Journal of Applied and Natural Science 1(2): 149-154 (2009)

JANS

Water quality indices and abiotic characteristics of western Yamuna canal in Yamunanagar, Haryana

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Abstract: The present paper deals with the monthly variations of physico-chemical characteristics of western Yamuna canal water, Yamunanagar which is polluted with industrial effluents and domestic sewage. Three sampling points i.e. station-1: Upstream of the river; station-2: Point of influx of industrial effluents and domestic sewage; Station-3: About 6 kms downstream from station 2 were selected for the investigation. Studies revealed high values of turbidity, conductivity, free CO_2, alkalinity, calcium, hardness, magnesium, chloride, orthophosphate, phosphate, sulphate and ammonia and low values of DO at station-2. The differences in various parameters were statistically significant ($P<0.05$) when compared from upstream and downstream stretches of the river particularly in summer. DO and BOD were found to be two important parameters which showed strong correlation with other parameters and hence can serve as good indices of river water quality. Water Quality index designated station-1 as highly polluted and station-2 and 3 as severely polluted. Thus the hydro biological conditions were not congenial/ optimum for the survival/ production of sensitive fish fauna, therefore, proper and efficient treatment of the effluents and sewage should be carried out before discharging these into the canal.

Keywords : Water quality index, Western Yamuna canal, Physico-chemical characteristics, Industrial effluent, Sewage

INTRODUCTION

Rivers have always been the most important fresh water resources and the role played by them is in almost all the development programs of the country not only to solve the purpose of water supply to domestic, industrial, agricultural needs and power generation but also to help in the disposal of industrial waste and sewage. The indiscriminate and continuous discharge of industrial effluent and domestic sewage has become a major source of water pollution. Many researchers have investigated the limnochemistry and the characteristics of Indian rivers *viz.* river Ghaggar (Bhatnagar and Garg, 1998), river Ganges (Ghosh *et al.*, 2000), river Hindon (Dalal and Arora, 2007), river Godawari (Deshmukh and Sonawane, 2007), rivers basins Kothaiyar and Pazhayar in Kanyakumari district (Raj and Jayasekher, 2007), and river Yamuna (Chopra *et al* ., 2009).

Yamuna canal is the largest tributary of river Yamuna in Haryana, which is considered as one of the important food producing state of India. Yamuna canal, as it meanders through Yamunanagar (Latitude 30^0 10' N, Longitude 77^0 283' E, Elevation 255m) is subjected to domestic and industrial discharges which make the water unfit for human use. Therefore, present studies have been undertaken to evaluate the water quality of Yamuna canal in Yamunanagar in terms of physico-chemical characteristics. An attempt has also been made to calculate numerical values of water quality indices to categorize the different zones of the canal when it meanders through Yamunanagar.

MATERIALS AND METHODS

A general survey of sources of sewage and industrial pollution was made as the Yamuna canal traverses through the city Yamunanagar and it was observed that near village Ghari in district Yamunanagar the canal receives wastes from a channel carrying industrial effluent from paper industry combined with discharge from sewage treatment plant. Keeping in view the pollution input sources three stations were selected Station 1: At upper reach of the river stretch before the influx of industrial and domestic pollution; Station 2: Middle reach of the canal where drain carrying industrial effluent combined with domestic sewage joins the river (here the sample was collected at a distance of about 5 meters from the point of influx of channel); Station 3: About 6 kms downstream after the influx of the pollutants. Surface water samples were collected monthly in three replicates from all the sampling stations from November 2007 to July 2008. The physico-chemical characteristics viz. temperature, dissolved oxygen, free CO_2 and alkalinity were analysed at the site itself, while parameters such as hardness, calcium, magnesium, chloride, orthophosphate and total phosphate were analysed in the laboratory in accordance with NEERI (1986) and APHA (1998) on the following 2-3 days during which samples were kept in cold storage. Multiline F-set 3 (E- Merck,Germany) was used for the determination of DO, pH, conductivity and salinity. BOD was estimated by seeding method. Water samples were diluted by adding distilled water and incubated for five days in BOD incubator (APHA, 1998). The coefficient of correlation "r" between different water quality parameters was calculated using SPSS packages while group means were compared by students't' test (Snedecor and Cochran, 1980).

In order to reflect the composite influence of a number of water quality factors on over quality of water, numerical relationships in terms of water quality indices (WQI) were calculated after mathematical design of Horton (1965) as per the modification made by Kaur *et al*.,(2001) (WQI A) and according to Mr. Brian Oram's WQI Index- consumer support group online calculator (WQI B) (Oram, 2007).

RESULTS

Monthly and stational variations in different physico-chemical characteristics are shown in Figs. 1 and 2. Table 1 depicts the mean values of the water quality characteristics at different stations. Dissolved oxygen (DO) contents gradually decreased from station 1 to station 2. Monthly variations showed (Fig. 1) that DO was high during winter months and low during summer where as conductivity depicted an increase during summer.

It was observed that rate of water flow in the Yamuna canal varied significantly during monsoon and non-monsoon seasons. During monsoon the water flow at station 1 was higher in comparison to station 2 and 3. The water flow during monsoon at station 1 was 6 m^3/ second.

Free CO_2, hardness, alkalinity and ammonia showed a decline during June (heavy monsoon) and again rise during July. pH remained alkaline (7.3 to 7.7) through out the study period. (Fig. 1). Orthophosphate was, however, high during February. Chloride and sulphate did not reveal any definite trend of increase or decrease.

Turbidity, conductivity, free CO_2, alkalinity, sulphate, phosphate and ammonia increased from station 1 to station 2 and thereafter a decline in their values was observed at station 3. Initially, a slight increase in DO and decline in other water quality characteristics was observed at station 3 but during January 2008, the river water was diverted from station 2 so that the values of these parameters at station 3 showed a deteriorating trend. Values of water quality indices (WQI A and B) also showed a decline from station 1 to station 3.

Table 1. Mean values (± S.E.) of Physico-chemical parameters and water quality indices of water of Yamuna canal in Yamunanagar.

Parameters	Station 1[a]	Station 2[b]	Station 3[c]	I.C.M.R Standards
Temperature ºC	19.9±1.9	22.6±2.0	15.56±0.547	-
DO mg L^{-1*}	8.6±0.6	3.2±0.3	4.66±0.517	>5 mg L^{-1}
BOD mg L^{-1}	3.7±0.1	5.6±0.1	4.9±0.1	<5 mg L^{-1}
pH	7.7±0.2	7.3±0.1	7.3±0.3	<7.0-8.5>
Conductivity µm cm^{-1*}	295.0±13.6	790.6±25.7	345.6±16.94	-
Turbidity NTU**	16.8±0.3	19.6±0.2	28.8±9.17	-
Free CO2 mg L^{-1*}	10.6±1.7	36.9±3.9	78.77±24.02	-
Alkalinity mg L^{-1*}	92.2±5.0	304.2±23.0	409.8±108.08	<120 mg L^{-1}
Hardness mg L^{-1*}	123.3±4.9	192.0±14	339.2±86.85	-
Calcium mg L^{-1*}	28.3±2.0	160.8±23.2	89.19±25.17	<75 mg L^{-1}
Magnesium mg L^{-1*}	12.7±2.2	20.6±2.6	31.31±8.01	<50 mg L^{-1}
Chloride mg L^{-1*}	8.5±0.6	50.3±3.6	134.35±56.87	<250 mg L^{-1}
Orthophosphate mg L^{-1*}	0.4±0.1	3.8±0.4	2.316±0.50	-
Total Phosphate mg L^{-1*}	1.9±0.4	4.7±0.7	2.66±0.359	-
Sulphate mg L^{-1**}	101.2±6.3	121.8±7.9	111.36±10.02	<200 mg L^{-1}
Ammonia mg L^{-1*}	0.1±0.0	3.1±0.8	2.08±0.78	-
WQI 'A'**	55.0±2.1	30.7±2.9	39.9±2.7	-
WQI 'B'**	42.4±1.9	37.6±0.6	36.3±1.5	-

WQI 'A': Water quality index according to Kaur *et al.* (2001), WQI 'B': Water quality index according to Oram (2009)
* significant (P< 0.05) [a] versus [b], [a] versus [c], and [b] versus [c] (Students 't' test), ** significant (P<0.05) [a] versus [b] only (Students 't' test)

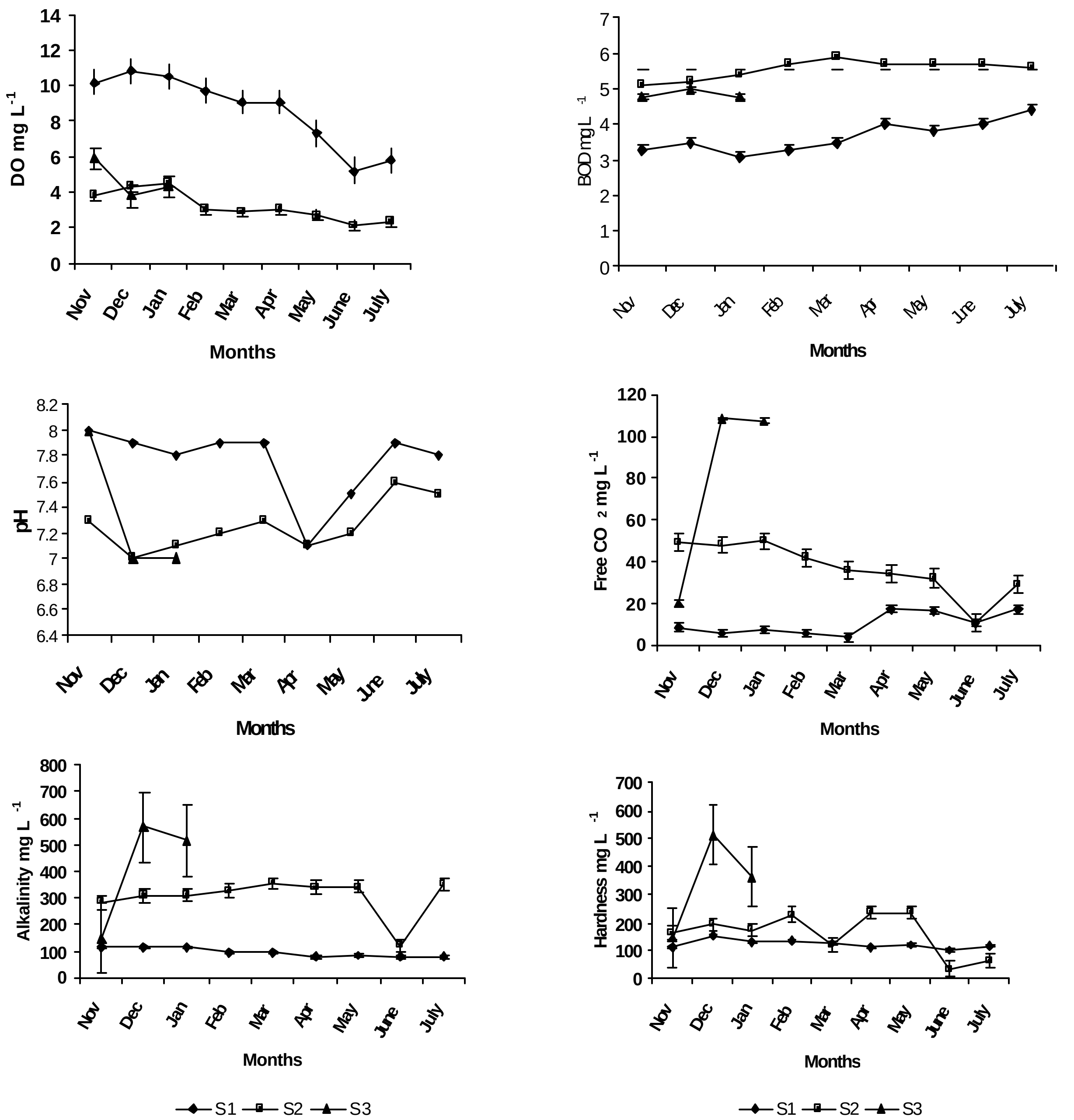

Fig. 1. *Monthly variations in dissolved oxygen, BOD, pH, Free CO_2, alkalinity and hardness at station 1 (S 1), station 2(S 2) and station 3 (S 3).*

DISCUSSION

Decrease in DO, increase in BOD, high ammonia, nitrite and low values of water quality indices (WQI) in the present studies are some of the factors depicting that introduction of industrial waste and domestic sewage has changed the overall condition of the canal water.

Decline in dissolved oxygen at station 2 (Table 1 , Fig. 1) was found to be associated with the industrial effluents and domestic sewage and high DO at stations 1 may be correlated with comparatively low organic load. Bhatnagar and Garg (1998), Bellos *et al*., (2006) and Chopra *et al.* (2009) have also reported that increased industrial activities and sewage from point and non-point sources results in low dissolved oxygen. According to the Central Pollution Control Board (CPCB, 2000), 70% of the pollution in rivers is from untreated sewage, which results in low DO and high BOD (Khaiwal *et al*., 2003). In the present studies influx of industrial waste and discharge from sewage treatment plant have also decreased DO and increased BOD depicting the severity of pollution in rivers.

Seasonally DO was high during winter and decreased with increase in temperature, since a lower temperature known to favour greater dissolution of oxygen in water (Miller, 1994 and Khaiwal *et al.*, 2003). Very high DO during November and December was observed at station 1. During that time the fishing activity was going on by the local fisher men and mechanical action because of boating might have increased DO up to higher level. Kulshrestha *et al*. (1991) have also reported DO up to 10-11 mg L^{-1} because of mechanical action. High BOD at Free Carbon di-oxide was also higher at this station. The increase in the free CO_2 might have increased the total alkalinity and the phosphate level of the canal and this is further conformed by a positive correlation of o-phosphate with free CO_2 ($r = 0.50$, $P<0.05$). Presence of free CO_2, may be responsible for releasing of phosphate ions into surroundings from its insoluble compounds like ferric sulphate as supported by Wetzel (2001) and this may be responsible for low pH at this station.

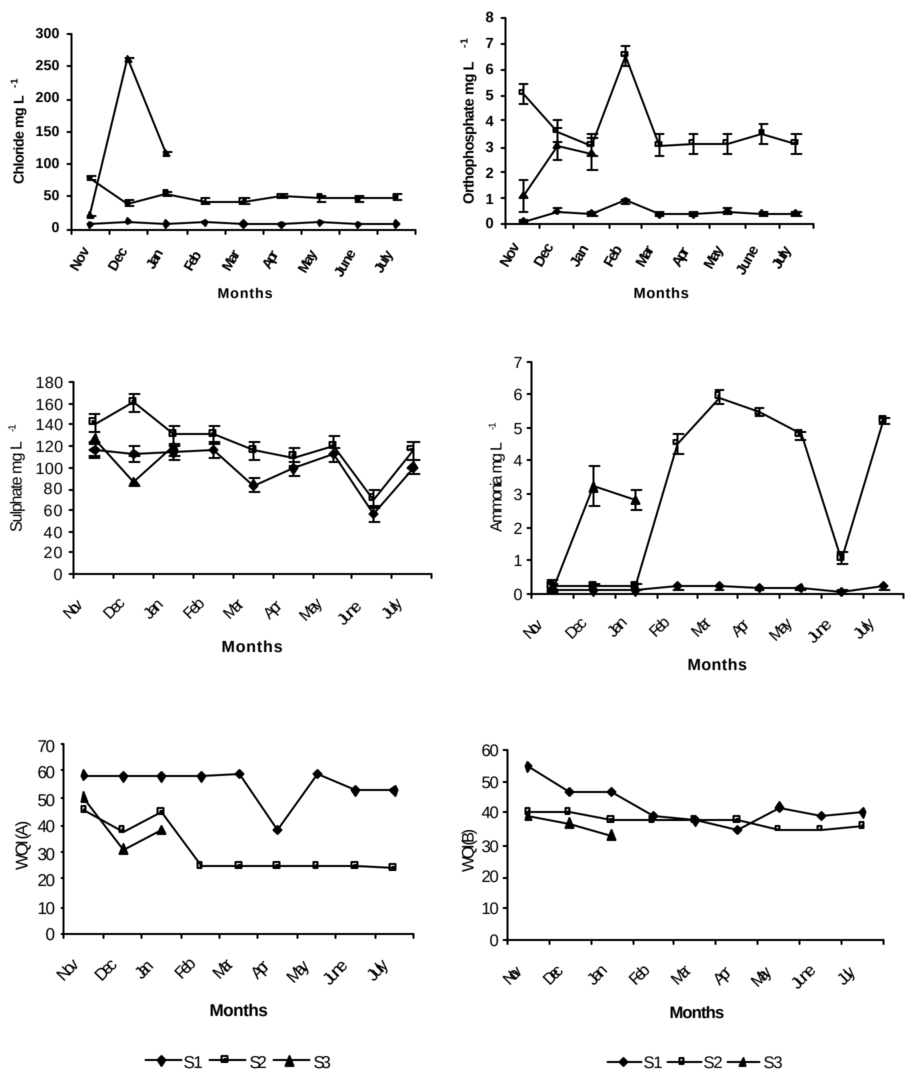

Fig.2. *Monthly variations in chloride, orthophosphate, sulphate, ammonia and WQI at station 1 (S 1), station 2(S 2) and station 3(S 3).*

station 2 indicates the presence of high biodegradable organic matter which consumes DO (Table 1, Fig. 1). pH was alkaline through out the study period. The values were significantly ($P<0.05$) high at station 1, decreased at station 2 and station 3. The lowering of pH at station 2 seems to be due to input of wastes (Bhatnagar and Sanghwan, 2009). pH was low but alkalinity was higher at this station.

According to Sechriest (1960) pH of waters is independent of total alkalinity. However, no significant differences in pH were observed with respect to season. Mean values in free carbondioxide also depicted an increase from station 1-3. According to Swingle (1959) free carbondioxide at a concentration of more than 15 ppm is detrimental to fish life. In the present studies the values were higher at station 2 and 3. According to

Burggren (1979) high free CO_2 affects respiration of aquatic organisms and slows the rate of metabolism of fishes. High CO_2 in the present investigations perhaps, may be one of the factor influencing fish survival, production and reproduction. Its significant negative correlation (r=-0.475, P<0.05) with DO also depicts its detrimental effect.

Alkalinity increased from station 1-3, however, no significant variations were observed with respect to season. According to Manahan (1994) alkalinity is the index of productive potential of water. Hardness of the water depicted a decline at station 2 and sharp increase at station 3 whereas the values remained intermediate at station 1.

Chloride contents which indicate the pollution of animal origin increased from station 1 to station 3 due to the discharge of effluents. The increased values at station 3 may be due to the restriction of flow of water. An excess of chloride in inland water is usually taken as an index of pollution (Hasalam, 1991). Kuczynski (1987) has stated four categories of water status on the basis of alkalinity and chlorides according to which although the values of alkalinity and chlorides increased from station 1 to 2, yet fall under the category of medium/ moderate pollution. Increase in available phosphate from station 1 to 2 and then slight decrease at station 3 indicate agricultural runoff containing, phosphate fertilizers or detergents might also be a part of waste added at station 2. Similar trend of total phosphate further indicate the addition of wastes at station 2. Sulphate was also high at Station 2 may be due to waste from papermills, Khaiwal *et al*. (2003) have also reported that waste water from the industries contribute to the sulphate ions in water. Statistically, also it showed significant (P<0.05) positive correlation with alkalinity (r=0.549) and hardness (r=0.547) again indicating its increase due to influx of effluents. Ammonia concentration increased significantly from station 1 to 2 and slightly decreased at station 3. According to Meade (1985) maximum acceptable limits of ammonia concentration for aquatic organisms is 0.1 mg L^{-1} as high values of ammonia causes ammonia toxicity resulting in osmoregulatory imbalances, kidney failure, suppressed excretion of endogenous ammonia and damage to gill epithelium which leads to suffocation. In our studies although the values were low at station 1, yet these were higher than 0.1 mg L^{-1} whereas at station 2 and 3 the values are very high. Statistically it showed a significant positive correlation with alkalinity (r=0.683, P<0.05), hardness (r=0.540, P<0.05) and o-PO_4 (r=0.534, P<0.05) advocating its increase with increase in the organic load. To communicate the information on water quality depicting the overall quality of water at all the selected stations of western Yamuna canal, the mathematical value in terms of water quality index (WQI) according to Horton (1965) and Kaur (2001) was calculated. It was found that the values decreased from station 1 to 2 and slightly increased at station 3. According to Kaur *et al*. (2001) based on extent of pollution, water has been designated as Absolutely clean when WQI is 100, Slightly to moderately polluted when WQI is between 60-80, Excessively polluted when WQI is between 40-60 and Severely polluted when WQI is between 0-40. Our studies (WQI A) revealed station 1 as excessively polluted and station 2 and 3 as severely polluted. According to Oram's water quality index (Oram, 2007) water quality legend (WQI B) in the range of 90-100 indicates excellent quality, 70-90 good, 50-70 medium, 25-50 bad and 0-25 very bad. Present studies showed a decline in values from station 1 to 2 and 3, however, all the stations fall under the category of "Bad". From these studies it can be concluded that discharge of industrial effluents and sewage have altered the overall ecology of the canal resulting a decline in fish catch and rise in all pollution indicating parameter making it unfit for human consumption. WQI also designate it in excessively polluted class. Therefore it is suggested that proper and efficient treatment of the effluents and sewage should be carried out before discharging them into the canal.

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