Intervention of Water Quality Index (WQI) for Assessment of Bhima River water for Drinking from its Origin to Ujjani Reservoir.

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Abstract

Aim of the present study was to asses water quality of Bhima river for drinking purpose. Perennial river Bhima originates at Bhimashankar in Pune district and flows towards eastward. During course of journey several tributary rivers merge in to Bhima river. Study area of present work lies from origin of Bhima river to Ujjani reservoir in Pune district. For physicochemical analysis of water in Bhima river was collected from total twenty (20) sampling sites as per the guidelines by APHA and WHO for period of two years (2015 and 2016) and two months intervals. Water Quality Index (WQI) calculated by using NSF WQI equation put forward by Brown et al (1970). WQI calculator was used by using nine (9) parameters. Study investigated that, 'Excellent' quality water doesn't find among any sampling site of Bhima river. Water quality of Bhima river among all the sampling site wasn't too good to posses criteria to fit this water for drinking purpose. Anthropogenic activities around Bhima and tributary rivers discharges untreated waste water make serious concern of water pollution. This study concluded that Bhima river water during January to May months not suited to drinking purpose without conventional treatment.

Key Words: water quality index, drinking water purpose, Bhima river, Pune district.

Introduction

Water Quality Index (WQI) generally used to symbolize the common value for water usages for various purposes. Numerous studies proposes definition of Water Quality Index. Rao S. (2013) defines it is rating of reflection the composite influence of different water quality parameters were taken into consideration for the calculation of Water Quality Index. Malaysian Environmental NGO (2008) defines Water Quality Index is a phrase to describe the chemical, physical and biological characteristics of water. Darapu S.S.K. (2011) et al., defines Water Quality Index is a single number (grade) that expresses overall water quality at a certain location and time based on water quality parameters. Kumar A. and Sharma M.P.(2014) gives definition of WQI is a number to express the overall water quality of certain location and transforms the complex physic-chemical parameters into information that is usable and understandable by general public. Ramakrishnaiah C.R. et al., (2009), defines WQI as a rating reflecting the composite influence of different water quality parameters. United State of America's EPA (1974) define WQI is a single numerical expression which reflects the composite influence of nine physical, chemical and microbiological parameters of Water Quality. Brown et al (1970) concluded that single numerical expression indicating the composite influence of single analyses affecting the water quality was feasible.

Various Water Quality Indexes developed and used around world (House and Ellis, 1987). However, Horton (1965) laid the foundation stone for development of WQI in USA. In 1959 USA based committee on National Water policy of the conference of state sanitary Engineers (CSSE) felt the need of uniform method for management of water quality. Then in 1965, United State of America's Environmental Pollution Panel recommend the development of index for chemical pollution in water (USEPA,1974). Brown et al (1970) develop Water Quality Index with the reference of data assembled from the panel of 142 persons in the expertise in water quality management. Brown et. al. (1970) assigns weitage of each parameter according to the

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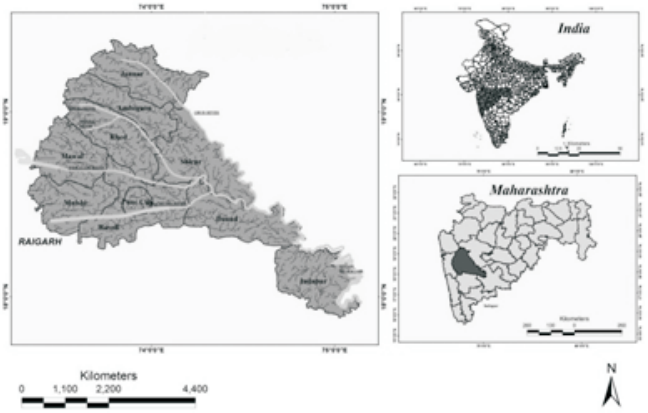
responses from panelists. In 1970, USA National Sanitation Foundation recommended to use the WQI of Brown et al (1970) for the purpose of determination of Water Quality Index (WQI). In 1974 US Environmental Protection Agency studied WQI for analysing river pollution (Ott, 1978). In India WQI first time used to find the possibility of drinking water supply of river Ganga. It is suggested that, for public water supply for drinking WQI is more than 90 (Bhargava, 1985). Ved Prakash (1990) modified NSFWQI for different categories of uses as set by CPCB (Abhasi, 2002). Maharashtra Pollution Control Board (MPCB) also recommended NSFWQI for water quality usages for drinking superpose. The study attempted to investigate feature of Bhima river water especially for drinking water purpose from its origin upto Ujjani reservoir within Pune district.

MATERIALS AND METHOD

Study Locale: The Bhima river initiated from the Bhimashankar hills near Karjat in Western Ghats at Bhimashankar an altitude of about 945 meter above the sea level. It is known as Sahyadri in Maharashtra. The Bhima river flows in the southeast direction. However at Ujjani in Maharashtra the water of Bhima river is tapped by constructing major dam named as Yeshwant Sagar in 1972.



Map No.1: Study Area Bhima river from Origin to Ujjani reservoir.

WQI (Water Quality Index)- Following equation gives numerical value of water for drinking purpose.

$$\text{NSF WQI} = \sum_{i=1}^{n} w_i q_i$$

Where,
qi = sub index for ith water quality parameter;
wi= weight associated with ith water quality parameter;
n= number of water quality parameter

Table No. 1: Significance ratings and weights for nine parameters include in WQI

Parameter	Weight
pH	0.11
Change in temp	0.10
DO	0.17
BOD	0.11
Turbidity	0.08
Phosphate	0.10
Nitrate Nitrogen	0.10
E. coli*	0.16
Total Dissolved Solids	0.07

Source: Brown et al, 1970

Calculation of oxygen saturated percent-

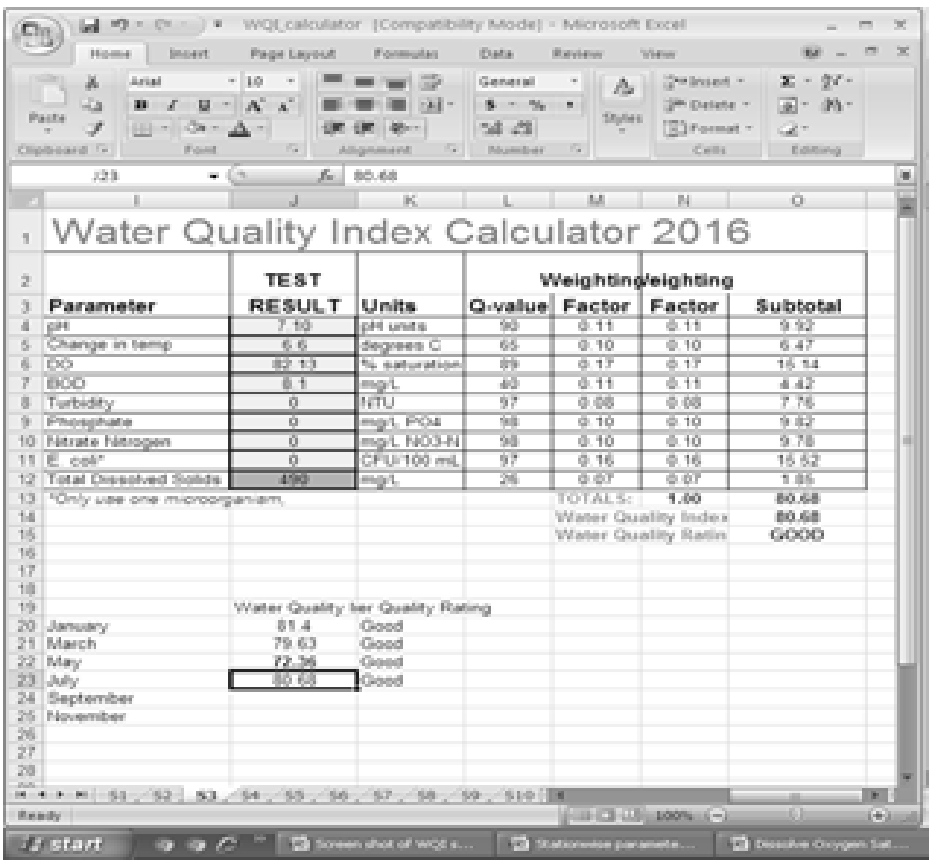
$$\text{DO \%} = \frac{DO\ Vlaue\ from\ Chart\ at\ temp.and\ salinity}{Dissolved\ oxygen\ (mg/lit)} \text{ x } 100$$

Table No. 2: Water quality ratings of NSFWQI.

WQI Value	Rating of Water Quality
91-100	Excellent
71-90	Good
51-70	Medium
26-50	Bad
0-25	Very Bad

Source: Brown et al, 1970

Water Quality Index (WQI) Calculator- For present study NSFWQI is use through the calculator with the help of simple programming on Microsoft Excel 7. Although Wilkis University in USA bring online calculator for NSFWOI. The screen image of the WQI is shown in the picture number 1. This is most effective method to resolve calculation hassle as well it use offline. This software gives instant results even find the dominant parameter responsible for degradation of water quality.



Picture No. 1: NSFWQI Software based Calculator.

RESULTS

Table No. 3: Water Quality Index at Different sampling stations

Sampling Stations	Study Period year						Study period year				
	2015			2016			2015			2016	
Origin of Bhima River	Water Quality Index	Water Quality Rating		Water Quality Index	Water Quality Rating	**S11 After Confluence with Bhama**	Water Quality Index	Water Quality Rating		Water Quality Index	Water Quality Rating
January	78.65	Good	January	80.46	Good	January	**48.22**	**Bad**	January	**46.52**	**Bad**
March	73.67	Good	March	78.81	Good	March	**45.31**	**Bad**	March	**39.97**	**Bad**
May	**71.26**	Good	May	**74.39**	Good	May	**42.41**	**Bad**	May	**33.87**	**Bad**
July	79.17	Good	July	80.89	Good	July	53.94	Medium	July	**49.82**	**Bad**
September	77.38	Good	September	79.89	Good	September	50.61	Medium	September	55.01	Medium
November	71.14	Good	November	79.51	Good	November	49.4	Medium	November	52.06	Medium
S2	**2015**			**2016**			2015			2016	
Gupta Bhima River	Water Quality Index	Water Quality Rating		Water Quality Index	Water Quality Rating	**S12 Near Sanghavi Village**	Water Quality Index	Water Quality Rating		Water Quality Index	Water Quality Rating
January	77.17	Good	January	76.75	Good	January	50.54	Medium	January	52.08	Medium
March	75.55	Good	March	77.19	Good	March	**47.33**	**Bad**	March	**44.21**	**Bad**
May	**73.2**	Good	May	**74.19**	Good	May	**43.08**	**Bad**	May	**41.63**	**Bad**
July	79.55	Good	July	80.99	Good	July	57.59	Medium	July	60.35	Medium
September	76.85	Good	September	79.8	Good	September	52.29	Medium	September	58.82	Medium
November	77.09	Good	November	79.26	Good	November	52.81	Medium	November	61.13	Medium
S3	**2015**			**2016**		**S13 Before Confluence with Mula Mutha**	**2015**			**2016**	
Backwater of Chakasman Dam	Water Quality Index	Water Quality Rating		Water Quality Index	Water Quality Rating		Water Quality Index	Water Quality Rating		Water Quality Index	Water Quality Rating
January	80.61	Good	January	81.4	Good	January	52.26	Medium	January	53.58	Medium
March	80.19	Good	March	79.63	Good	March	51.11	Medium	March	**47.26**	**Bad**
May	**77.9**	Good	May	**72.36**	Good	May	46.57	Bad	May	**46.51**	**Bad**
July	84.07	Good	July	80.68	Good	July	63.45	Medium	July	63.44	Medium
September	80.55	Good	September	81.68	Good	September	56.86	Medium	September	62.05	Medium
November	82.65	Good	November	78.11	Good	November	55.95	Medium	November	56.85	Medium
	2015			**2016**		**S14 Mula-Mutha River Before Confluence with Bhima River**	**2015**			**2016**	
S4 Mouth of Chakasman Dam	Water Quality Index	Water Quality Rating		Water Quality Index	Water Quality Rating		Water Quality Index	Water Quality Rating		Water Quality Index	Water Quality Rating
January	81.57	Good	January	80.99	Good	January	**42.78**	**Bad**	January	**39.7**	**Bad**
March	80.92	Good	March	76.63	Good	March	**28.82**	**Bad**	March	**25.94**	**Bad**
May	**75.55**	Good	May	**76.78**	Good	May	**21.08**	**Very Bad**	May	**22.58**	**Very Bad**
July	87.18	Good	July	87.84	Good	July	**49.33**	**Bad**	July	52.88	Medium
September	80.26	Good	September	83.27	Good	September	**39.92**	**Bad**	September	50.96	Medium
November	83.83	Good	November	84.77	Good	November	**40.09**	**Bad**	November	**47.34**	**Bad**
S5	**2015**			**2016**			**2015**			**2016**	

DISCUSSION

Table number 3 showed the details of NSFWQI at different locations of Bhima river. Water quality of river Bhima from the origin upto sampling site S4 (backwater of Chasakman reservoir) is 'Good' during all the season. Although river Bhima originated from the hilly areas which has high rainfall region. Even during monsoon quality of water was 'Good' but event doesn't have "Very Good/Excellent" status. Highest WQI (87.84) during July 2015 was found at sampling site S4. Water Quality Index is improved during the monsoon followed by winter and then gets poorer during summer. This result of the present study corresponds to outcome of study by Kumar A. and Sharma M.P. (2014), Ramakrishnaiah C.R.(2009). Evaporation enhances the concentration of ions during summer season and diluted those ions in monsoon (Kumar A. and Shrama M.P., 2014).

NSFWQI at sampling site S5 (near Rajgurunagar town) start changing from 'Good' to 'Medium' during January to May months of 2015 and 2016. Human interventions alter the quality of natural water stream. Rise in TDS, pH, conductivity and turbidity responsible for the deterioration of water quality of Bhima river. When water quality deprived from 'Good' to 'Medium' makes water to not to use other than drinking (Yogendra K. and Puttaiah E.T., 2008). Bhima river's WQI at sampling S6 (near Rajgurunagar town) shows the magnitude of pollution problem by anthropogenic activities. NSFWQI of Bhima river near Rajgurunagar dynamically changes during the late post monsoon till end of summer season.

Increasing organic pollution by domestic discharges by Rajgurunagar disturb the overall water quality of Bhima river. Here FWQI is deprived to 'Bad' level. Even during July 2016, value of NSFWQI is 28.59 illustrate 'Bad' water quality which mean water is not suitable for any purposes. During March to May months WQI is 'Bad' and in rest of season it was remains 'Medium.' Aquatic ecosystem almost vanished when water quality is 'Bad' (USEPA, 1974). During field visits similar depiction seen on Bhima river.

During the course of journey WQI of river Bhima is little bit improved during monsoon and post monsoon seasons. Dissolution and dissipation of pollutants tends to improve quality of river water. Natural purification system of Bhima river also filter out organic as well as inorganic contaminants released by anthropogenic activities. Study of Kumar A. and Sharma M.P. (2014) detects the similar results. WQI depressed after confluence of tributaries. WQI after confluence with Bhama at sampling site S9 turns to 'Medium' to 'Bad'. During months of May, September 2015 and May 2016 WQI was 'Bad' while in rest season it was 'Medium.' Tributary river Bhama add sewage waste by anthropogenic activities and industrial discharges from catchment areas. WQI at sampling site S10 (before confluence with Indrayani) over Bhima river was identical i.e.'Medium' and 'Bad' during monsoon and summer season respectively.

Then, Bhima river have second confluence with Indrayani river at Tulapur village (S11). On sample site S11, WQI was further declining towards. 'Bad.' During July 2016 status of WQI was depressed to 'Bad'. The storm water in monsoon season carrying organic waste and modifies to alter the chemical and biological property of water and resulted as pollution (Moore J.W., 1991). WQI in Bhima river is enhanced over next sampling site S12 and S13 (before to confluence with Mula-Mutha). On sampling site S13, WQI was improved to 'Medium' in monsoon months while it tends to 'Bad' in summer season.

Sampling site S14 was only exceptional because it doesn't lies on the Bhima river. This sampling site was purposively selected on Mula-Mutha river before confluence with river Bhima. Over all WQI of Mula-Mutha river e\was 'Bad' to 'Very Bad' throughout study period except in year July to September 2016. Discharge of sewage drains pollutants from Pune, Pimpri-Chinchwad Municipal Corporations and suburban areas makes Mula-Mutha a river of drains.

This study showed that, WQI on sampling site S15 immediate after confluence with Mula-Mutha river shows full pollution load in river Bhima. Here WQI was inferior during May 2015 (24.50). However during 2015 WQI of river Bhima was turn downs 'Bad' to 'Very Bad'. WQI in successive year 2016 was 'Bad' during months of January to May while it was 'Medium' during July to November months. This was because of prolonging monsoon in year 2016. WQI of Bhima river before confluence with Mula-Mutha was 'Medium' and after confluence it was radically goes down to 'Very Bad'.

WQI at sampling site S16 (near Daund city) shows seasonal variations. Organic waste in river Mula-Mutha persist upto this sampling site. Overall water quality of this sampling site was 'Medium' to 'Bad.' Successively Bhima river merges in to Ujjani reservoir. Therefore, it is pertaining to find the status of water quality over different places around the Ujjani reservoir. WQI at Ujjani backwater near Kumbhargaon village (sampling site S17) was 'Medium' to 'Bad' recorded within study period. Here WQI was 'Bad' except month of July 2015 and July to November 2016. Pollutants from Bhima river accumulated and scattered around Ujjani reservoir. Overall impacts of pollutants alter the water quality of Ujjani reservoir. Changing physicochemical and biological properties of Ujjani reservoir damage the quality of water. Trends of WQI at sampling site S18 is remains same like S17.

Since July onwards WQI at rest of the sampling site S19 and S20 was 'Medium' to 'Bad'. Water Quality Index (WQI) turns to 'Medium' in the beginning of January and it remains 'Bad' still month of March to May. This means that pollution concentration among these site was very sever and harming the aquatic environment. During July 2016 WQI at sampling site S19 was 'Good' then it deprived to 'Medium'. Ujjani reservoir work like buffer to soak up the pollution from Bhima and tributary rivers. WQI over last sampling site S20 was located near pumping station which supplies water to Solapur city. Here WQI wasn't been healthier and doesn't recommend to use water directly for drinking purpose. Water Quality of Ujjani reservoir was optimize and suggested to use water for outdoor activities, bathing, irrigation and industrial purposes. During study period half of the times WQI was 'Bad' and indicate seriousness of health concern to supply water for drinking without prior treatment.

CONCLUSION

Overall WQI during study period wasn't been influential to 'Very Good or Excellent' level. Somewhere this finding shows the severity and concern of pollution within Bhima river basin which progressively increasing with anthropogenic forces. Water of Ujjani reservoir doesn't safe for direct consumption and irrigation during late post monsoon to summer season. This study recommend that water of Bhima river was safe to use only during monsoon and few months of early post monsoon (i.e. upto November) seasons.

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