Evaluation of Water Quality Indices for the Drinking water of Engineering Colleges in Kolhapur city.

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ABSTRACT

The present work is aimed at evaluating the water quality index (WQI) for the drinking water of engineering colleges in Kolhapur city. This has been determined by collecting a monthly for period of one year from Feb 2011 to Jan 2012 of four engineering colleges of Kolhapur city and subjecting the samples to a comprehensive physico-chemical and biological analysis. For calculating the water quality index, nine critical parameters have been considered. The WQI for these fourty eight samples ranged from 66.26 to 98.80 with an average value of 84.14. The analysis reveals that the overall drinking water of the sampling sites, in general, can be considered fit for educational institutions of the student community and sampling sites B are slight to moderate water pollution and their water can be used for drinking purposes only after proper treatment.

Key Words: Drinking water, Water quality, Quality rating, Water quality index

INTRODUCTION

Water is essential for the existence of life on this planet. Most human activities involve the use of water in one way or other. It may be noted that man's early habitation and civilization sprang up along the banks of rivers. Although the surface of our planet is nearly 71% water, only 3% of it is fresh. Of these 3% about 75% is tied up in glaciers and polar icebergs, 24% in groundwater and 1% is available in the form of fresh water in rivers, lakes and ponds suitable for human consumption. (Firmal, 2009)

The status of quality of water that is supplied today in most of the areas worries the people. The quality of water depends on the location of the sources and the state of environment. All biological reactions occur in water and it is the integrated system of biological metabolic reactions in an aqueous solution that is essential for the maintenance of life. (Mishra, 2005)

Due to increasing industrialization on one hand and exploding population on the other, the demands of water supply have been increasing tremendously. Moreover considerable part of this limited quality of water is polluted by sewage, industrial waste and a wide range of synthetic chemicals. Fresh water which is a precious and limited vital resource needs to be protected, conserved and used wisely by man. But unfortunately such has not been the case, as the polluted lakes, rivers and streams throughout the world testify. According to the scientists of National Environmental Engineering Research Institute, Nagpur, India, about 70 % of the available water in India is polluted. (Pani, 1986)

Improper waste management, unscientific sewage waste disposal and carelessness of the industries deteriorate ground water quality in and around Kolhapur city. It is essential to monitor the water quality that is supplied to the colleges around Kolhapur city. Hence, the present study was undertaken to analyze the physico-chemical and biological quality of drinking water and to evaluate the Water Quality Index (WQI) of colleges of Kolhapur city.

Water quality index is commonly used for the detection and evaluation of water pollution and may be defined as a rating reflecting the composite influence on the overall quality of a number of quality parameters. (Tambekar, 2007)

The main objective of WQI is to turn complex water quality data into information that is understandable and usable by the public. WQI based on some important parameters can provide a simple indicator of water quality. It gives the public, a general idea of the possible problems with water in a particular region. Thus, a water quality index synthesizes complex scientific data into an easily understood format. (Shankar et al, 2008)

MATERIALSAND METHODS OF ANALYSIS

Details of the study area:

Kolhapur is a city situated in south-east at 16.41°N 74.13°E, Maharashtra. It is situated on banks of the sacred river Panchganga flowing in south-west part of Maharashtra, India. (**Fig. 1.**) Kolhapur's has an elevation of 569 meters (1867 ft) which is higher than that of Pune. Hence its climate is usually pleasant. The population of Kolhapur city was 493,167, as per the 2001 census and is

expected to grow further on account of rapid urbanization. The city receives abundant rainfall from June to September due to its proximity to the Western Ghats. The heavy rains often lead to severe flooding in these months. Temperatures are low in the rainy season and range between 19°C to 30°C. Kolhapur experiences winter from November to February.

The quality of water depends on the location of the source and the state of environment. The sources of water supply to Kolhapur city are mainly surface water and ground water sources. The demand is met by municipal supply distribution to 135 MLD of the city from Bhogavati river (Balinga), Panchganga river (Shingapur), Kasaba Bavada and Kalamba talav. Total number of bore wells constructed by municipalities is 200 in different localities.

In Kolhapur city there are many types of colleges. For the study of drinking water quality of engineering colleges are selected as sampling sites. Engineering colleges are very important in educational institute.

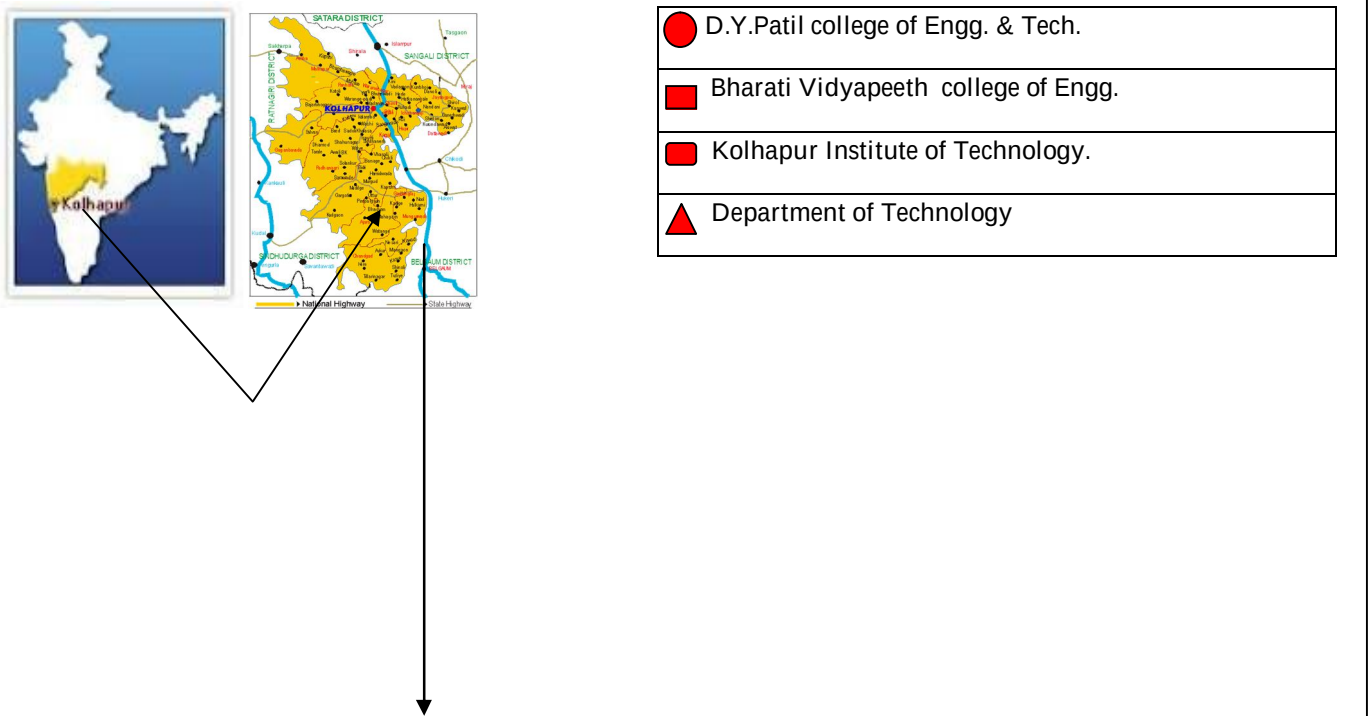
Local students are adapted to local drinking water quality. This is not the case with students from engineering colleges of other district and states and hence they may be affected. But in case of engineering colleges most of the students are admitted from other district and states. So, they face the difficulty of adapting to local drinking water.

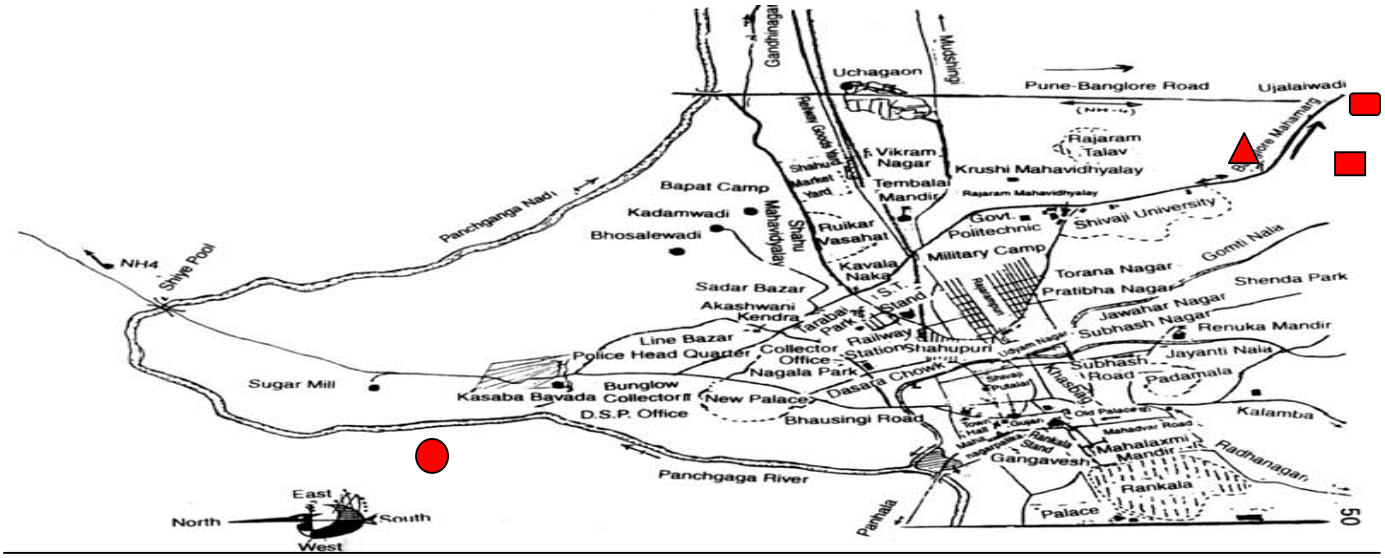
As the quality of drinking water plays an important role in maintaining sound health, its monitoring is essential for water that is supplied for drinking. The educational institutions should seriously monitor the quality of water that is supplied to the student community. Hence, an attempt has been made to study the quality of water supplied to the engineering colleges in Kolhapur city. The water quality indexing will help to indicate bad or fair quality which provides guidelines to protect the water quality and identifying the threatened and impaired sites.

Sampling Sites.

A) D.Y.Patil college of Engineering and Technology, Kolhapur.
B)Bharati vidyapeeth college of engineering, Kolhapur.
C)Kolhapur Institute of Technology, Kolhapur.
D)Department of Technology, Shivaji University, Kolhapur.

Figure 1. Map of Kolhapur City.





Sample Collection and analysis of water:

The drinking water samples from sampling sites of Kolhapur city are collected in one-L clean polythene bottles monthly for a period 1 year from Feb 2011 to Jan 2012. The physio-chemical and biological analysis of drinking water comprised determination of the following parameters. pH, dissolved oxygen (DO), turbidity, total dissolved solids (TDS), Total alkalinity, total hardness, Chlorides, nitrates and MPN coliforms for calculating water quality index (WQI). These parameters determined by standard methods and compared with the standards (**Table 1 and Table 2**)

Determination of water quality index (WQI):

For the purpose of present investigation, we have selected 9 physio-chemical and biological characteristics of drinking water. These parameters are pH, dissolved oxygen (DO), turbidity, total dissolved solids (TDS), Total alkalinity, total hardness, Chlorides, nitrates and MPN coliform. To calculate the water quality index, we have followed an approach similar to that of Horton (1965), who made one of the earliest attempts in formulating water quality index.
These parameters maximum contribute for the quality of drinking water. The steps for WQI are:

Weightage

For water quality index calculation, we first have to know the weightage of each factor (**Table 1**) Factors which have higher permissible limits are less harmful because they can harm quality of drinking water when they are present in very high quantity. So weightage of factor has an inverse relationship with its permissible limits. Therefore,

$$Wi \propto 1/Vi$$

Or

$$Wi = K/Vi$$

Where, K = constant of proportionality.

Wi = unit weight of factor.

Vi =maximum permissible limits as recommended by Indian Council of Medical Research/ Public Health Environmental engineering Organization Value of K was calculated as:

$$K = \frac{1}{\sum_{i=1}^{9} 1/Vi}$$

The weightage of all the chemical factors are calculated on the basis of this equation.

Rating Scale

Rating scale (**Table 2**) was prepared for range of values of each parameter. The rating varies from 0 to 100 and is divided into five intervals. The rating Vr = 0 implies that the parameter present in water exceeds the standard maximum permissible limits and water is severely polluted. On the other hand Vr = 100 implies that the parameter present in water has the most desirable value. The other ratings fall between these two extremes and are Vr = 40, Vr = 60 and Vr = 80 standing for excessively polluted, moderately polluted and slightly less polluted

respectively. This scale is modified version of rating scale given by Tiwari and Mishra (1985).

Water Quality Index Calculation

Essentially, a WQI is a compilation of a number of parameters that can be used to determine the overall quality of drinking water. WQI is calculated for each month and is given in **Table 5**. The numerical value is then multiplied by a weighting factor that is relative to the significance of the test to water quality. The sum of the resulting values is added together to arrive at an overall water quality index. Water Quality Index is equal to the product of rating (Vr) and unit weight (Wi) of all the factors.

$$WQI = Wi \times Vr$$

$$Wi \times Vr = Wi(pH) \times Vr(pH) + Wi(TDS) \times Vr(TDS) + Wi(Total\ Hardness) \times Vr(Total\ Hardness) + Wi(Total\ Alkalinity) \times Vr(Total\ Alkalinity) + Wi(DO) \times Vr(DO) + Wi(Turbidity) \times Vr(Turbidity) + Wi(Chlorides) \times Vr(Chlorides) + Wi(Nitrates) \times Vr(Nitrates) + Wi(MPN) \times Vr(MPN)$$

The values of Vi, Wi and Vr are given in **Table 1** and **Table 2**. Hence by multiplying Wi and Vr. We can get the value of WQI. It is basically a mathematical means of calculating a single value from multiple test results.

Table 1: Water Quality Factors: ICMR/CPHEEO Standards and Assigned Unit Weights

Water Quality Factors	ICMR/CPHEEO Standards (Vi)	Unit Weight (Wi)
pH	7.0-8.5**	0.180
TDS	<1500**	0.001
Hardness	<600**	0.002
Total Alkalinity	<120*	0.012
Dissolved Oxygen	>5*	0.307
Turbidity	5-25*	0.307
Chlorides	250-1000*	0.006
Nitrates	<50*	0.031
MPN, coliforms/100 ml	10 or < 10 coliforms*	0.154

*ICMR Standards (1975) ** CPHEEO Standards (1991)

Table 2: Rating Scale for Calculating WQI

Parameter	Range of value				
pH	7.0-8.5	8.6-8.7 6.8-6.9	8.8-8.9 6.7-6.8	9.0-9.2 6.5-6.7	>9.2 <6.5
TDS	0-375	375.1-750	750.1-1125	1125.1-1500	>1500
Hardness	0-150	150.1-300	300.1-450	450.1-600	>600
Total Alkalinity	21-50	50.1-70 15.1-20	70.1-90 10.1-15	90.1-120 6-10	>120 <6
Dissolved Oxygen	>7.0	5.1-7.0	4.1-5.0	3.1-4.0	<3.0
Turbidity	<5.0	5.0-10.0	10.-17.5	17.6-25	>25
Chlorides	0-50	51-100	101-150	151-250	>250
Nitrates	0-13	14-26	27-39	40-50	>50
MPN, coliforms/100 ml	≤1	2-4	5-7	8-10	>10
Vr	100	80	60	40	0
Extent of Pollution	Clean	Slight	Moderate	Excess	Severe

Month &site		pH	D.O.	Turbidity	Alkalinity	TDS	Chlorides	Hardness	Nitrate	MPN
	A	7.36	5.7	3.4	136	340	29.30	94	4.35	>23

RESULTS AND DISCUSSION

The physico-chemical and bacteriological parameters have shown temporal and spatial variations. As shown in **Table 3,**

The pH value of sampling site A, B, C and D varied from (6.88 to 7.69), (6.83 to 8.09), (7.24 to 8.00) and (7.59 to 8.21) respectively. pH is very important in regulation of enzyme system. The sampling sites show distinct variations of pH in different months of the year. The pH of sampling site A, D, and B, C are found to be maximum in the months of January, December, and June, respectively. Minimum in August, May and March respectively. The observed pH value of sampling site C and D are within the permissible limit as per water quality standard.

Dissolved oxygen also fluctuated in drinking water samples. The maximum D.O. value of sampling site A, B, C and D varied from 7.7, 6.4, 7.5 and 8.8 mg/L respectively. The minimum D.O. value of sampling site A, B, C and D varied from 4.7, 4.9, 5.0 and 5.2 mg/L respectively. Rising temperature causes low solubility of oxygen and increase in MPN values in sampling site A and B, resulting in the decrease of D.O. content during May month.

Turbidity of drinking water of sampling site A, B C and D in range of (0.9 to 9.3) NTU, (1.0 to 5.1) NTU , (0.8 to 4.6) NTU and (0.3 to 2.8) NTU respectively. The maximum values of turbidity found in sampling site A, B in the months of September and august respectively. Turbidity is a measure of the amount of particulate matter that is suspended in water. Water that has high turbidity appears cloudy and opaque.

Feb 2011	B	7.20	5.4	1.1	182	535	49.28	162	28.10	>23
	C	7.75	6.2	1.0	200	615	39.10	120	14.90	<1.1
	D	8.11	6.6	0.6	170	380	29.15	106	0.7	1.1
Mar 2011	A	7.53	6.0	2.3	154	300	35.60	98	3.75	5.1
	B	6.83	5.0	1.1	182	425	39.66	135	33.20	>23
	C	7.24	5.8	0.8	180	455	35.83	131	15.50	7.2
	D	8.08	6.3	0.3	130	300	30.42	91	0.85	1.1
Apr 2011	A	7.12	4.8	2.0	78	520	30.00	132	3.40	>23
	B	7.27	5.2	1.6	78	648	53.00	108	32.64	>23
	C	7.75	5.2	1.2	80	548	31.81	136	24.40	3.6
	D	7.92	5.8	1.0	66	600	30.07	95	0.80	1.1
May 2011	A	7.24	4.7	1.8	82	640	30.50	117	2.90	>23
	B	7.50	4.9	1.4	96	665	74.25	152	33.25	>23
	C	7.75	5.0	1.3	77	465	39.75	167	26.60	<1.1
	D	7.59	5.2	0.9	74	480	33.80	99	1.00	5.1
Jun 2011	A	7.25	5.3	4.4	74	340	31.66	120	4.10	>23
	B	8.09	5.3	2.1	161	465	75.42	104	33.65	>23
	C	8.00	5.4	1.8	136	405	30.08	157	25.40	5.1
	D	8.15	5.8	1.4	110	360	26.00	93	1.20	1.1
July 2011	A	7.11	5.4	3.3	82	440	40.80	96	4.40	>23
	B	7.73	5.3	3.2	177	485	56.66	108	29.15	>23
	C	7.84	6.1	2.5	182	618	33.75	120	22.05	1.1
	D	8.20	5.9	1.5	96	380	28.08	95	1.35	1.1
Aug 2011	A	6.88	6.1	6.8	98	460	38.00	104	5.60	5.1
	B	7.61	6.0	5.1	148	450	49.41	166	29.00	5.1
	C	7.58	6.6	3.5	88	660	37.28	146	19.15	<1.1
	D	8.10	6.4	2.1	146	300	37.60	99	3.2	1.1
Sep 2011	A	7.20	5.2	9.3	94	600	25.00	219	3.15	>23
	B	7.84	5.3	3.2	254	676	50.32	298	32.40	>23
	C	7.90	5.8	2.6	244	912	39.30	266	22.40	3.6
	D	8.11	6.3	1.7	136	460	28.10	173	1.52	7.2
Oct 2011	A	7.41	6.1	6.5	144	540	31.20	146	5.70	<1.1
	B	7.80	5.4	4.2	310	590	67.10	298	25.20	>23
	C	7.73	5.7	3.8	268	1060	42.06	203	23.34	<1.1
	D	8.12	5.4	1.7	180	420	35.00	152	1.67	>23
Nov 2011	A	7.12	6.7	5.5	134	380	30.00	135	4.70	3.6
	B	7.70	6.4	4.9	297	610	68.96	253	21.60	5.1
	C	7.91	6.0	4.6	272	830	41.76	176	11.25	1.1
	D	8.12	6.7	2.8	180	370	32.65	149	0.65	1.1
Dec 2011	A	7.54	7.7	5.2	128	300	28.40	103	3.45	<1.1
	B	8.04	6.0	4.0	261	512	36.82	232	18.32	>23
	C	7.93	7.3	3.5	218	856	36.23	181	11.08	<1.1
	D	8.21	6.8	2.4	184	270	25.42	118	0.28	5.1
Jan 2012	A	7.69	6.4	0.9	96	330	25.50	100	2.20	12
	B	7.89	5.4	1.0	200	505	43.80	205	18.20	>23
	C	7.91	7.5	0.9	168	625	63.03	151	11.45	<1.1
	D	8.16	8.8	0.5	124	310	28.78	92	0.55	1.1

Table 3: Monthly variations of physio-chemical and bacteriological parameters data.

Alkalinity values are recorded as sampling site A, B, C and D varied from (74 to 154), (78 to 310), (77 to 272) and (66 to 184) mg/L respectively. The maximum alkalinity values of sampling site C and D found from the month of October

and November respectively. The higher values of alkalinity indicate presence of bicarbonate, carbonate and hydroxide in water body.

TDS values of sampling site A, B, C and D varied from (300 to 640), (425 to 676), (405 to 1060) and (270 to 600) mg/L respectively. Water containing high TDS concentration may cause laxative or constipation effects, (vyas, 2008).The low TDS values are found to be in sampling sites A, B, C and D as March-Dec, March, June and December respectively and maximum as May, September, October and April respectively. The period of some months the TDS values is above the permissible limit of water quality standard.

The Chlorides in the study area of sampling sites A, B, C and D are found from (25.50 to 40.80), (36.82 to 75.42), (31.81 to 63.03) and (25.42 to 37.60) mg/L respectively. From the observed results, the chloride content of drinking water is below permissible limit of water quality standard.

Total hardness of sampling sites A, B, C and D are varied from (94 to 219), (104 to 298), (120 to 266) and (91 to 173) mg/L respectively. The maximum value of hardness of all sampling sites is recorded during September month and minimum value of hardness of sampling sites A, B, C and D varied from February, June, Feb-July and March of month respectively. The rising of total hardness value due to increasing the solubility of calcium and magnesium salts.

The nitrate is recorded of the sampling sites A, B, C and D in the ranges of (2.20 to 5.70), (2.20 to 5.70), (18.20 to 33.65), (11.08 to 26.60) and (0.28 to 3.2) mg/L respectively. The nitrate values of sampling sites A and D is below the permissible limit and sampling sites B and C is above the permissible limit of water quality standard.

MPN values of sampling site A, B, C and D in ranges of (<1.1 to >23), (5.1 to >23), (<1.1 to 7.2) and (1.1 to >23) respectively. The minimum values obtained only in sampling site C and maximum values in sampling site A, B and D. From the observed results, the MPN of drinking water is above permissible limit of water quality standard.

The ICMR/CPHEEO standards and unit weights for different water quality factors are shown in **Table 1**; rating scale for calculating WQI is given in **Table 2**. It is shown in **Table 1** that the parameter which is required in least amount has more unit weight. It is because the recommended water quality standard (Vi) is inversely proportional to the unit weight (Wi). The WQI rating (**Table 2**) shows excess and severe pollution when DO is low. **Fig. 1** represents the sampling site and **Fig. 2** represents graph showing the comparison of WQI for Feb-2010 to Jan-2011. The highest value of WQI is 98.80 at sampling site at D while the lowest value of WQI is 66.26 occurs at sampling site at B. In fact, the WQI and the number of parameters having values within the permissible range are directly related to each other. An examination of data shows that all of the sampling sites considered here show large values of MPN coliform and alkalinity. Thus all of these sites show slightly amount of pollution, thus the WQI calculated in this paper give us some idea of the overall pollution of drinking water of educational institutions of sampling sites. The values of WQI very much depend upon the value of dissolved oxygen in water. The higher the DO in water, the clearer the water. The value of DO at the sampling site is lesser than 5 mg/l except for two months indicating that the water is moderately polluted at the sampling site A, B and C. On the basis of the WQI, the quality of the water is categorized from very bad to excellent (Tiwari and Mishra, 1985).

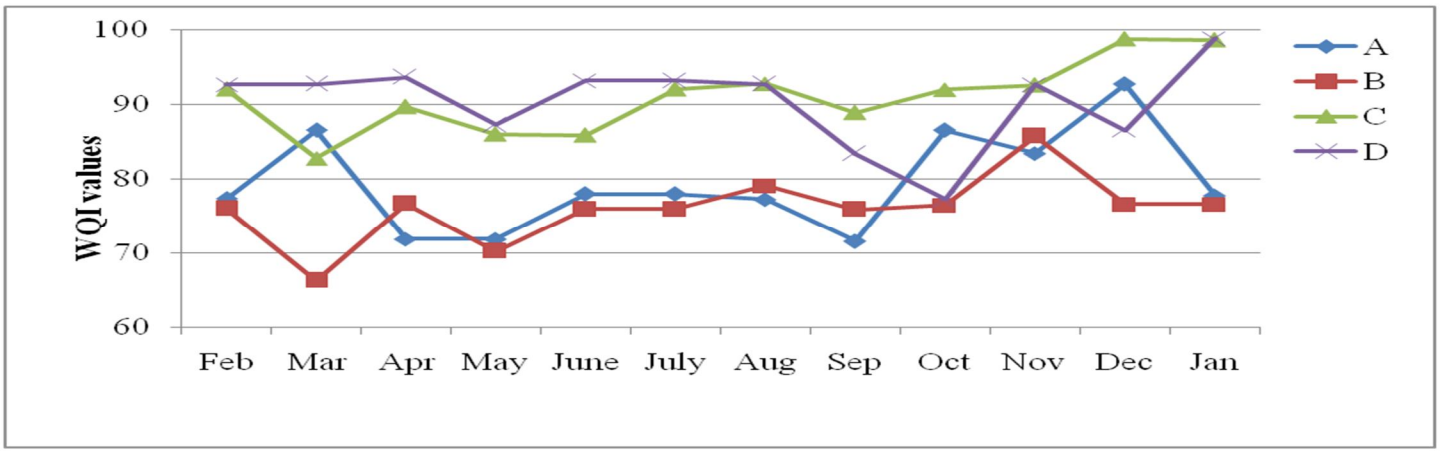


Fig 2: Graph showing the comparison of WQI for the years of Feb-2011 to Jan-2012.

Table 4. WQI ranges.

Value of WQI	Quality of water

90-100	Excellent
70-90	Good
50-70	Medium
25-50	Bad
0-25	Very Bad

The higher value of WQI show that the water is very much clear i.e., it is free of any impurities. At the sampling site B The water quality index for months of year Feb-2011 to Jan-2012 is shown in **Table 5**.

except for 1 month when its values are less than 70. As average value of WQI is 84.14, thus the results that overall quality of drinking water is good at the sampling site A, B, C and D. The higher values of WQI indicated that the water is very much clear and free of any impurities, and the water is in good condition to support the biotic communities.

Table 5. Water Quality Index for the Feb-2011 to Jan-2012.

Sampling sites	WQI											
	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan
A	77.26	86.50	71.82	71.82	77.96	77.96	77.22	71.54	86.50	83.42	92.66	77.74
B	75.96	66.26	76.60	70.18	75.88	75.88	79.06	75.84	76.46	85.70	76.58	76.58
C	92.02	82.78	89.66	85.94	85.82	92.02	92.74	88.88	91.96	92.58	98.72	98.62
D	92.64	92.66	93.60	87.20	93.14	93.12	92.66	83.36	77.20	92.64	86.50	98.80

CONCLUSION

The highest value of WQI is 98.80 at sampling site D (clean extent of pollution) while, the lowest value 66.26 occurs for sampling site B (Moderate pollution range). The WQI range of sampling site B varies between 66.26 to 85.70 which shows moderate to slight water pollution while WQI range of sampling site C between 82.78 to 98.72 which shows slight to clean water pollution. The Dissolved oxygen level is mostly responsible for the variations occurring in the WQI values. Fluctuations in the dissolved oxygen levels (beyond 7.0 and b/w 7.0-5.1) altered the rating factor (from 100 to 80) which had a direct implication on the WQI values. The drinking water quality of sampling sites varied from medium to excellent. On the basis of WQI it is suggested that as the MPN has greater value so proper treatment, like boiling, etc., should be strictly followed. So as to minimize the MPN and making it suitable for drinking purpose and it is advised not to consume water without proper treatment. As the quality of drinking water plays an important role in maintaining sound health, its monitoring is essential for water that is supplied for drinking. The overall drinking water of the sampling sites, in general, can be considered fit for educational institutions of the student community. However, WQI may be used as a tool to convey the information regarding the quality of water and to take up necessary measures so as to maintain the quality and life.

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