Sampling locations	Water quality parameter																
	DO (mg/L)	COD (mg/L)	pH	T (°C)	TDS (mg/L)	Hardness (mg/L)	Cl^- (mg/L)	SO_4^{2-} (mg/L)	Fe (mg/L)	F (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	PO_4^{2-} (mg/L)	NO_3 (mg/L)	NO_2 (mg/L)	Mn (mg/L)	Na (mg/L)
S_1	3.8	40	7.21	21	367	210	210	14	0	0.3	56	17	4	7	0.2	0	20
S_2	4.2	160	7.32	21	361	200	200	12	0	0.3	54	16	3.5	7	0.2	0	24
S_3	5	80	7.22	21	358	198	198	14	0	0.3	53	16	3.2	7	0.2	0	22
S_4	3.2	180	7.41	22	370	210	210	13	0	0.3	56	17	3	7	0.2	0	20
S_5	3	700	7.22	21	377	56	56	24	0	0.3	56	17	3	7	0.2	0	24
S_6	2.6	900	7.35	21	376	210	210	14	0	0.3	56	17	2.8	7	0.2	0	24
S_7	2.4	180	7.38	21	382	212	212	15	0	0.3	56	17	2.5	7	0.2	0	24
S_8	2.6	40	7.32	21	378	210	210	14	0	0.3	56	17	2.3	7	0.2	0	24
S_9	2.6	20	7.25	22	382	212	212	15	0	0.3	56	17	2.2	7	0.2	0	24
S_{10}	3.4	40	6.95	22	1400	400	400	180	0	0.6	106	32	3	40	0.4	0	260

mg/L. This average DO is less as compared to other weeks of subsequent sampling. On that day, the strewing of funeral materials along the river was witnessed. This could have been due to the low average DO concentration as compared to the other sampling period.

On 13/02/2011, the DO concentration recorded was from 4.4 to 7.2 mg/L. The lower DO concentration of 4.4 mg/L was recorded due to washing activities at S_5. The higher DO concentration of 7.2 mg/L was recorded at S_4 and S_7 because temperature of water at this sampling

Table 5. Water quality parameters on 17/01/2011.

Sampling locations	Water quality parameter						
	DO (mg/L)	COD (mg/L)	pH	T (℃)	TDS (mg/L)	Hardness (mg/L)	SO_4^{2-} (mg/L)
S_1	8	140	7.34	25	600	186	2123.7
S_2	8.8	150	7.11	23	330	116	2007
S_3	10.8	160	7.06	24	412	118	2217.1
S_4	6.4	110	7.4	23	500	136	2240.4
S_5	7.6	20	7.7	25	300	128	1864
S_6	6.8	80	7.34	23	495	136	1890.4
S_7	8	50	7.3	24	600	124	1820.3
S_8	7.6	110	7.4	24	700	118	1703.7
S_9	8	100	7.2	25	412	130	1610.34
S_{10}	8.4	50	7.94	22	1319	294	2473.8

Table 6. Water quality parameters on 23/01/2011.

Sampling locations	Water quality parameter						
	DO (mg/L)	COD (mg/L)	pH	T (℃)	TDS (mg/L)	Hardness (mg/L)	SO_4^{2-} (mg/L)
S_1	7.6	30	7.4	24	303	142	1563.66
S_2	10.4	40	7.48	22	379	132	1376.96
S_3	9.6	40	7.63	24	600	155	1330.28
S_4	8	100	7.57	23	500	175	1587
S_5	7.6	150	7.42	25	300	165	1423.6
S_6	7.6	140	7.35	22	379	185	1400.3
S_7	8	140	7.36	25	400	165	1283.6
S_8	7.2	70	7.3	23	313	140	1400.3
S_9	8	70	7.38	24	303	160	1190.25
S_{10}	7.6	100	7.99	22	1364	210	1470.31

Table 7. Water quality parameters on 01/02/2011.

Sampling locations	Water quality parameter							
	DO (mg/L)	COD (mg/L)	pH	T (℃)	TDS (mg/L)	Hardness (mg/L)	SO_4^{2-} (mg/L)	Cl^- (mg/L)
S_1	5.6	1500	7.5	26	1000	150	1376.9	60
S_2	8.8	80	7.5	24	939	195	1376.9	60
S_3	7.6	50	7.5	25	700	100	1260.2	70
S_4	8.4	200	7.5	23	768	135	1213.5	90
S_5	7.2	90	7.5	26	900	140	1166.9	70
S_6	8.4	300	8.5	23	700	140	1376.9	90
S_7	1.2	120	7.5	23	1000	160	1283.6	70
S_8	6	50	7.5	26	800	160	1283.6	70
S_9	3.6	120	7.5	24	300	155	606.79	90
S_{10}	2	330	7.5	25	1700	230	1376.9	140

sites were recorded as 23℃ which was less as compared to other sampling locations on this day.

On 20/02/2011, the DO varies between 8.8 to 11.6 mg/L, this DO concentration is comparatively higher than the previous weeks. On that day, no discharge of sewage was waste observed. Since the river is free flowing in nature, previously discharged pollution might have been diluted.

Table 8. Water quality parameters on 07/02/2011.

Sampling locations	Water quality parameter							
	DO (mg/L)	COD (mg/L)	pH	T (°C)	TDS (mg/L)	Hardness (mg/L)	SO_4^{2-} (mg/L)	Cl^- (mg/L)
S_1	6.8	120	8	26	407	130	1516.9	90
S_2	6.4	20	7.5	23	489	125	1516.9	80
S_3	6.8	40	7.5	24	600	145	1423.6	90
S_4	5.6	70	7.5	25	400	145	1400.3	250
S_5	7.2	120	7	23	600	210	1260.2	100
S_6	6.4	40	7	26	400	225	1446.9	270
S_7	3.2	100	8.5	25	700	130	1516.9	290
S_8	7.6	140	7	23	300	140	1143.5	60
S_9	6.4	80	7	24	500	120	1493.6	70
S_{10}	6	50	7.5	26	1385	260	1680.36	70

Table 9. Water quality parameters on 13/02/2011.

Sampling locations	Water quality parameter							
	DO (mg/L)	COD (mg/L)	pH	T (°C)	TDS (mg/L)	Hardness (mg/L)	SO_4^{2-} (mg/L)	Cl^- (mg/L)
S_1	5.6	80	7.5	25	1100	105	1750.37	80
S_2	6.4	150	7.5	24	800	150	1797	90
S_3	6.8	180	7.5	26	1300	95	1516.9	90
S_4	7.2	40	7.5	23	800	110	1633.6	80
S_5	4.4	20	7.5	24	700	125	1446.9	100
S_6	5.6	110	7.5	25	1200	110	1283.6	80
S_7	7.2	120	7.5	23	800	120	1563.6	110
S_8	6.4	90	7.5	24	954	155	1306.9	130
S_9	6.8	70	7.5	26	700	120	1260.2	250
S_{10}	6.4	160	8.5	25	2147	230	2007	340

Table 10. Water quality parameters on 20/02/2011.

Sampling locations	Water quality parameter							
	DO (mg/L)	COD (mg/L)	pH	T (°C)	TDS (mg/L)	Hardness (mg/L)	SO_4^{2-} (mg/L)	Cl^- (mg/L)
S_1	10	70	7.5	28	400	165	2380.5	90
S_2	10.8	50	7.5	26	400	185	1633.6	100
S_3	10.4	60	7.5	28	600	165	1493.6	80
S_4	11.2	60	7.5	27	500	150	1750.37	80
S_5	8.8	60	7.5	28	500	160	1563.6	90
S_6	11.6	60	7.5	27	300	185	1423.6	90
S_7	10	30	7.5	26	500	180	1750.37	120
S_8	11.6	30	7.5	28	700	185	1820.39	80
S_9	8.8	50	7.5	26	800	265	2147.129	300
S_{10}	8.4	50	7.5	28	1300	280	2147.129	310

On 27/02/2011, the DO has been recorded higher, between 6.8 to 10 mg/L. This high DO level is due to the recent rainfall before the day the sampling set has was collected. Based on the above discussion it can be said that the water is not fit for drinking purpose. The prime requirements for DO arise in connection with fish life and it is generally true that if water quality is suitable for fish life; the cardinal point about the solubility of oxygen in

Table 11. Water quality parameters on 27/02/2011.

Sampling locations	Water quality parameter							
	DO (mg/L)	COD (mg/L)	pH	T (℃)	TDS (mg/L)	Hardness (mg/L)	SO_4^{2-} (mg/L)	Cl^- (mg/L)
S_1	10	120	7.5	25	1500	200	1797	300
S_2	10	320	7.5	27	900	300	2077	600
S_3	9.2	360	7.5	25	900	200	1867	400
S_4	10	120	7.5	26	900	200	1727	600
S_5	7.6	400	7.5	27	1400	300	1633.6	700
S_6	7.2	240	7.5	25	700	300	1563.6	500
S_7	8.4	1560	7.5	24	800	200	1843.7	600
S_8	6.8	160	7.5	26	400	400	1703.7	500
S_9	7.2	50	7.5	25	1300	100	1493.6	240
S_{10}	8.4	110	8.5	25	1300	150	1913.7	280

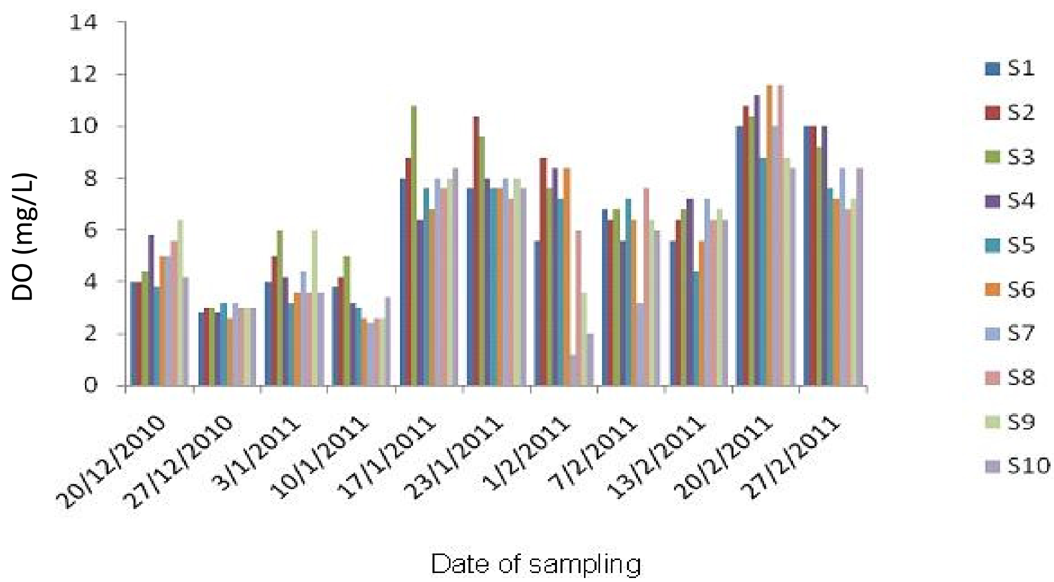

Figure 2. Variation of DO over a period of time.

water is that it has an inverse relationship with temperature.

Variation of temperature

The temperature was recorded between 17 to 19℃ on 20/12/2010 and 27/12/2010. This lower temperature of about 17℃ has been recorded due to light drizzling and weather change dramatically (Dhage et al., 2006). The temperature was recorded between 22 to 28℃ from 3/01/2011 to 27/02/2011. This normal temperature is recorded due to the normal atmospheric temperature and the high temperature will affect the DO concentration.

Variation of pH

The variation between the pH of samples collected from 20/12/2010 to 17/01/2011, S_1 to S_9 is 7.4 to 7.52. The pH for S_{10} is 7.7 to 8.6 over the same period of three weeks. This is comparatively higher than that of S_1 to S_9 for the period of same three weeks, because the S_{10} is highly utilized by people for domestic purposes such as washing, bathing etc. This increases the soap content in water at S_{10}. This might have increased pH at that sampling location. The pH was recorded in the range of 7 to 8 for all samples (S_1 to S_9) collected from 23/01/2011 to 27/02/2011. The pH of S_{10} is above 8. The high pH shows that the water is alkaline due to the addition of soap and sewage intrusion at S_{10}.

In generally accepted sense, Dissolved gases such as CO_2, H_2S, and NH3 also affect the pH of water. The industrial waste water will be strongly acidic or basic and their effect on the pH value of receiving water depends on buffering capacity of water. Higher value of pH has a bitter taste. Higher values of pH hasten the scale

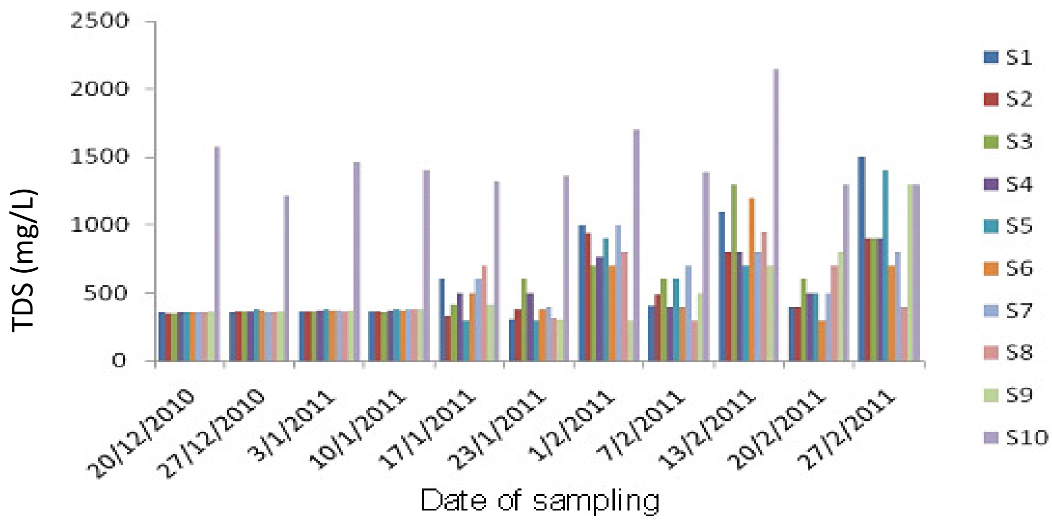

Figure 3. Variation of TDS over a period of time.

formation in water heating apparatus.

Variation of total dissolved solids

The variation of TDS over a period of time is shown in the Figure 3. The TDS concentration recorded for S_1 to S_9 from 20/12/2010 to 27/02/2011 is between 300 to 1000 mg/L. The TDS for S_{10} up to the same period of time is between 1214 to 2147 mg/L. This change is due to high exploitation of that location of the local people for washing, domestic purpose and intrusion of sewage.

The permissible limit of TDS is 500 mg/L for drinking water as per the IS 10500: 1991. More number of values are not within the permissible limit, only few values are within the permissible limit. Many dissolved substances are undesirable in water. Dissolved minerals, gases and organic constituents may produce aesthetically displeasing color, taste and odour. Some dissolved organic chemicals may deplete the DO in receiving waters and some may be inert to biological oxidation, yet others have been identified as carcinogens. Water with higher solids content often has a laxative and some time reverse effect upon people whose bodies are not adjusted to them.

Variation of hardness

The variation of hardness over a period of time is shown in the Figure 4. Hardness recorded between 98 to 540 mg/L for S_1 to S_{10} from 20/12/2010 to 27/01/2011. The high concentration of hardness was recorded due to the intrusion of sewage, pseudo hardness by utilization of soap for washing (Gupta and Sahara, 2009).

It denotes that the water is slightly and moderately hard. The high concentration of hardness above 350 mg/L indicates that the water is excessively hard. The hard water is useful to growth of children due to the presence of Ca^{2+} and Mg^{2+}. Moderately hard water is preferred to soft water for irrigation purpose. Cardiovascular diseases are reported in soft water areas (Jurgen, 1991). The permissible limit of hardness is 300 mg/L as per the IS 10500:1991.

Since Ca and Mg are hardness produced species, their variation over a period of time is discussed here. The Calcium was recorded between 34 to 144mg/L. At S_{10}, the Calcium concentration is high. When compared with other sampling location, the increased value of Calcium was found on 10/01/2011 sample. Its concentration was found to be 144 mg/L. Calcium is one of the most common constituents present in natural water. The high concentration of Calcium causes hardness in water and incrustation in boilers. It was within the permissible limit of 75 mg/L except S_{10}.

The magnesium was ranging between 10 to 43 mg/L and is the entire sampling range. All the Mg^{2+} values are within the permissible limit of 30 mg/L except S_{10} values. Magnesium is a common constituent in natural water. Mg^{2+} salts are important contributors to the hardness of water which break down heated, forming scale in boilers. The increase in Mg^{2+} concentration at S_{10} may be due to sewage disposed to that sampling location. Softening, reverse osmosis, electro dialysis, or ion exchange reduces the Mg^{2+} and associated hardness to acceptable limits.

Variation of sulphate

The variation of sulphate over a period of time is shown in the Figure 5. The sulphate was recorded between 12 to 2473.8 mg/L at S_1 toS_{10} during 20/12/2010 to 27/02/2011. The reason for this is sewage discharge by the local area people near river. Comparing to all sampling locations, value at S_{10} have been recorded as

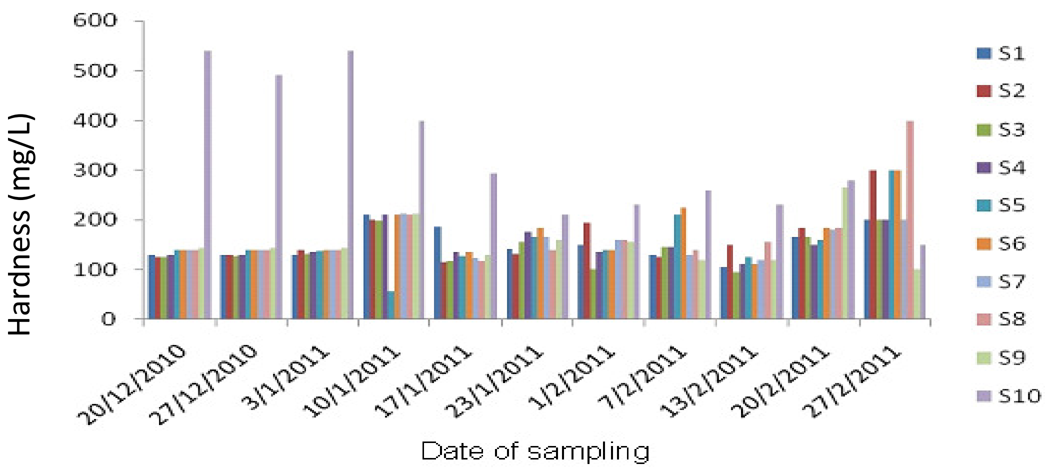

Figure 4. Variation of hardness over a period of time.

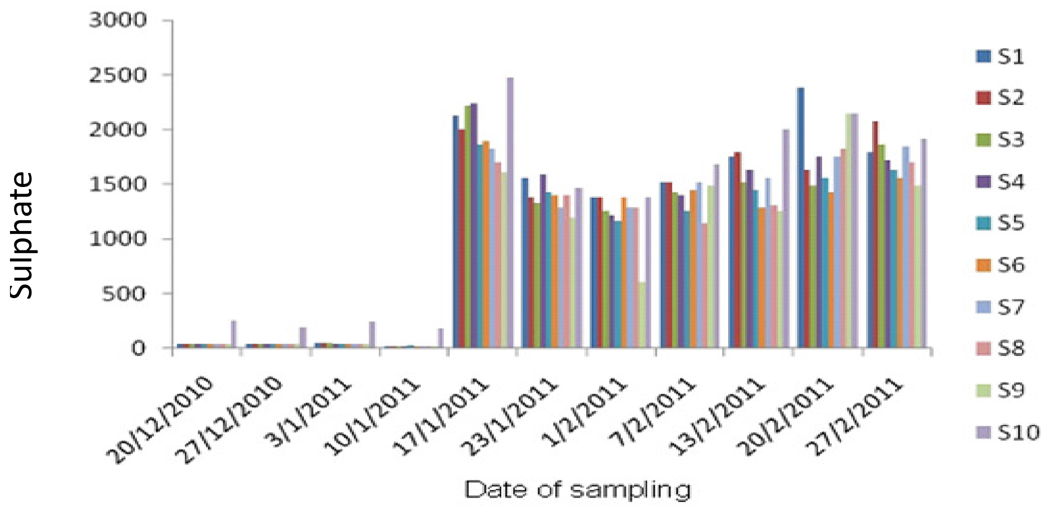

Figure 5. Variation of Sulphate over a period of time.

high value of sulphate. Most of the readings which were recorded are not within the permissible limit of 200 mg/L as per IS 10500:1991. The sulphate content in water is important in determining the suitability of water for public and industrial use. Sulphate may also contribute to the corrosion of pipelines in the distribution system. The major physiological effects resulting from the ingestion of large quantities of sulphate are catharsis, dehydration and gastrointestinal irritation. The Mg^{2+} and Na^{+} are present in most sources of their combination with sulphate and will have an enhanced laxative effect.

Variation of chloride

The variation of chloride over a period of time is shown in the Figure 6. The chloride concentration ranged from 36 to 700 mg/L was recorded during 20/12/2010 to 27/02/2011. The chloride concentration always exceeded the permissible limit at S_{10}. If the water with high chloride is used for construction purpose, this may corrode the concrete. The highest concentration of chloride at S_{10} is due to the intrusion of sewage water into the river. At S_{10}, the chloride concentration is not within the permissible limit of 250 mg/L. High chloride content may harm metallic pipes and structures as well as growing plants. It will not develop any adverse effect once the human system becomes adapted to the water. The sewage is a rich source of chloride, a high value at S_{10} in all sampling periods indicating pollution of water by a sewage effluent. On 27/02/2011 before the day of sampling, rain was over there. Hence runoff water into the river might be contributing to chloride concentration in the river.

Variation of chemical oxygen demand

The variation of COD over a period of time is shown in

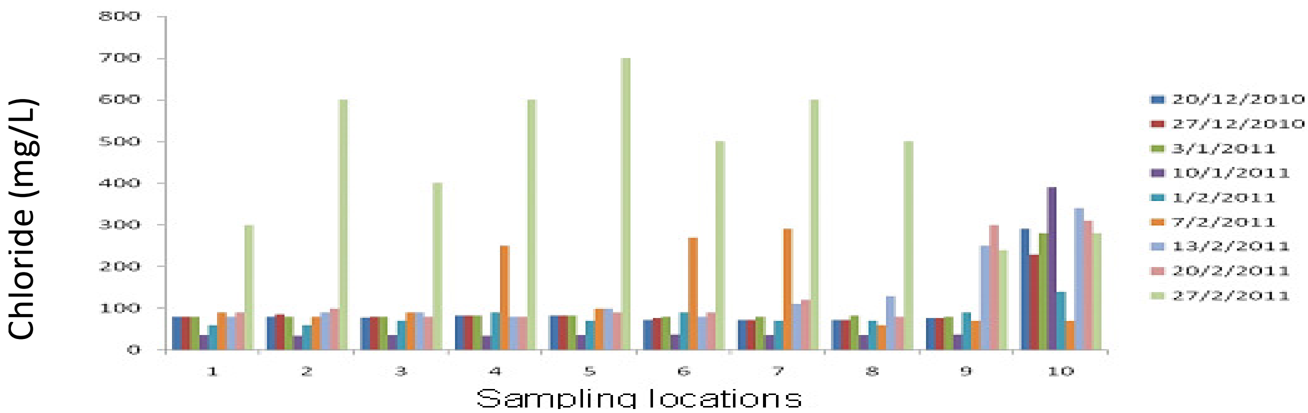

Figure 6. Variation of Chloride over a period of time.

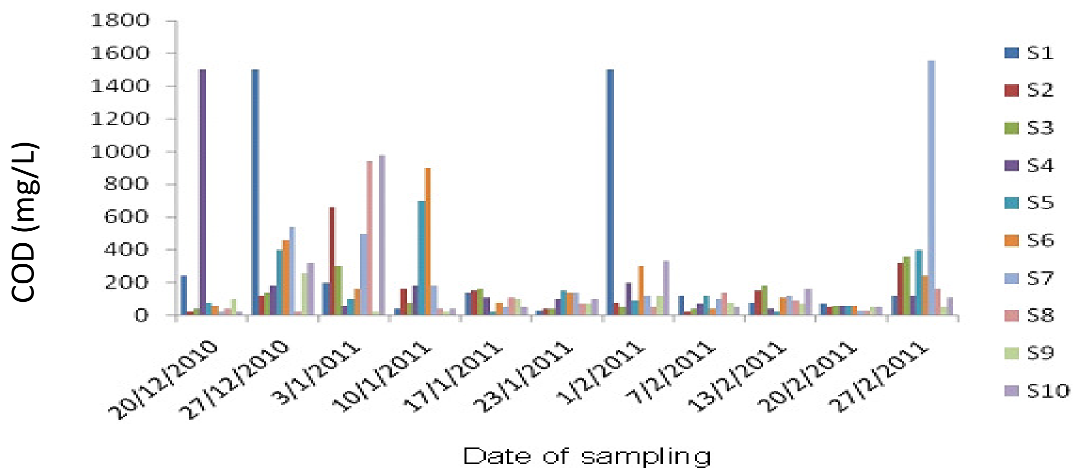

Figure 7. Variation of COD over a period of time.

the Figure 7. The COD concentration was recorded between 20 to 1500 mg/L. In the S_4 locations, it has a maximum value of COD which is due to the washing and bathing activities on the location. The lower concentration of COD was recorded as 20 mg/L. In the sampling location S_1, the COD concentration was found to be as high as 1500 mg/L so DO get decreased in that location of 2.8 mg/L. It is obvious that COD has an inverse relationship with DO. Whenever the sewage discharge is observed in S_6 the COD concentration is found to be high. This COD concentration was recorded as 900 mg/L.

Variation of iron

The values of iron were between 0.1 to 0.34 mg/L. All the values are within the permissible limit of 0.3 mg/L except S_{10} of 27/12/2010. On 27/12/2010 at S_{10} high iron value of 0.34 mg/L was observed. Iron is essential nutrition to the human health. Turbidity and color will develop in piped systems at levels above 0.05 to 0.1 mg/L. Long time consumption of drinking water with a high concentration of iron can lead to liver disease. Iron also promotes the growth of iron bacteria in water and it gives a rusty appearance to the water. The highest concentration of iron at S_{10} is due to the sewage intrusion. On 10/01/2011 for all the samples (S_1 to S_{10}) iron concentration is zero. The nil iron concentration observed was due to no discharge of sewage; since the river is free flowing, previously discharged pollution might have been diluted.

Variation of phosphate

The variation of phosphate over a period of time is shown in the Figure 8. The values of phosphate were between 1.5 to 4 mg/L. Phosphate occurs as trace in natural water. Stream receiving raw or treated sewage, agricultural drainage and certain industrial water normally

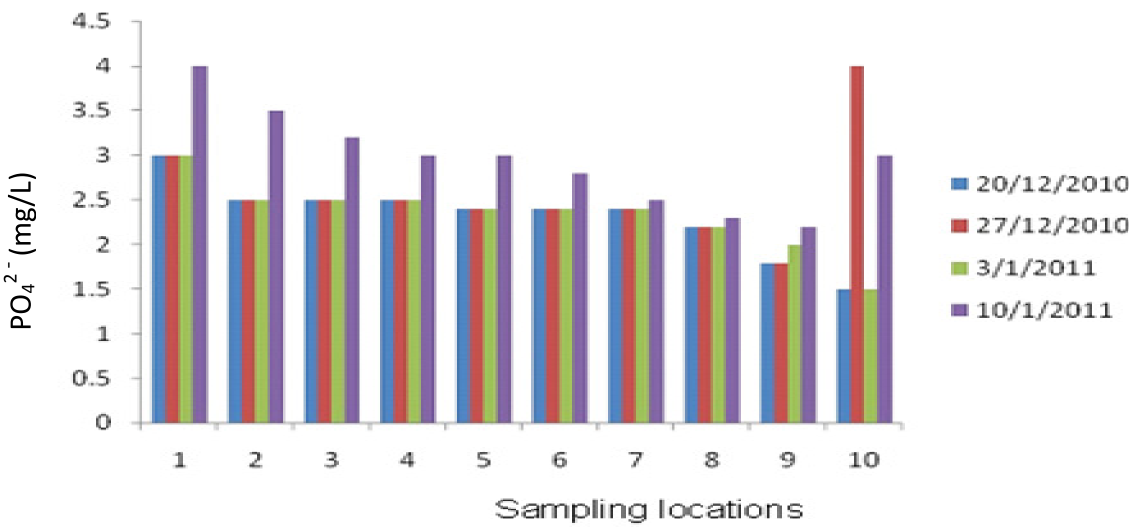

Figure 8. Variation of Phosphate over a period of time.

contain significant concentrations of phosphate. Trace of phosphate increase the tendency of troublesome algae growth. The highest concentration of phosphate was found to be 4 mg/L and is due to detergent leached into the streams through the waste water generated industrially, domestically or from cloth dyeing and garment industries.

Variation of manganese

The Mn recorded was zero for all samples from 20/12/2010 to 10/01/2011. The main source of Mn pollution is from steel industry but this river is polluted with textile effluent so the Mn pollution is not discharged into the river. As a result, Zero Mn concentration was obtained. The intake of manganese can be high as 20 mg/day without apparent ill effects. It should be noted that manganese may be objectionable to the consumer if it is deposited in water mains and cause discoloration. Concentrations below 0.1 mg/L are usually acceptable to consumers. This may vary with local circumstance.

Variation of nitrate and nitrite

In this study, the nitrate concentrations were between the 20 to 44 mg/L. The nitrite was recorded between the 0.01 to 0.6 mg/L. At S_5 during 20/12/2010, 27/12/2010, 3/01/2011 the nitrite concentration was zero. Nitrate generally occurs in trace quantities in surface waters but may attain high levels in some ground water. Nitrite in water is either due to oxidation of ammonium compounds or due to a reduction of nitrate. It can be toxic to certain aquatic organism even at concentrations of 1 mg/L. Excessive limits of it contributes to the illness known as methanoglobinemia in infants. All NO_3 concentrations are within the permissible limit of 50 mg/L as per the IS 10500:1991.

Variation of sodium

The sodium was recorded between 20 to 260 mg/L. This is due to the discharge of sewage and it took place at S_{10}. Sewage is the main source of sodium salts. The permissible limit for sodium in Drinking Water is 200 mg/L as per the IS 10500:1991.

Variation of fluoride

The fluoride was ranging between 0.3 to 0.6 mg/L. Trace of fluorides is present in many waters. All the fluoride concentrations are within the permissible limit of 1 mg/L. The fluoride is designated as two edge sword because if it is less than limit and also greater than limit it will cause harm to the human and aquatic organisms (Jurgen, 1991). Presence of large amounts of fluoride is associated with dental and skeletal fluorosis (1.5 mg/L) and inadequate amounts with dental caries (< 1 mg/L).

Water quality index

Water quality index (WQI) is defined as a rating reflecting the composite influence of different water quality parameters. WQI is calculated from the point of view of the suitability of ground water for human consumption. In computing WQI three steps are followed. In the first step, each of the ten parameters has been assigned a weight (w_i) according to its relative importance in the overall quality of water for drinking purposes. It is shown in the Table 12. The maximum weight of 5 has been assigned to the parameter TDS due to its major importance in water quality assessment. Iron which is given the weight of 1 due to the low value was observed in surface water. In the second step, the relative weight, (W_i) is computed

Table 12. Relative weight of water quality parameters.

Chemical parameter	IS10500: 1991	Weight (w_i)	Relative weight (W_i)
TDS	500 – 1000 mg/L	5	0.1724
pH	6.5 - 8.5	4	0.1379
Hardness	300 - 600 mg/L	3	0.1034
Chloride	250 - 1000 mg/L	3	0.1034
Sulphate	200 - 400 mg/L	3	0.1034
Nitrate	50 mg/L	3	0.1034
Fluoride	1 – 1.5 mg/L	3	0.1034
Magnesium	30 - 100 mg/L	2	0.0689
Calcium	75 - 200 mg/L	2	0.0689
Iron	0.3 – 1.0 mg/L	1	0.0344
Summation		$\Sigma w_i = 29$	$\Sigma W_i = 1.000$

Table 13. Water quality classification based on wqi value.

WQI value	Water quality	Percentage of water samples
< 50	Excellent	1.8
50 – 100	Good water	33.6
100 – 200	Poor water	62.72
200 – 300	Very poor water	1.8
>300	Water unsuitable for drinking	-

from the Equation 1. In the third step, a quality rating scale (q_i) for each parameter is assigned by dividing its concentration in each water sample by its respective standard according to the guidelines laid down in the IS 10500:1991. For computing the WQI, the SI is first determined for each water quality parameter, which is then used to determine the WQI as shown by the Equation 4. Table 13 shows the percentage of water samples that falls under different water quality.

In this study, the computed WQI values from 46.56 to 217.8 therefore, can be categorized into five types “Excellent Water” to “Water unsuitable for drinking”. The high value of WQI at sampling locations has been found to be mainly from the higher values of TDS and Sulphate. Among the total sampling, 62.72% of collected sample fell in the range of 100 to 200 on water quality index scale. Since the most percentage fell in that category it can be concluded that the Noyyal River has poor water quality. On the entire sampling, 1.8% fell in the range of 200 to 300 this indicated the very poor water quality in Noyyal River.

Conclusion

The following conclusions were drawn on the basis of the physico-chemical analysis of surface water for Noyyal River in Coimbatore city:

1. Comparing all the sampling locations, at S_{10} the samples have the highest concentration of TDS, sulphate, hardness, pH, chloride due to the sewage disposal and utilization of soap for clothes washing.
2. The DO concentration was found to be low at sampling location S_7 and is due to the dumping of used mats, pillows, garlands at that location. It leads to mortified fishes and were floating on the river.
3. COD concentration was found to be high due to the domestic waste discharge into the river.
4. Water quality index (WQI) for 110 samples ranges from 46.56 to 217.8. Among the total samples, 62.72% of the samples exceed WQI of 100. The high values of WQI at these sampling locations have been found to be mainly from the higher values of sulphate and TDS. These 62.72% of water samples were found to be poor quality. It needs some degree of treatment for human consumption. So, it is concluded that the Noyyal River has poor water quality. On the entire sampling, 1.8% fell in the range of 200 to 300 and this indicated the very poor water quality in Noyyal River.
5. The result from the data analysis show that, the water is certainly not fit for drinking purpose without any form of treatment, but may be considered for other purpose like washing, bathing of animals etc.

REFERENCES

Basanta KM, Chitta RP (2009). ‘Assessment of water quality index in Mahanadi and Atharabanki Rivers and Taldanda Canal in paradip Area’. India J. Hum. Ecol. 26(3):153-161.

Dhage SS, Chandorkar AA, Rakesh K, Srivastava A, Gupta I (2006). Marine water quality assessment at Mumbai West Coast. Environ.

Int. 32:149-158.
Gupta DP, Sahara JP (2009). ‘Physiochemical Analysis of Ground Water of Selected Area of Kaithal City (Haryana) India Res. 1(2). http://www.city-data.com/world-cities/Prague-Environment.html.
Indian Standard (IS) (1991). 10500, Indian standard drinking water – Specification.
Islam MR, Alam MDJB (2007). ‘Water quality parameters along rivers’. J. Environ. Sci. Technol. 4(1):159-167.
Jurgen P (1991). ‘Chemical analysis for drinking water’.
Lenin Sundar M, Saseetharan MK (2008). ‘Ground water quality in Coimbatore, Tamil Nadu along Noyyal River’. J. Environ. Sci. Eng. 50(3):187-190.
Merriam Webster online dictionary (2010). ‘http://www.merriam-webster.com/dictionary/pollution’, pp. 08-13.
Ramakrishnaiah CR, Sadashivaiah C (2009). ‘Assessment of Water Quality Index for the Groundwater in Tumkur Taluk, Karnataka State’. India E-J. Chem. 6(2):523-530.
Rainwater harvesting (2007). ‘http://www.rainwater harvesting.org/crisis/river-noyyal.html’ 02-01.
Sajidu SMI, Henry EMT (2007). ‘Water quality assessment in streams and wastewater treatment plants of Blantyre, Malawi’. J. Phys. Chem. Earth 32:1391-1398.
www.cpcb.nic.in.