STUDIES ON WATER QUALITY INDEX OF THREE MAJOR RIVERS OF PUNE IN SUMMER SEASON

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ABSTRACT: The population in and around Pune largely survives on the flowing waters from the three rivers namely Mula,Mutha and Pavana. Regular auditing of various water quality parameters of these rivers is important to maintain their quality. Present work is a probe into the water quality of these rivers carried out at different locations during summer season in the year 2015. The composite effect of various Physico-Chemical parameters is studied through calculation of Water Quality index for these samples. The WQI recorded was the highest for Khadakwasla and the lowest for Yerwada rendering the water to be of good and bad quality respectively at these locations. It has been concluded from the study that summer as a season does have an impact on the WQI and is low for the samples as compared to those in winter though not as bad as that in monsoon.

KEYWORDS: **water quality index,summer, Mula,Mutha, Pavana,,DO,Temperature**

I. INTRODUCTION

Mula,Mutha and Pavana are the main sources of water for Pune.The river Mulla has its origin at Deoghar, 70Km to the west of Pune and meets Pavana river at Dapodi. Pavana with its source in the western Ghats flows for 65 kms to meet Mula. Mula there after joins the Mutha Sangam and both these rivers then flow as the Mula-Mutha as single river for 56 Km to join Bhima River which subsequently merges with Krishna river and proceeds to Bay of Bengal.These are the water bodies much prone to pollution because of their role in carrying municipal and industrial wastes and run-off from agricultural lands in their vast drainage basins of various standards.Many industries discharge their wastes directly into these rivers,degrading the water quality.The water quality restoration and maintenance in these rivers flowing through the city has been a major challenge to the environmentalists and authorities concerned [1].In view of this, assessment of water quality of these rivers is highly imperative.The quality of water is a function of many Physico-Chemical parameters like Temperature, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD),Nitrates,,Phosphates and pH [2-3]. However,these parameters do also depend on the environmental conditions.Seasonal variations play an important role in bringing about changes among these parameters which in turn grossly affect the water quality of the rivers [4-5]. In the earlier studies, it has been observed that the level of pollution was more during pre-and post-monsoon seasons [6]. Present investigation is an attempt to understand the impact of summer as a season on the water quality of river waters. Many researchers have studied the influence of pre-monsoon conditions and hot climatic conditions on the water quality [7]. Water quality is generally assessed by evaluating the combinatorial impact of various Physico-Chemical parameters on the river waters. A widely-accepted index worldwide that reflects this overall influence on water quality is called Water Quality Index (WQI) [8]. The aim of the work under the title is to study the water quality of the three rivers by dividing it into various sampling stations and analysing the reasons for the obtained results. Herein a total of 9 sampling stations were selected for water sampling. It has been endeavoured here to calculate the WQI of the three river waters at nine different locations and analysis of the relative quality of these samples has been carried out.

2. MATERIALS AND METHODS:

The river water samples were collected for a period of three months in the summer season from first week of Mar 2015 to end of May 2015. The Physico-Chemical analysis of Mula, Pavana and Mutha River waters were conducted to analyse the effects of pollution in stretch of the river, starting from Khadakwasla to Yerwada. Various station points were selected for sampling. A total of 9 locations were selected along the stretch of river. Samples were collected taking care to prevent formation of air bubbles and bottles were corked tightly under the surface of water. Table 1 gives the details of locations from where samples were collected. The analysis of water samples was done for various physical and chemical parameters namely pH, Temperature, BOD, COD, DO, MPN, Nitrate, Phosphate, Turbidity and Total Solids following standard methods APHA – AWWA – WPCF (1989) [9]. Of these five most significant water parameters viz,pH, Nitrates, Phosphates, DO and Turbidity were used to calculate the WQI, using a renowned method of calculation [10,11]. In the present investigation, to study the quality index of water, nine sampling stations were selected in about 20 km stretch of River Mutha, about 15 km of River Pavana, around 10 km of River Mula and 15 km stretch of the river Mula– Mutha.

Table 1 The details of sampling stations

Station No	Name of the Sampling Station	Name of the River
S1	Panshet Dam	Mutha River
S2	Khadakwasla Upstream	Mutha River
S3	Khadakwasla Downstream	Mutha River
S4	Mulshi Dam	Mula River
S5	Paud	Mula River
S6	Pavana Dam	Pavana River
S7	Bevad Ovhal	Pavana River
S8	Aundh	Mula River
S9	Yerwada	Mula-Mutha

3. RESULTS AND DISCUSSION:

Table 2. Summary of details of various physico-chemical parameters obtained from S1-S9

Sample Point	Month	Temparature	PH	BOD	MPN	DO	COD	Phosphate	Nitrate	Turbidity	Total Solids
S1 Panshet Dam (Mutha)	Mar	25	7.71	28	25	6.5	9.7	3.1	3	2.4	350
	Apr	27.5	7.1	26	28	6.2	14.6	2.8	2.9	2	380
	May	26.5	6.9	25	15	6.6	11	3.3	3.1	1.9	410
	Mean	**26.33**	**7.24**	**26.33**	**22.67**	**6.43**	**11.77**	**3.07**	**3.00**	**2.10**	**380.00**
S2 Khad Upstream (Mutha)	Mar	23.5	8.4	2.9	6	7.5	8.8	0.8	0.1	1.5	260
	Apr	24.5	8.12	2	7	7.2	9.2	0.2	0.05	1.3	245
	May	24.8	8.3	2.8	9	7.3	8.6	0.6	0.12	1.4	230
	Mean	**24.27**	**8.27**	**2.57**	**7.33**	**7.33**	**8.87**	**0.53**	**0.09**	**1.40**	**245.00**
S3 K Dour Shan (Mutha)	Mar	24.5	8.4	3.2	10	7.4	9.3	0.9	0.05	1.6	280
	Apr	25	7.9	4.9	12	7.2	9.5	0.8	0.15	1.4	275
	May	24.8	8.2	3.9	15	7	9	0.6	0.1	1.2	225
	Mean	**24.77**	**8.17**	**4.00**	**12.33**	**7.20**	**9.27**	**0.77**	**0.10**	**1.40**	**260.00**
S4 Mulshi Dam (Mula)	Mar	24.5	7.2	31	33	6.3	10.5	3.5	3.5	2.9	430
	Apr	25.5	6.9	28	35	6.6	11.8	2.9	3.3	2.6	420
	May	26.2	7.1	30	39	6.1	12.6	3.4	3.1	3	390
	Mean	**25.40**	**7.07**	**29.67**	**35.67**	**6.33**	**11.63**	**3.27**	**3.30**	**2.83**	**413.33**
S5 Paud (Mula)	Mar	24.8	6.92	29	48	6.5	11.5	4.2	2.9	3.1	480
	Apr	26.3	7.31	33	28	6.7	14	3.8	3.1	2.8	510
	May	25.5	7.01	32	51	6.3	13.5	3.3	3	2.7	430
	Mean	**25.53**	**7.08**	**31.33**	**42.33**	**6.50**	**13.00**	**3.77**	**3.00**	**2.87**	**473.33**
S6 Pavana Dam (Pavana)	Mar	24.6	7.4	39	25	5.8	12.6	2.9	3.2	3.5	510
	Apr	25.7	7.01	40	38	6.1	14.6	3.2	2.9	2.9	490
	May	25.5	7.9	42	51	6	13.8	2.8	3	3.2	525
	Mean	**25.27**	**7.44**	**40.33**	**38.00**	**5.97**	**13.67**	**2.97**	**3.03**	**3.20**	**508.33**
S7 Bevard Ovhal (Pavana)	Mar	25.8	7.51	38	27	3.5	85	3.1	4.2	3.3	580
	Apr	26.3	7.32	43	32	4.9	85	2.9	3.9	2.9	610
	May	25.5	7.01	40	35	3.8	85	2.8	4	2.8	585
	Mean	**25.87**	**7.28**	**40.33**	**31.33**	**4.07**	**85.00**	**2.93**	**4.03**	**3.00**	**591.67**
S8 Aundh (Mula)	Mar	26.5	6.12	53	350	2.8	112	5.1	4.9	4	850
	Apr	27.3	6.5	51	225	2.7	112	4.9	4.8	3.9	890
	May	27.2	6.32	54	275	2.6	113	5	5	4.2	900
	Mean	**27.00**	**6.31**	**52.67**	**283.33**	**2.70**	**112.33**	**5.00**	**4.90**	**4.03**	**880.00**
S9 Yerwada (Mula-Mutha)	Mar	26.8	5.84	60	450	2.8	95	5.2	5.3	4.9	912
	Apr	27.5	6.1	65	520	1.9	94	4.9	5.1	4.8	910
	May	27.6	5.9	63	430	2	95	5.1	4.9	4.2	892
	Mean	**27.30**	**5.95**	**62.67**	**466.67**	**2.23**	**94.67**	**5.07**	**5.10**	**4.63**	**904.67**

Parameter wise results of the study are presented and discussed in the following paragraphs. Table 2 shows the results of sampling data at each sample station.

Temperature:

Temperature of water is a decisive physical parameter in determining the electrical conductivity, pH and dissolved ions present in each water sample. It affects the alkalinity, chemical and biological reactions and chemical equilibrium of water. As temperature increases Dissolved Oxygen content decreases [12]. In the present investigation, average temperature observed for the summer season was 27.6°C. The temperature for different samples from S1 to S9 varied between24.3°C to 27.3°C.

pH:

pH is an essential parameter as it determines the acidity and alkalinity of waters. [13]. The pH at non-polluted area i.e. Khadakwasla was 8.2. The water turns acidic as the pH goes below 7. Minimum was recorded at Yerawada (5.9) which infers to degraded quality of water flow.

Biological Oxygen Demand (BOD):

BOD is one of the significant water parameters in evaluating the water quality.The BOD limits per BIS should not exceed 6mg/L [14].BOD is a parameter used to assess the required oxygen level in stabilizing the domestic and industrial wastes. In the present report, the observed ranges of BOD were between 2mg/L at S2 i.e.,Khadakwasla upstream and 62.7 mg/L at S9 (Yerawada).

Fecal Coliform (MPN):

Fecal coliform also known as Most Probable Number (MPN) is another parameter that is used as an indicator to know the safety levels of water by the presence of bacteria in the given water sample [15]. It varied between 7.3 MPN/100ml at S2 to 500 MPN/100 ml of water at S9. The observations show that the water at S2 is the safest for human consumption.

Dissolved Oxygen (DO):

DO measurement refers to the pollution levels in water as its levels indicate the favourability of growth and multiplication of aquatic life. The DO levels are also read as the measure of degree of organic pollution of water.The Oxygen levels were high at

Khadakwasla 7.3 mg/l, but fell considerably at Yerwada to 2.2 mg/L. Such observations were made earlier by researchers at stations where these rivers were flowing [16].

Chemical Oxygen Demand (COD):

It is another Physico-Chemical parameter that indicates the degree of pollution in surface waters. When COD and BOD are high in magnitude, water bodies are subjected to eutrophication near city areas due to treated or untreated discharges. This leads to decline in oxygen levels of these waters [17]. COD was recorded to be minimum for S2 (8.9 mg/L) and maximum for S8(112.8 mg/L).

Phosphates:

Phosphate levels are indicative of domestic sewage. Phosphates feed the algae present in water bodies and are responsible for their uncontrolled growth. Their growth in water ecosystems leads to imbalances leading to destruction of other forms of life besides producing harmfultoxins [18]. The observed values for phosphates ranged between 0.5 mg/L and 5.1 mg/L. The greenish untidy alggaeic growth was apparently seen at the locations like Aundh and Yerwada supporting the high phosphate levels recorded at these stations.

Nitrates:

Nitrates in water play significant role in maintaining its quality since excess levels of nitrates in it can create conditions that make it difficult for aquatic life. Similar to phosphates nitrates also nurture the unchecked growth of algae in waters as they act as source of food [19]. Chemical sewage from industries, and agricultural run-off due to use of plant fertilizers contribute to nitrates in waters. Nitrate concentration exceeding 45mg/L also causes blue baby syndrome in infants. S2 and S9 have recorded 0.1 and 5.1 mg/L respectively.

Turbidity:

Particulate matter in suspension causes turbidity in fluids. The suspended particulate matter in water makes the water opaque and alters the scattering property of light in the liquid. As the pollution increases, the amount of particulate matter increases leading to increase in the turbidity of water [20].

Total solids:

Total solids constitute dissolved and suspended colloidal solids in each water sample.NaCl, silt and planktons are examples of these. Water run-off from soil and rocks besides agricultural fields contribute to TS. Excess of these in water samples is a matter of concern [21]. In the present study, the TS values recorded are very high. Highest and lowest values of TS were recorded as 904.6 and 245 ppm respectively at Khadakwasla and Yerawada.

Though, all the aforesaid parameters do separately have an impact on the quality of water, it is very difficult to get an immediate inference about the water quality from these parameters. In view of this, the index of water quality including all the aforesaid parameters is a parameter that is calculated for assessing the samples S1 to S9 according to NSF.WQI is discussed briefly in the following paragraph.

Water Quality Index:

As discussed earlier, water quality is often evaluated through the calculation of water quality index (WQI). The synergetic effect of all the aforesaid parameters is incorporated in the calculation of this parameter. This is taken as a standard parameter to gauge the water quality worldwide. As interpretation of various complex Physico-Chemical water parameters and their correlation is cumbersome and tedious, such a single index to determine the water quality is not only handy but also highly important.

A commonly used water quality Index (WQI) was developed by the National sanitation foundation (NSF) in 1974 [22]. Then NSF WQI was developed to give a standardized method for comparing the water quality of various bodies of water. NSF water quality index was found by using weighted factor of individual parameter and sub-index of each water quality parameter. The sub-index is based on their respective testing values which can be determined by water quality index calculator or water quality index curve of relative parameters.

$WQI = 0.17\ I_{DO} + 0.11 I_{pH} + 0.1\ I_{dT} + 0.071_{TD}$----for all parameters.

Of all the parameters, the NSF WQI uses nine water quality parameters to evaluate water quality.

1. Dissolved Oxygen (DO)
2. Fecal Coliform (MP)
3. pH
4. Biological Oxygen Demand (BOD)(5-day)
5. Temperature Change
6. Total Phosphate
7. Nitrate
8. Turbidity
9. Total Solids

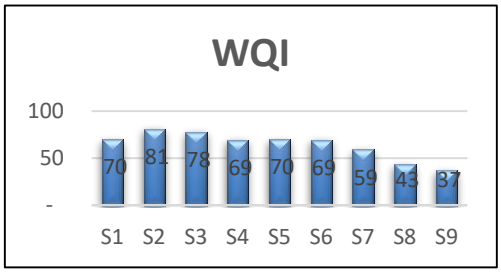
. One of the major merits of WQI is that it can incorporate data from a number of water quality parameters into a mathematical equation that rates the health of water quality with number (23).Though each of the parameters studied above have an impact on the water quality, as mentioned earlier only five of these which are significant were considered for the calculation of WQI in this

work using an established method of calculation of WQI in agreement with that developed by NSF in 1974 [22]. The WQI for all the sample stations were calculated from the data tabulated in Table 2. The variation of different sample parameters obtained

Figure 1. Variation of different water parameters from S1 to S9 is also graphically represented in Figure 1.

The results of WQI for S1 to S9 are graphically represented in Figure 1 and 2. The classification of water based on obtained WQI is tabulated in Table 3. S2 recorded the highest WQI of 81 and the same for S9 is the lowest with a value of 37.

Figure 2. WQI and five important parameters for S1 to S9



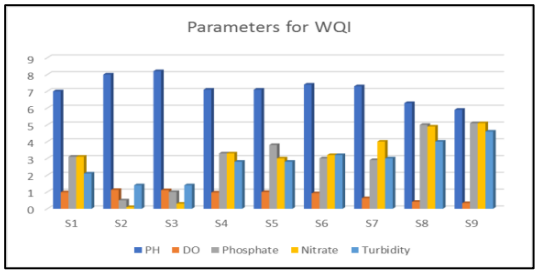


Table 3. Classification of S1 to S9 based on WQI

Sample Station	WQI Index	Classification
S1	70	Medium
S2	81	good
S3	78	Good
S4	69	Medium
S5	70	Medium
S6	69	Medium
S7	59	Medium
S8	43	Bad
S9	37	Bad

Standard classification of water based on WQI indicates that S9 and S8 are 'BAD' in terms of quality and S2 and S3 emerged as waters that are 'GOOD' in quality. Samples S1, S4,S5,S6 and S7 were of 'MEDIUM' quality. Higher values of WQI recorded for S2 and S3 are attributed to greater values of DO and lower values of phosphates and itrates besides being a little alkaline in terms of chemistry. Also, the water samples at these stations were less turbid as compared to the other samples. The phosphates and nitrates values obtained for the studied summer season are a little higher vis-à-vis other season. This resulted in low value of WQI as compared to winter and spring. However, as established in the studies before, the quality index for summer is superior as against the monsoon season [24].

The WQI values have varied between average to excellent in the spring season and the same altered between medium to good quality water in the summer. The effect of season on different parameters is understandable from Table 2. However, the composite effect of all these parameters on the water quality referred to as the WQI was affected considerably in summer. Another very important observation was that, turbidity is maximum in the summer due to the hot prevalent conditions in the environment. This is justified since the rate of evaporation in water is greater leading to enhanced conditions of turbidity. This further, contributes to reduction in WQI. This is one of the reasons for the show up of relatively lower WQI values in the samples studied.

4. CONCLUSION:

In the present work, different Physico-Chemical parameters were studied and analysed for various water sampling stations through which Mula, Mutha and Pavana Rivers flow during summer season of the year 2015. The results of the study indicate that, water quality has declined in the pre-monsoon season which agrees with the earlier studies. Among the all investigated locations 22% of them showed WQI of 76-100 indicating good water quality. 55% of the sampling locations showed WQI in the range 51-75 leaving the water quality to be called medium. The reaming locations displayed a WQI between 26 to 50 allowing the water to be rated as bad in these regions. Also, it has been conspicuously observed that WQI has fallen from 81 to 37 between the locations like Khadakwasla and Yerwada which may be attributed to pollution that is anthropogenic in origin.

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