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Pollution status of river Mula (Pune city) Maharashtra, India

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Abstract : *Present work deals with the seasonal variations in physico-chemical parameters of river Mula at Pune city. Water samples were collected monthly from selected sampling stations (Station I- Wakad; II-Aundh and III- Dapodi) in winter, summer and monsoon seasons during October 2007 to September 2008. The analysis was carried out for temperature, pH, dissolved oxygen (DO), free carbon dioxide (free CO_2), total alkalinity, total hardness, biological oxygen demand (BOD), chemical oxygen demand (COD), chloride, nitrate and phosphate. It was observed that, temperature, chloride, BOD, COD, total alkalinity, total hardness, nitrate and phosphate content was high during summer than winter and less during monsoon seasons. Whereas, the DO content decreased in the summer and increased in the winter followed by monsoon seasons. The quality of water at station II and station III were high in term of nutrient loads, due to influent domestic wastewater. These results suggest that the water quality of river Mula is adversely affected and impaired by the discharge of domestic waste.*

Key Words: Mula river, Physico-chemical parameters, Water pollution.

Introduction

According to the United Nation's World Water Development Report (2003), 70% of the earth's surface is covered by water; of which only 2.5% of water is fresh and only 0.3% water is available for human use. Growing urbanization and industrialization brings many changes in quality of air and water. A water body around these developing centers shows deterioration in its quality. Increasing contamination with toxic effluent is of major concern. According to a WHO estimate (Bhuvaneswaran *et al*., 1999) about 80% water pollution in developing countries like India is caused by domestic wastes. Therefore water pollution and its management are of major concern. Mula is one of the major river in Pune city. The Pune city is spread along the bank of rivers Mula, Mutha and Pavana. The river receives untreated and or treated domestic and industrial wastes from settlements and industries located along the river site.

Numerous researchers have studied the physico-chemical parameters of various river water in the India. It has been found that the water quality of the river lying in the vicinities of urban areas is heavily polluted due to industrial and domestic wastes. The water quality of river Mula from Pune city was reported by Gunale (1978). Gunale and Balakrishnan (1981) emphasized mainly on biomonitoring of eutrophication in Pavana, Mula and Mutha river. Patwardhan *et al*. (2003) assessed the impact of urbanization on the water quality of the river Mula-Mutha and Pashan Lake. Jafari and Gunale (2005) carried out an ecological status of these rivers.

As a part of continuous assessment of water quality of river Mula from Pune city and to compare changes taking place over the time the present study was undertaken.

Materials and Method

Pune is located 560 m above MSL (180 31' N,

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730 51' E) and on the western margin of the Deccan Plateau spread on the banks of the rivers Mula and Mutha. The river Mula originates along the Western Ghats, Maharashtra, India. The Mula enters in the Pune metropolitan's area near Wakad and it merges with the river Mutha in the Pune city.

For present study, Mula river water were collected from three sampling stations between upstream at Wakad and downstream at Dapodi in Pune city on the basis of drainage pattern and activities in its catchment (Fig. 1). The water samples were collected monthly from October 2007- September 2008 at the selected sampling stations I, II and III (Fig. 1). Collection of the water samples were done in the morning time from 9.00 am to 12.30 pm. Observations for temperature and DO were made at the sampling stations. While for DO the sample were collected in 300 ml sized glass stopper BOD bottles. For the remaining parameters, water samples were collected in two liter sized cleaned cans and brought to the laboratory. The analysis was carried out for determination of physico-chemical parameters such as: DO, free CO_2, total alkalinity (TA), total hardness (TH), BOD, COD, chloride, nitrate and phosphate by using standard methods described by (APHA, 1998). These parameters were compared with water quality standards to indicate pollution status in river.

Results and Discussion

Seasonal assessment of water quality from sampling stations of river Mula, Pune city was conducted during October 2007- September

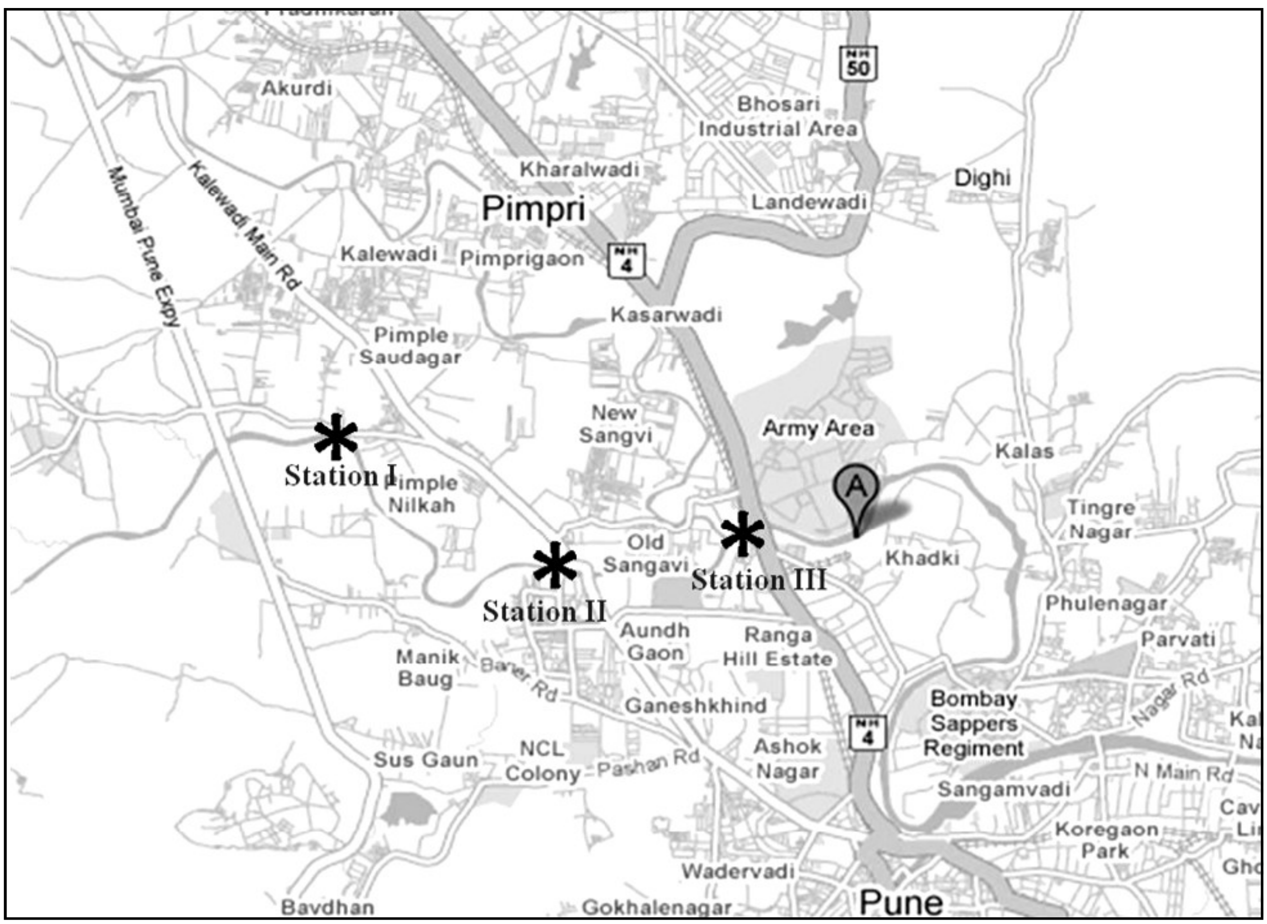

Fig. 1. Map of study area showing sampling stations in river Mula, Pune City.

2008. The water quality based on analysis of physico-chemical parameters from selected sampling stations are summarized in the Table 1 and Fig. 2-12. There is no data for the month of July 2008 and August 2008 due to the floods.

Temperature is an important parameter that regulates dissolution of gases such as free CO_2 and DO. In the present study, the water temperature at the three sampling stations was in the range 18.51°C – 26.03°C (Table 1). The minimum temperature was found in winter (18.51±0.87°C) at station I, whereas the maximum water temperature was recorded in summer (26.03±1.28°C) at station III (Table 1 and Fig. 2). Similar observations were recorded by many workers (Gunale, 1978; Bellos and Sawidis 2005; Durmishi, *et al*., 2008). Higher

Table 1. Seasonal variation of physico-chemical parameters from river Mula (Pune)

Parameters	Stations	Seasons		
		Winter	Summer	Monsoon
Temperature	I	18.51±0.87	22.84±1.33	22.03±2.13
	II	20.79±0.94	24.38±1.43	22.03±1.33
	III	22.43±1.27	26.03±1.28	25.40±3.13
pH	I	7.49±0.06	7.39±0.10	7.21±0.02
	II	7.46±0.17	7.74±0.12	7.11±0.26
	II	7.71±0.06	7.62±0.17	7.31±0.02
DO	I	6.41±0.80	4.28±0.69	6.60±2.40
	II	1.55±0.63	1.35±0.34	4.46±2.23
	III	1.21±0.47	0.00±0.00	4.05±2.03
Free CO_2	I	10.03±1.63	17.43±2.63	13.20±11.33
	II	19.23±1.93	25.40±2.70	19.73±6.53
	II	27.49±1.45	39.47±1.96	35.93±15.40
Chloride	I	42.60±7.84	48.40±2.45	24.85±4.50
	II	61.63±6.71	69.82±4.55	29.59±4.03
	II	71.41±5.87	75.64±5.54	50.76±6.74
Total Alkalinity	I	89.17±10.60	118.33±9.95	75.00±11.67
	II	155.83±13.15	176.67±10.09	116.67±20.00
	III	176.67±13.45	210.00±7.58	123.33±20.00
Total Hardness	I	82.00±11.73	125.83±8.29	75.33±20.00
	II	115.00±20.75	180.83±5.66	111.33±46.00
	III	147.00±19.80	199.17±8.89	114.67±47.33
BOD	I	60.88±9.50	91.36±7.73	59.78±13.10
	II	76.67±5.34	114.05±6.86	71.60±11.50
	III	80.65±7.45	121.31±5.89	74.33±16.24
COD	I	85.33±8.36	149.33±14.65	94.33±19.67
	II	128.67±12.57	182.08±11.79	110.67±33.33
	III	153.50±14.90	216.67±15.68	138.67±37.33
Nitrate	I	4.58±1.16	9.08±1.42	3.83±1.17
	II	8.67±1.64	16.17±2.67	9.17±1.83
	III	14.08±1.08	21.75±3.08	11.83±2.83
phosphate	I	3.83±1.42	7.25±1.03	5.00±1.00
	II	10.83±0. 73	11.25±1.55	7.67±1.00
	III	8.08±0.89	15.67±2.35	10.00±2.00

Except Temperature and pH all values are in mg/L. Values represent the mean ± SE of three replicates.

temperature during summer was due to higher ambient temperature (Bahadur and Chandra, 1996; Kumar and Bahadur, 2009).

DO is considered as the most important measurement of water quality. Its deficiency directly affects the ecosystem of a river due to degradation of wastes (Hacioglu and Dulger, 2009). Sources of oxygen in water are by diffusion of oxygen from the air, photosynthetic activity of aquatic autotrophs and inflowing streams (Ramachandra and Solanki, 2007). The mean values of DO varied according to the seasons at all the stations (Fig. 3). The DO content during monsoon were maximum at (4.05±2.03 mg/L to 6.60± 2.14 mg/L), while it was slightly less during winter (1.21±0.47mg/L to 6.41±0.80 mg/L) and much declined during summer (0.00±0.00mg/L to 4.28± 0.69 mg/L) (Table 1). DO content was found to be maximum at upstream (Station I) than downstream (Station II and III) (Fig. 3). Similar results were recorded by Jha (2003). In contrast to the results obtained in the present study, Chatterjee and Raziuddin (2002) reported that the DO concentration was low in summer and monsoon. Seasonal variations observed in DO content with higher values in monsoon could be due to increase aeration because of rainfall and mixing up of well aerated runoff from streams (Jain, 2002; Adeyemo *et al*., 2008). During summer, DO was absent at station III due to increase in domestic waste. Low DO concentrations (< 3 mg/L) in fresh water aquatic systems indicates high pollution level of the waters and causes negative effects on life in this system (Yayintas *et al*., 2007).

During present study, the free CO_2 content was found to be higher in the summer followed by monsoon and winter seasons (Fig. 4). The free CO_2 content varied from station to station. Higher free CO_2 concentration was recorded during summer 39.47±1.96 mg/L at station III and minimum during winter 10.63 ± 1.63 mg/L at station I (Table 1). Dorssi *et al*. (1963) were of the opinion that free CO_2 content during summer was high due to oxidation of sewage. In present study, the free CO_2 content was more at station II and III as compared to station I in all seasons due to increase in domestic wastewater. The concentration of free CO_2 is higher in polluted water as compared to fresh water bodies.

In the current study, the DO content showed inverse relationship with temperature and free CO_2. Similar observations were recorded by Yunus and Nakagoshi (2004) during study on water quality of the Pinang River, Malaysia. Gunale (1978), Francis *et al.,* (2007) and Magar, (2008) also showed that the low concentration of DO during summer due to oxygen demand for aerobic degradation of sewage. Haarstad and Maehlum (1999) and Fafioye *et al.,* (2004) reported that temperature affects the oxygen content of water. The amount of DO that can be held by the water depends mainly on the water temperature (Garg 2006; Agunwamba *et al.,* 2006).

BOD is used for determination of relative demand of oxygen for aerobic degradation of waste which indicates pollution level of waters (Durmishi *et al.,* 2008). In present investigation, it was observed that during monsoon BOD content was minimum at station I (59.78 ± 13.18 mg/L) while maximum during summer (121.31 ± 5.89 mg/L) at station III (Table 1 and Fig. 5). The BOD values were higher in the summer season due to the addition of sewage (Rathod, 2005). Minimum BOD concentration was recorded in winter (76.67± 5.34 mg/L) at station II. This may due to the low level of organic waste and poor biological activity of microorganism (Chatterjee and Raziuddin, 2002). BOD decreased in all the water bodies as the rains progressed (Ajibola *et al.,* 2005).

COD measures the capacity of water to consume oxygen during the decomposition of organic matter. It was noticed that, maximum COD content at station III (216.67±15.60 mg/L)

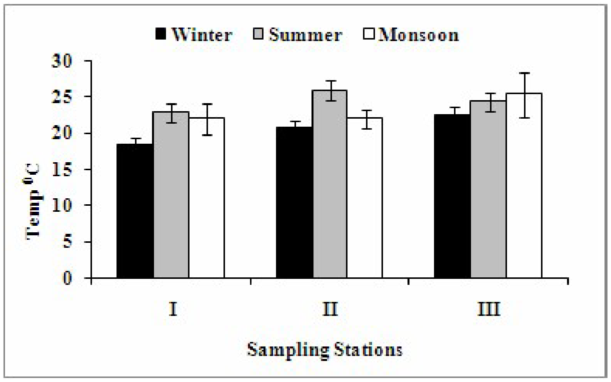

Fig. 2. Seasonal variation of Temperature from three sampling stations of river Mula, Pune city during October 2007 to September 2008.

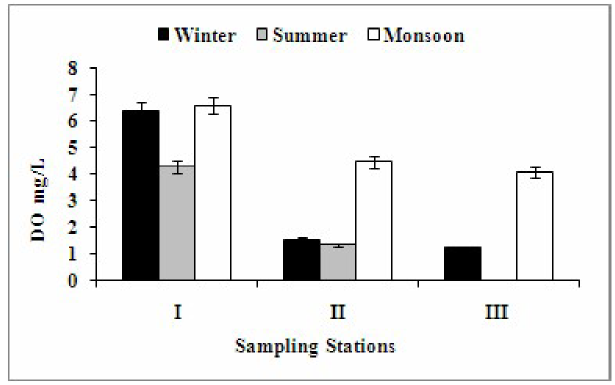

Fig. 3. Seasonal variation of DO from three sampling stations of river Mula, Pune city during October 2007 to September 2008.

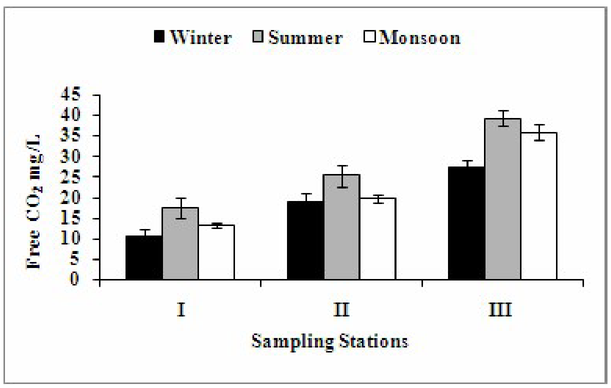

Fig. 4. Seasonal variation of Free CO_2 from three sampling stations of river Mula, Pune city during October 2007 to September 2008.

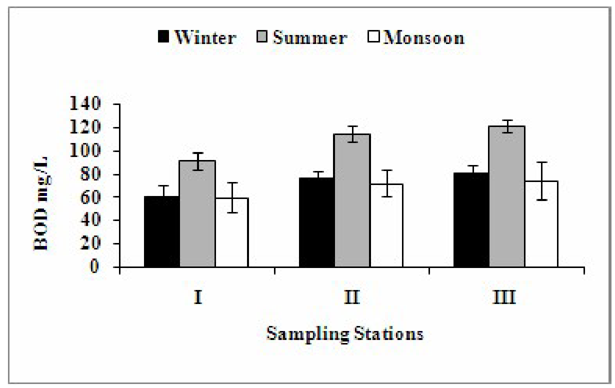

Fig. 5. Seasonal variation of BOD from three sampling stations of river Mula, Pune city during October 2007 to September 2008.

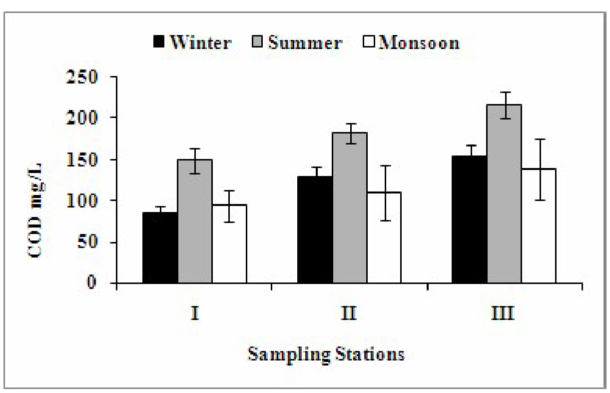

Fig. 6. Seasonal variation of COD from three sampling stations of river Mula, Pune city during October 2007 to September 2008.

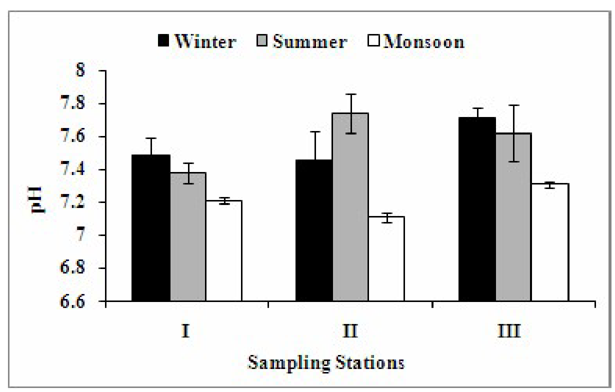

Fig. 7. Seasonal variation of pH from three sampling stations of river Mula, Pune city during October 2007 to September 2008.

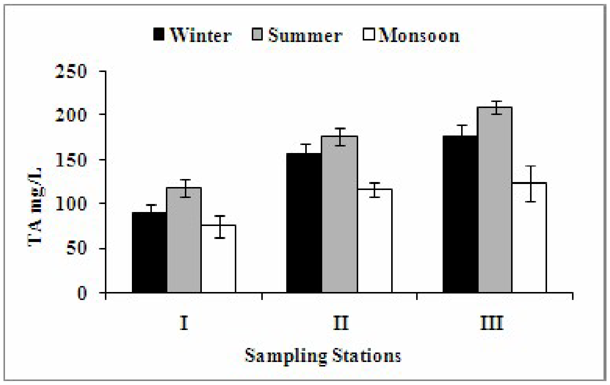

Fig. 8. Seasonal variation of TA from three sampling stations of river Mula, Pune city during October 2007 to September 2008.

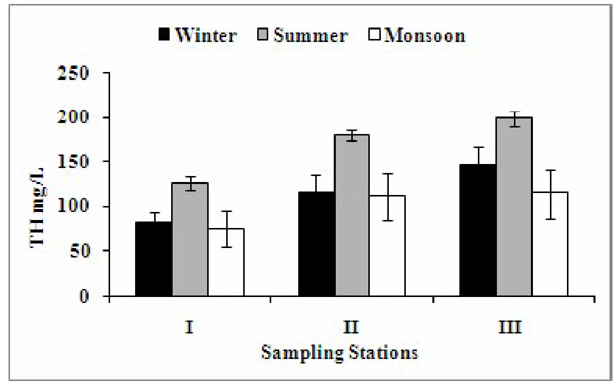

Fig. 9. Seasonal variation of TH from three sampling stations of river Mula, Pune city during October 2007 to September 2008.

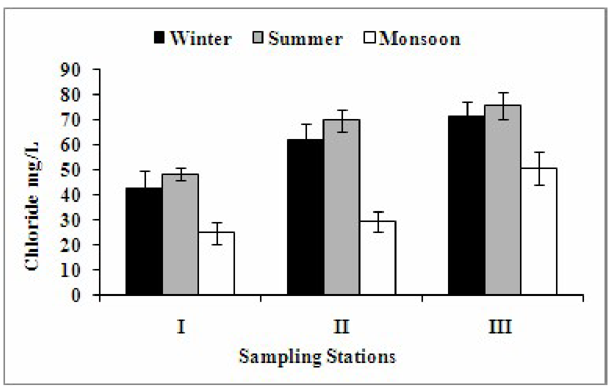

Fig. 10. Seasonal variation of Chloride from three sampling stations of river Mula, Pune city during October 2007 to September 2008.

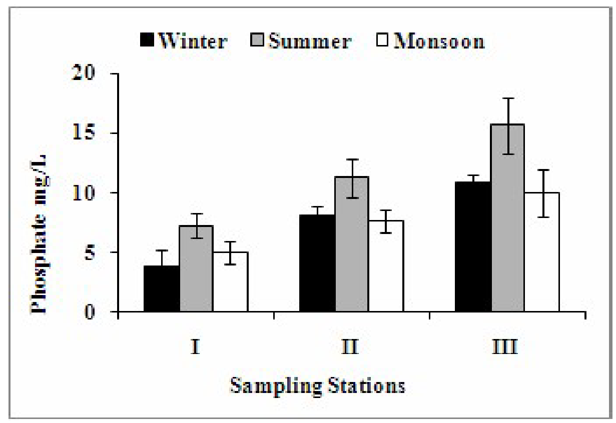

Fig. 11. Seasonal variation of Phosphate from three sampling stations of river Mula, Pune city during October 2007 to September 2008.

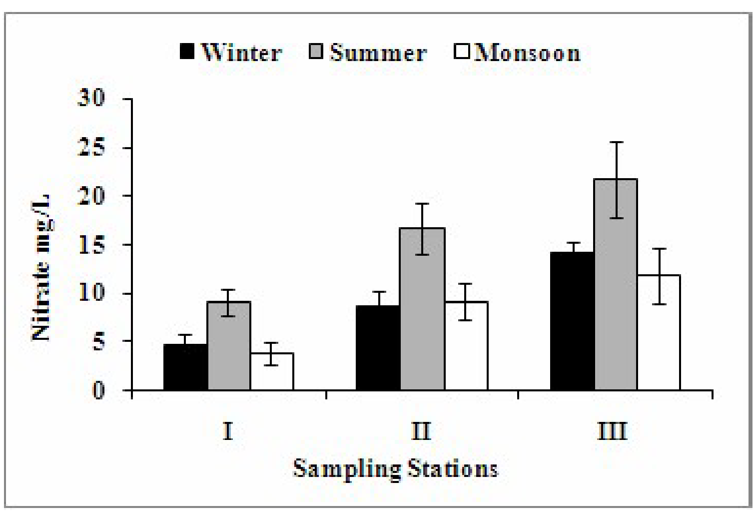

Fig. 12. Seasonal variation of Nitrate from three sampling stations of river Mula, Pune city during October 2007 to September 2008.

in summer; while minimum content COD in winter at station I (85.33± 8.36 mg/L) (Table 1 and Fig. 6). The COD content was minimum at station II and III in monsoon seasons due to dilution in dilution in rainy season. It was observed that COD values were higher than BOD value at all the sampling stations of the Mula river. Our results are confirmed with the findings of the COD was higher at station III due to flowing of Pavana river which is mainly covering industrial area.

When BOD and COD level are high then DO levels decreases; similar observations were recorded by the Ghavzan *et al*., (2005). The DO depletion rates were maximum between station II and station III with high BOD and COD due to the inflow of wastewaters in the river. DO content was lower during summer and higher during monsoon while BOD content was higher during summer; similar observations were recorded by Alam *et al*., (2007) on the Surma river water.

The pH is a measure of the concentration of hydrogen ions in water. It is found that pH of the river water slightly varies from various samples (Fig. 7). It is observed that the pH of the water was slightly alkaline (7.11±0.26 to 7.74±0.06) and only minor fluctuation in pH was recorded (Table 1). Prapurna and Shashikanth (2002) also found the pH having alkaline trend throughout the study period.

Total alkalinity (TA) is a measure of the buffering capacity of water or the capacity of bases to neutralize acids. The alkalinity varied between 75.00±1.67 mg/L to 210.00±7.58 mg/L during the study period (Table 1). TA content was maximum at station III as compare to station II and station I (Fig. 8). TA values maximum during summer and winter and declined during monsoon seasons. Higher values of TA were observed during summer at all sampling stations. This might be due to presence of excess of free CO_2 produced due to degradation of organic matter (Khatoon, 1994; Singh, 2000; Sanap, 2007). The Mula river water content shows higher alkalinity which may be due to sewage waste (Ghazvan *et al.,* 2005).

Total hardness (TH) is the property of water which prevents the lather formation with soap and increases the boiling point of water. It was observed that during the monsoon TH values were minimum and increased during the winter and summer at all sampling stations. Dwivedi and Sonar (2004) also showed the increased hardness during summer than in winter; while in monsoon it was decreased. At station III, maximum TH was observed during summer (199.17±8.89 mg/L) while minimum at station I during monsoon (75.33±20.0 mg/L) (Table 1 and Fig. 8). Ajmal and Raziuddin (1988) recorded similar observation in river Hindon and Kali. Higher values of hardness during summer seasons can be attributed to low water level and high rate of evaporation (Chatterjee and Raziuddin, 2002). The increase in hardness may be due to the domestic activities like washing clothes, animals, vehicles etc. done at the river site also shown by (Prasad and Patil, 2008).

Maximum TA and TH value is attained between stations II (Aundh downstream) and station III (Dapodi downstream) probably due to the use of soaps and detergents. TA and TH of the Mula river increases along the downstream station III, the river gets heavily polluted due to the discharge of domestic and industrial wastes through the several drains.

Maximum chloride concentration was found during summer and winter. Chloride concentration was considerably higher at station III (75.64±5.54 mg/L) in summer due to the reduced flow of domestic waste (Table 1 and Fig. 9). Higher chloride levels normally due to domestic waste also shown by Munawar (1970). Low chlorides in monsoon at station I (24.85±4.50mg/L) was due to dilution. The present work was shown to be in the line of

Chatterjee and Raziuddin (2002); Kumar *et al*. (2006) and Klein (1957). Compared to the standard limits recommended limits by WHO (1999), the values in this study are lower than 200.0 – 500.0 mg/L.

Phosphorous is the essential element for the organism growth and act as a limiting nutrient for primary productivity (Durmishi *et al*. 2008). Agricultural activities and sewage are some of the main contributors of phosphorous. It was reported that, the concentration of phosphate was low (3.83±1.42mg/L) during winter and high (15.67±2.35 mg/L) during summer (Table 1 and Fig. 10). Samples from station II phosphate was high (10.83±0.73 mg/L) during winter may be due to detergents. In the present study, the phosphate concentration was found to be low at upstream station than downstream station; similar observations were recorded by (Ravindra *et al.,* 2003) during study on Yamuna river.

Nutrient enrichment in river normally leads to eutrophication and DO depletion (Henry and Heinke, 2005). Natural sources of nitrate to surface waters include igneous rocks, land drainage and plant and animal debris. Nitrate, is potentially harmful if its concentration is high in water and serves as a good indicator of chemically polluted water (Peter 1998). Environmental protection agency (EPA) has set the maximum contaminant level (MCL) for nitrate-N in drinking water at 10 mg/L (Gould, 1995).

During present study, the mean nitrate values ranged between 3.83 ± 1.17 mg/L to 21.75±3.08 mg/L (Table 1 and Fig. 12). Similar observations were recorded during study of hydrobiological parameters of Narmada River water at Hoshangabad City, India. Nitrate at level above 3mg/L; is introduced by the human activities (Nielson and Lee, 1987). During current study at station II minimum concentration of nitrate was during winter and at station I and III minimum during monsoon; while maximum during all station during summer seasons. Adeyemo *et al*, (2008) also recorded that nitrate content was higher during the summer season. The concentration of nitrates decreased as the rainfall increased (Ajibola *et al.,* 2005). The WHO standard drinking water quality guideline for nitrate is 45 mg/L.

During present study, high concentrations of nitrate, phosphate and chloride were generally in summer and low at monsoon seasons. In present study, nitrate concentration showed positive correlation with phosphate and chloride; similar observation recorded by Sharma *et al.,* (2007). The increasing application of fertilizers in agricultural land has resulted in water pollution due to leaching of nutrients like nitrogen and phosphorus (Ramachandra and Solanki, 2007).

During present investigation, the increase in temperature, concentration of free $CO_{2,}$ COD, BOD, chloride, nitrate, phosphate, TH and TA; whereas decrease in concentration of DO at station II and station III as compared to station I. At stations II and III free CO_2, BOD, COD, and phosphate levels were relatively higher than the WHO (1999) standards for river water.

Due to the increasing population and human activities at river sites, the increase in concentrations of the water parameters was observed. This result suggests that the water quality of river Mula is adversely affected and impaired by the discharge of domestic wastes. Studies by Gunale (1978); Patwardhan *et al.,* (2003); Jafari and Gunale (2005) also found the same trends in water quality degradation status. Nowadays, there is a growing interest in restoring the quality of the water of the Mula river, and in protecting the riverside from pollution. Thus, it is necessary to know the level of contamination in the river, to identify point sources of pollution. The present investigations has led us to conclude that the quality of water samples subjected to study was not acceptable from majority of physico-chemical parameters and the water needs to be treated before using for domestic applications. In summary, river Mula from Pune city is in heavily polluted, therefore the responsibility to protect and use them properly must be taken most seriously, because the present state of water pollution in Mula is a real risk for the economy and human health.

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