

Physico-Chemical Analysis of Municipal Wastewater Discharge in Ganga River, Haridwar District of Uttarakhand, India

SABA SHIRIN^{1,2*} and AKHILESH KUMAR YADAV^{1,2}

¹Department of Mining Engineering, Indian Institute of Technology (Banaras Hindu University), Varanasi – 221 005, India.

²Civil Engineering Department, Madan Mohan Malaviya Engineering College, Gorakhpur – 273 010 (U.P.), India.

<http://dx.doi.org/10.12944/CWE.9.2.39>

(Received: May 21, 2014; Accepted: June 25, 2014)

ABSTRACT

This study was aimed to screen the water quality of Ganga River in Haridwar city, Uttarakhand, India. The study was conducted based on their water source, origin of pollution such as utilisation by human and animals. Monthly changes in physico-chemical parameters such as pH, Temperature, Total Dissolved Solids, Total Solids, Total Suspended Solids, Chemical Oxygen Demand, Dissolved oxygen, Biochemical Oxygen Demand and Volatile Suspended Solids were analyzed for a period of two year from January 2010 to December 2011. The results of this study reveal the status of water quality of Ganga River it may helpful to protect the water resources and create awareness about the water pollution among the people living around the city. The results indicated that physico-chemical parameters of the water were within the permissible limits.

Key words: TDS; COD; BOD; TSS; VSS; Water Quality.

INTRODUCTION

The wastewater pollutants are harmful to environment and public health. The biological decomposition of organics could result in fish kills and foul odours. Water borne diseases are also eliminated through proper wastewater treatment. There are many pollutants that could exhibit toxic effects on aquatic life and the public. The wastewater treatment is removal of contaminants from water in order to decrease the possibility of detrimental in part on the ecosystem including humans (Zhang, *et al.*, 2010). The major part of the soluble BOD contained in the primary effluent. The chemical contamination of water sources due to certain industries or from natural sources (Wang, *et al.*, 2004).

High turbidity can inhibit the effects of disinfection against micro-organisms and enable bacterial growth. Drinking water should be colourless,

since drinking water colouration may be due to the presence of coloured organic matter. Organic substances cause water odour, though odours may result from many factors, including biological activity and industrial pollution also microbial pathogens cause health hazards (Mahananda, *et al.*, 2010). The present study was under aken in Haridwar on Ganga River to analyze water quality parameters of municipal wastewater discharge of various sources.

MATERIAL AND METHODS

Study Area

Haridwar is one of the important tourism of Uttarakhand. It is situated on the right bank of river Ganga and at the foot hills of Shivalik ranges. It is located at 29°58' N of latitude and 78°10' E of longitude. It is one of the most ancient towns and a very important pilgrim centre of India where people from all over the country come round the year to

have a dip in the river Ganga on an average around two lakh people visit this city daily. It is closely interwoven with culture and tradition and the health, and years the river has been indiscriminately polluted. The study area is showing in the Fig. 1.

Important religious centre, Haridwar has gained its importance as an industrial town with the establishment of Bharat Heavy Electrical Limited (BHEL) at Ranipur. Adjoining to the BHEL, SIDCUL has also developed a big industrial area for 550 industries out of which about 350 units are in the process of installation where as about 150 units has started their production. Few important industries planed in study area i.e., Hindustan Lever Limited, Mahindra and Mahindra, ITC, Hero Honda, Calvin care, Somani, Eveready, Hevell's India, etc. The above planed industries are located at 10 km from Haridwar toward Delhi.

Sampling and Analysis

Collection of Samples

The experimental method involved the collection of grab samples in clean plastic containers of 5 liter capacity at four different locations inlet chamber (before treatment), primary clarifiers, c-tech basin and outlet chamber (after treatment) on a weekly basis for two years (January 2010 – December 2011). Total n=114 samples were collected. Sample were collected from the depth of 6 inches below the water surface in throughly cleaned plastic containers of 5 liters capacity provided with the double cap device. Opening and keeping the mouth of the container against the flow of water collected it.

The plastic containers was cleaned by 25% vw HNO₃ (kept in 24 hours) and rinsed with double distilled water 2 - 3 times. The preservation procedure includes keeping the samples in the dark, adding chemical preservative, lowering the temperature to retard reactions or combinations of these. The preservation methodologies are given the Table 1.

For BOD, the capacity of 300 ml of sample was used in BOD bottle made by Borrosil. These were washed with chromic acid and washing soda and rinsed with tap water followed by double distilled water, the neck and stopper were wrapped with butte paper with the help of rubber band. The bottles were

then sterilized in an autoclave at 15 lbs pressure, (121 °C) for 15 to 25 minutes. Pipettes of different volume size were washed and fitted with cotton plug at the upper end, these were then wrapped in butter paper and sterilized in an autoclave at 15 lbs pressure at 121°C for 15-20 minutes. Petridishes were washed and then sterilization in an oven at (160 °C - 180 °C) for 1 to 2 minutes.

Physico-chemical analysis

The samples were analyzed using the Standard Methods (APHA, AWWA, and WCF 1998). The primary parameter Total suspended solids (TSS), Dissolved oxygen (DO), 5-day Biochemical Oxygen Demand (BOD₅), Chemical Oxygen Demand (COD), chlorides and sulphates, the ratio of COD to BOD₅; while secondary parameters are, covering physical, chemical, and biochemical properties of the wastewater.

Temperature of water was measured using centigrade thermometer. The turbidity of water was measured with the help of "Jackson's Candle Turbidity meter". Total solids is the term applied to the material residue left in the vessel after evaporation of the sample and its subsequent drying in an oven at a temperature of 103 -105°C. Total solids include Total Suspended Solids (TSS), and Total Dissolved Solids (TDS). Dissolved solids are solids that are in dissolved state in solution. Waters with high dissolved solids generally are of inferior palatability and may induce an unfavourable physiological reaction in the transient consumer. Electronic digital pH meter measured the pH of the water sample. The dissolved oxygen was determined using Winkler's titrimetric method. The samples were incubated for 5 days at 20°C to measure BOD, COD of the sample is determined by oxidizing the organic matter in the sample with potassium dichromate in the presence of strong acid. Alkalinity of the sample was determined by titrating with standard solution of mineral acid using pH indicators i.e., Phenolphthalein, methyl orange, Chloride and Sulphite.

RESULTS AND DISCUSSION

The outline of the analysis of data in respect of Municipal Wastewater Discharge in Ganga River, Haridwar district of Uttarakhand, India are discussed here –

Table. 1: Preservation methodologies of wastewater quality parameter

Experiment holding	Preservative	Max. time
Biochemical Oxygen Demand	Cool, 4°C	4 hours
Chloride	Cool, 4°C	7 days
Chemical Oxygen Demand	Cool, 4°C	24 hours
Dissolved Oxygen	Fix on site	6 hours
p ^H	None	6 hours
Phosphorus	-	-

Concentration and Variation of Physico Chemical parameter of municipal wastewater**Hydrogen ion concentration (p^H)**

The p^H is a measure of the hydrogen ion concentration in water and indicates whether the water is acidic or alkaline. The measurement of acidity of p^H is required to determine the corrosiveness of the water. The p^H values were vary from 7.08 - 7.31 (Table 2). Monthly variation of p^H in Municipal wastewater is shown in the Fig. 2. The standard alkalinity and values of p^H for drinking water by BIS is between 6.5 - 8.5 as well as WHO standard range 7.0 - 8.5. High value of p^H may results due to waste discharge, microbial decomposition of organic matter in the water body (Patil, *et al.*, 2012). All observe samples have pH values well within the

Table 2: Physico-Chemical properties of Municipal Wastewater Discharge in Ganga River, Haridwar

Parameters	Range	Average	Skewness	Kurtosis
Flow Rate (MLD)	41.0 – 60.0	53.53 ± 4.97	-0.42	-0.86
p ^H	7.08 – 7.31	7.26 ± 0.05	-1.50	1.91
Temperature ^o C	16.0 – 27.5	19.35 ± 2.26	1.50	2.89
Total Dissolved Solids (mg/l)	376.0 – 484.0	426.63 ± 23.15	0.08	-0.11
Total Solids (mg/l)	103.1 – 688.1	336.86 ± 149.53	0.68	-0.32
Total suspended solids (mg/l)	276.0 – 366.0	311.65 ± 18.81	0.33	0.04
Chemical Oxygen Demand (mg/l)	276.0 – 392.0	339.16 ± 21.12	-0.48	0.77
Dissolved oxygen (mg/l)	6.03 – 7.24	6.68 ± 0.34	-0.06	-1.11
Biochemical Oxygen Demand (mg/l)	83.0 – 167.0	148.69 ± 14.17	-2.80	9.60
Volatile Suspended Solids (mg/l)	100.0 – 200.0	153.01 ± 20.40	-0.63	-0.18

Table. 3: Correlation Coefficient (r) among physico-chemical parameters of Municipal Wastewater Discharge in Ganga River, Haridwar

	Flow Rate	p ^H	T	TDS	TS	TSS	COD	DO	BOD	VSS
Flow Rate	1.00									
p ^H	-0.10	1.00								
T	0.05	-0.55	1.00							
TDS	0.22	0.05	-0.05	1.00						
TS	0.13	0.02	-0.08	-0.05	1.00					
TSS	0.01	0.19	-0.03	0.10	-0.02	1.00				
COD	0.10	-0.11	0.08	0.20	-0.21	0.19	1.00			
DO	-0.10	-0.08	0.02	-0.17	-0.04	-0.11	0.06	1.00		
BOD	0.10	-0.08	0.11	0.24	-0.14	0.16	0.64	0.05	1.00	
VSS	-0.16	-0.21	0.17	0.11	-0.47	-0.11	0.10	0.05	0.22	1.00

Critical value for 2-tailed test is 0.164 at 95% CI (n=100)

prescribed limit BIS as well WHO (BIS, 1982 and WHO, 1993).

Temperature (T)

The temperature is one of the most important ecological factor which controls the physiological behaviour and distribution of the organisms. The catabolic energy released in the form of heat during the decomposition of organic matter and respiration also slightly added to the temperature. In the present study water temperature values ranged from 16.0 to 27.5 °C (Table 2). From the Fig. 3 shows that the monthly variation of temperature.

Total dissolved solids (TDS)

TDS value of 500 mg.l⁻¹ as the desirable limit and 2000 mg.l⁻¹ as the maximum permissible limits (Jain, *et al.*, 2003). In the present study, it is found that almost all samples have TDS values well within the prescribed standard. Total dissolved solids value observed to be 426.63 ± 23.15 mg.l⁻¹ (Table 2 and Fig. 4).

Total Solids (TS)

Total Solids is the total matter that is left behind after drying a sample of water at 105°C. Total solids may be separated into several different fractions. The two primary ways fractions are

established or classified is dissolved or suspended and fixed or volatile. In study period, the TS were observed to be 336.86 ± 149.53 mg.l⁻¹ (Table 2 and Fig. 5).

Total suspended solids (TSS)

TSS is an important parameter for designing wastewater treatment plant and the length of time for which wastewater should be retained for primary treatment. Suspended solid do not mean that they are floating matters and remain on top of water layer. They are under suspension and remain in water sample. Total suspended solids play an important role in water and wastewater treatment. Their presence in water sample cause depletion of oxygen level. The value for TSS are shown in Table 2 and variation shows in the Fig. 6. The TSS were observed to be 311.65 ± 18.81 mg.l⁻¹.

Chemical Oxygen Demand (COD)

COD test is commonly used to indirectly measure the amount of organic compounds in water. Most applications of COD determine the amount of organic pollutants found in surface water making COD a useful measure of water quality which indicates the mass of oxygen consumed per litre of solution. COD were vary from 276.0 - 392.0 (339.16 ± 21.12) mg.l⁻¹ (Table 2). All the water samples

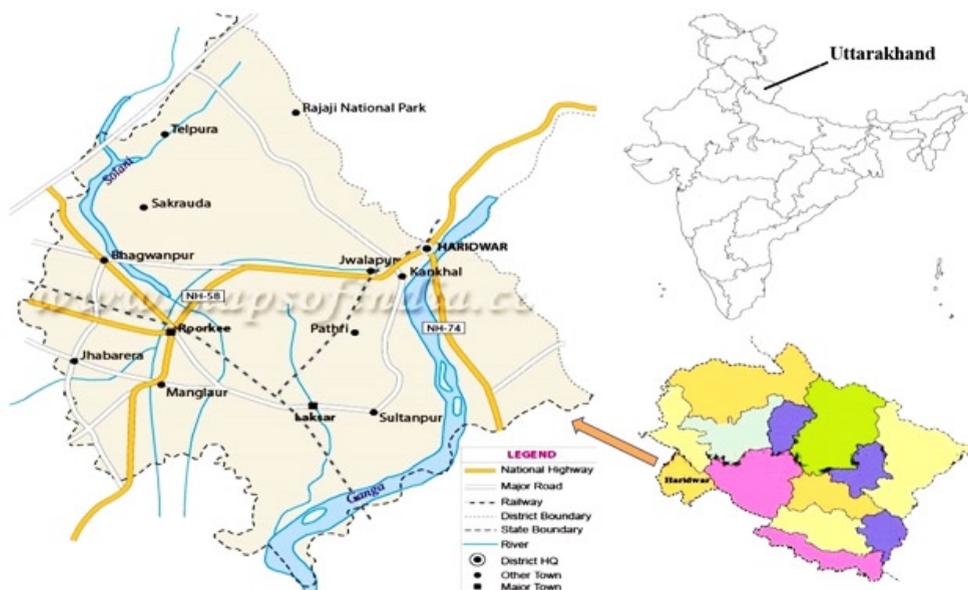


Fig. 1: Map of Study Area

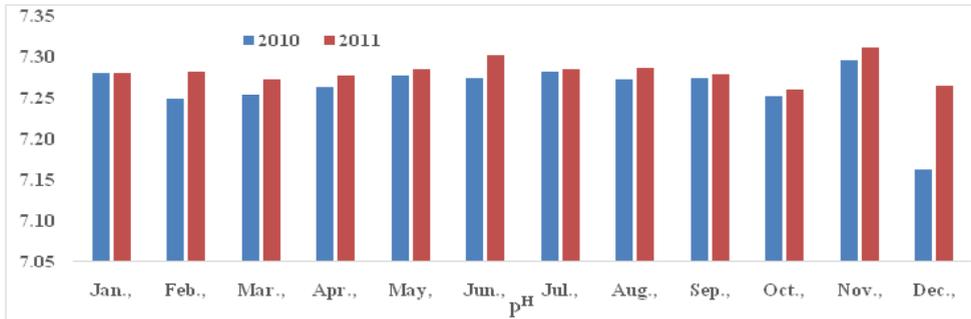


Fig. 2: Graph showing Monthly variation of pH

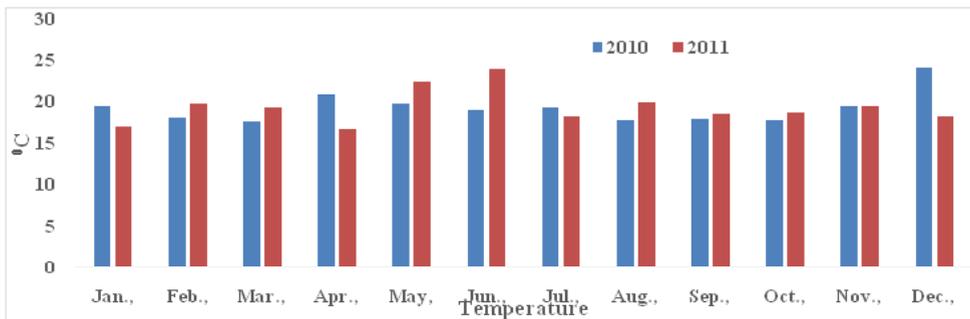


Fig. 3: Graph showing Monthly variation of Temperature

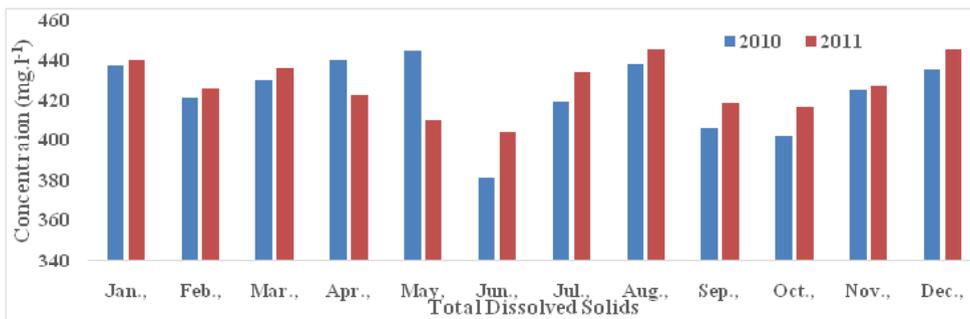


Fig. 4: Graph showing Monthly variation of Total Dissolved Solids

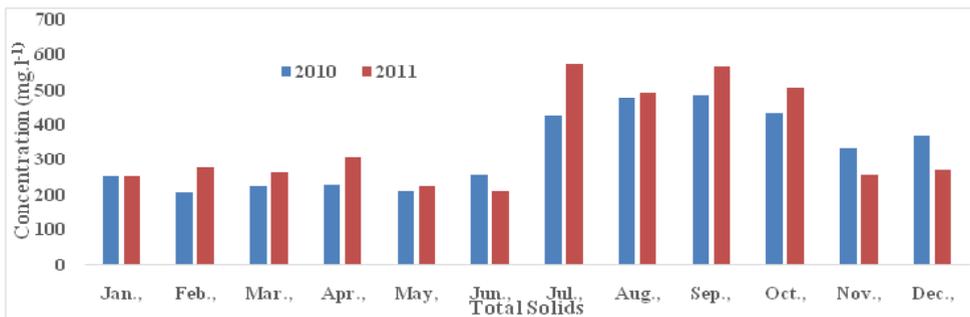


Fig. 5: Graph showing Monthly variation of Total Solids

analyzed in the present study had COD content within the prescribed limits and shown in the Fig. 7 (BIS, 1982 and WHO, 1993).

Dissolved Oxygen (DO)

Dissolved oxygen is important parameter in water quality assessment and biological processes prevailing in the water. The DO values indicate the degree of pollution in the water bodies. It depends on factors like temperature of water. DO values were found to be 6.68 ± 0.34 (6.03 - 7.24) mg.l⁻¹ as well as monthly variation of Dissolved Oxygen is shown in the Fig. 8 (Table 2).

Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand is nothing but the amount of oxygen utilized by microorganisms to stabilize the organic matter. BOD determines the strength of sewage, effluents and other polluted waters and provides data on the pollution load in all natural waters. It is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20°C and is often used as a robust surrogate of the degree of organic pollution of water. BOD can be used as a gauge of the effectiveness of wastewater treatment plants. In the study period BOD were vary from 83.0 - 167.0



Fig. 6: Graph showing Monthly variation of Total Suspended Solids

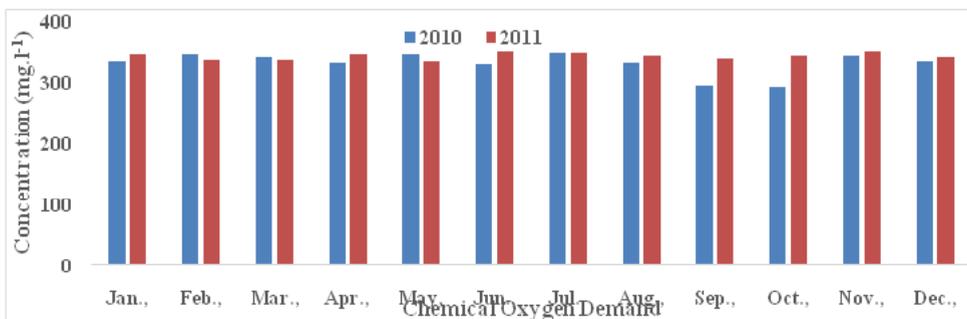


Fig. 7: Graph showing Monthly variation of Chemical Oxygen Demand

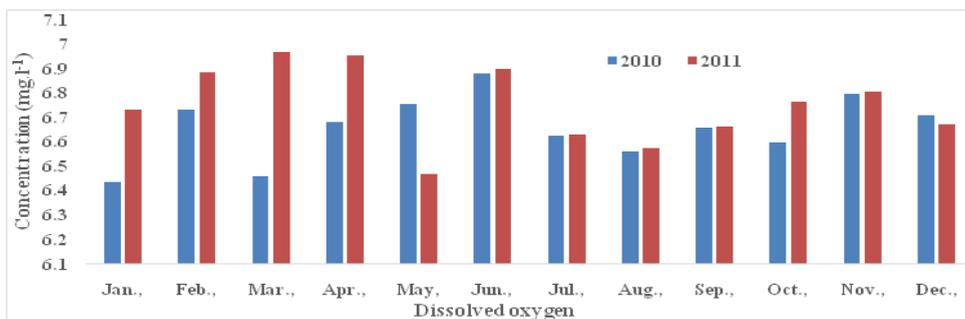


Fig. 8: Graph showing Monthly variation of Dissolved Oxygen

mg.l⁻¹ which is within the permissible range (Figure 8) and statistical data analysis is given in the Table 2 (BIS, 1982 and WHO, 1993). All the water samples analyzed in the present study has BOD content within the prescribed limits.

Volatile Suspended Solids

The suspended solids associated with volatile fraction are termed volatile suspended solids (VSS). In the study area, the volatile suspended solids were measure to be 153.01 ± 20.40 mg.l⁻¹ as well as statistical analysis given in the Table 2. The monthly variation of volatile is shown in the Fig.10.

Correlation coefficient relationship among different physico-chemical parameters

In the present study, the correlation coefficient (r) between each parameters pairs in computed by taking the average values as shown in Table 3. Correlation coefficient (r) between any two parameters are calculated for parameter such as water Flow Rate, p^H, Temperature °C, Total Dissolved Solids, Total Solids, Total Suspended Solids, Chemical Oxygen Demand, Dissolved oxygen, Biochemical Oxygen Demand and Volatile Suspended Solids of Municipal Wastewater

Discharge in Ganga River, Haridwar. The degree of line association between any two of the water quality parameters as measured by the simple correlation coefficient (r) is presented in Table-2 as 10×10 correlation matrix. The water p^H has found to be show positively correlated with Total Suspended Solids while Volatile Suspended Solids negatively correlated with p^H. Temperature has been correlated with Volatile Suspended Solids. The Total Dissolved Solids has been found to show positive correlation with Chemical Oxygen Demand, Biochemical Oxygen Demand while Dissolved oxygen negatively correlated. There is a strong positive correlation (r=0.64) between Chemical Oxygen Demand and Biochemical Oxygen. Biological oxygen demand showed significant positive correlation Volatile Suspended Solids. The p^H and Temperature showed a highly significant negative correlation (r="0.55). Data is the mean value of weekly collected samples.

CONCLUSION

In the present study, All analysed samples for physical and chemical properties of municipal wastewater discharge in Ganga River was found

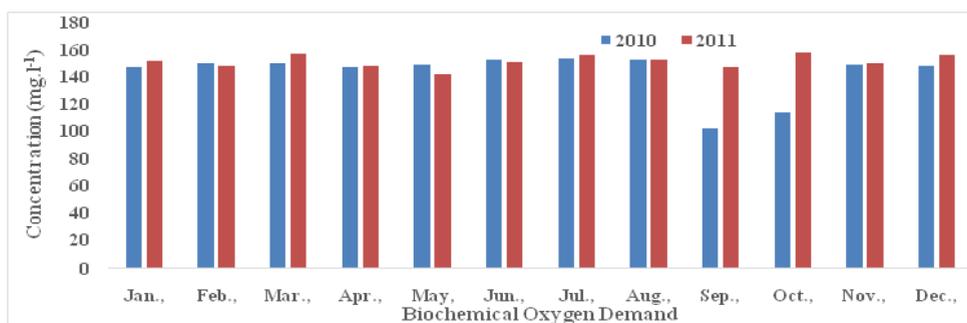


Fig. 9: Graph showing Monthly variation of Biochemical Oxygen Demand

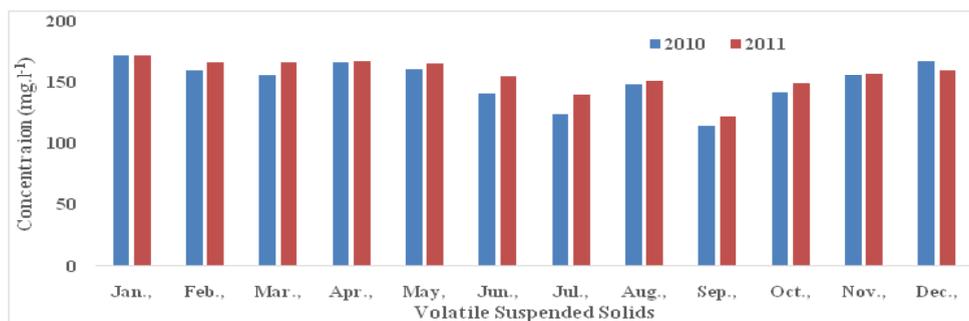


Fig. 10: Graph showing Monthly variation of Volatile Suspended Solids

to be within desirable limits by various agencies. Therefore, the present study, Based on scientific methodology clearly shows that the said study sites can be easily treated for further used and however it is suggested to monitor the same regularly for sustainable usage.

ACKNOWLEDGEMENT

The authors express their sincere thanks to Er. Mohd. Irfan Ansari and Mohd. Aurazeb Ansari for their encouragement and support during the study.

REFERENCE

1. BIS, IS: 2490 Standards for Industrial and Sewage effluents discharge, Bureau of Indian standards, New Delhi (1982).
2. Jain C. K., C. P Kumar, Sharma M. K., Ground water qualities of Ghataprabha command area Karnataka, Indian. *Journal of Environment and Ecoplanning*, **7**(2), 251-262 (2003).
3. Mahananda M. R., Mohanty B. P., Behera N. R., Physico-chemical analysis of surface and ground water of Bargarh district, Orissa, India. *IJRRAS*, **2**(3), 284-295 (2010).
4. Patil S. G., Chonde S. G., Jadhav A. S., Raut P. D., Impact of Physico-Chemical Characteristics of Shivaji University lakes on Phytoplankton Communities, Kolhapur, India, *Research Journal of Recent Sciences* **1**(2), 56-60 (2012).
5. Wang Y. C., Peng Y. A., Li Y. M., The characteristics of water pollution and engineering-oriented prevention on Dianchi. *Areal Research and Development* **23**, 88-92 (2004).
6. WHO, World Health Organization, Guidelines for drinking water quality-I, Recommendations, 2nd Ed. Geneva (1993).
7. Zhang L. Y., Zhang L., Liu Y. D., Shen Y. W., Liu H., Xiong Y., Effect of limited artificial aeration on constructed wetland treatment of domestic wastewater. *Desalination* **250**(3), 915-920 (2010).