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Assessment of Water Quality Index and Correlation for the Study of Water Quality Deterioration of Pravara River

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Abstract An attempt has been carried out to assess the seasonal water quality index (WQI) using four water quality parameters pH, BOD, DO, FC. For which 10 different stations along Pravara River have been selected which covers two seasons pre-monsoon and post-monsoon. Physico-chemical parameters have been analyzed by standard method. The Karl Pearson correlation matrix has been established to examine relationship between the water quality parameters. The study is conducted to analyze the water quality status of Pravara River in terms of water quality Index (WQI). The computed WQI values are found between 37.5 to 78.9. The WQI values shows non-polluted water at upper stream in the study area, but as it enters in city considerable changes in WQI were observed and water become polluted (S_6 & S_{10}) to heavily polluted (S_5 & S_7). These Field observations reveal that water quality is declined due to many human activities mainly industrial, domestic and religious. To analyze that Physio-chemical characteristics of water and WQI is the main aim of the research with remedial measures to mitigate the deterioration and related consequences in future.

Keywords: *water quality, water quality index, Pravara River, Physico-chemical analysis, The Karl Pearson correlation matrix*

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1. Introduction

Water resource is an imperative asset on the earth surface. Surface water in the form of river are very much essential for sustenance and wellbeing of hale and hearty society [1]. Rivers are biggest reserve of potable and other activities for human populace. Many villages which are situated along river experienced rapid economic changes, many of them convert into important towns and cities. Anthropogenic activities related to unplanned urbanization [2], agricultural practices, industrialization and population expansion lead to worsen the water quality [3]. Rivers have capacity to detoxify a certain quantity of pollutants discharged into them [4] but if discharged of pollutants are exceed, water quality will deteriorate. Human interventions proves gripes for river system. [5] Impure surface water might initiate water borne diseases and stomachic infection, so clean water is going to be the greatest constraint for human health [6]. There is great need to access surface water quality, it can determining its use for domestic, drinking, irrigation and industrial purpose [7].

Pravara River of Ahmednagar district in Maharashtra is an appropriate example of an intervented channel which is facing gripes about last 20 years. Pravara River is an important drainage system in Ahmednagar district. Excluded northern west part of district it lies in rain shadow zone so river Pravara prove as a boon for district for drinking, irrigation, industrial and tourism purpose. After construction of Bhandardara dam about 23,750 hectare of land is irrigated by water of dam. Area also has strong industrial base due to large numbers of sugar industries as well as it is on the fore-front in Co-operative movements [8]. Because of dam area has been brought under economic change. Rapid economic development rising repetitive human interventions in and along river that results water quality deteoriotion. [9,10]

Water Quality Index is used to understand a general water quality status of water resource hence it has been used to determined the water quality of surface and ground water quality. Number of studies are carried out related to Water Quality Index (WQI). Horton (1965) [11] used WQI for first time as an indicator of water polllution. Brown et. al (1970) [12] also calculated WQI by basic arithmatic weighting but without multiplicative variables these efforts were supported by National Sanitation Foundation (NSF) [13] in which water quality variables were calculated using Delphi method (Dalkey 1968). Bhargava (1985) also suggested Water Quality Index for

river Ganga. Ichwana et.al. [14], Shah & Joshi [15], Bora & Goswami [1], Verma et.al [16] and Akukumtoshi Lkr. et.al. [3] have calculated WQI for different rivers.

The main objective of present study is to develop simplified WQI in order to examine effects of anthropogenic activities on water quality of Pravara River in Sangamner Tehsil. Further research will helpful to minimize activities which are responsible for water contamination and for creating awareness among local people, farmers, entrepreneur etc.

2. Study Area

For further study Pravara river in Sangamner Tehsil has been selected. Pravara River is an important drainage pattern of Ahmednagar district. The northern part of district is drained by Pravara. The total length of River is about 230 Km the River Pravara rises at an elevation of 1080 meters near Ratanvadi village in Akole Tehsil. Sangamner Tehsil is the one of the developed Tehsil in the district which located about 58 km. downstream from the origin of Pravara River. It is on the confluence (*sangam*) of river Pravara, Mahlungi and river Nataki that's why city got its name Sangamner. Sangamner is located at 19°57'north and 72° 22'east. Sangamner has an average elevation of 549 meters from mean sea level. Sangamner is the second largest city in Ahmednagar district by population. After 1967 establishment of co-operative sugar mill at Sangamner, the agriculture in the area has witnessed rapid changes. Sugarcane has become dominant commercial crop in the area. River Pravara is a major irrigation source for the agriculture.

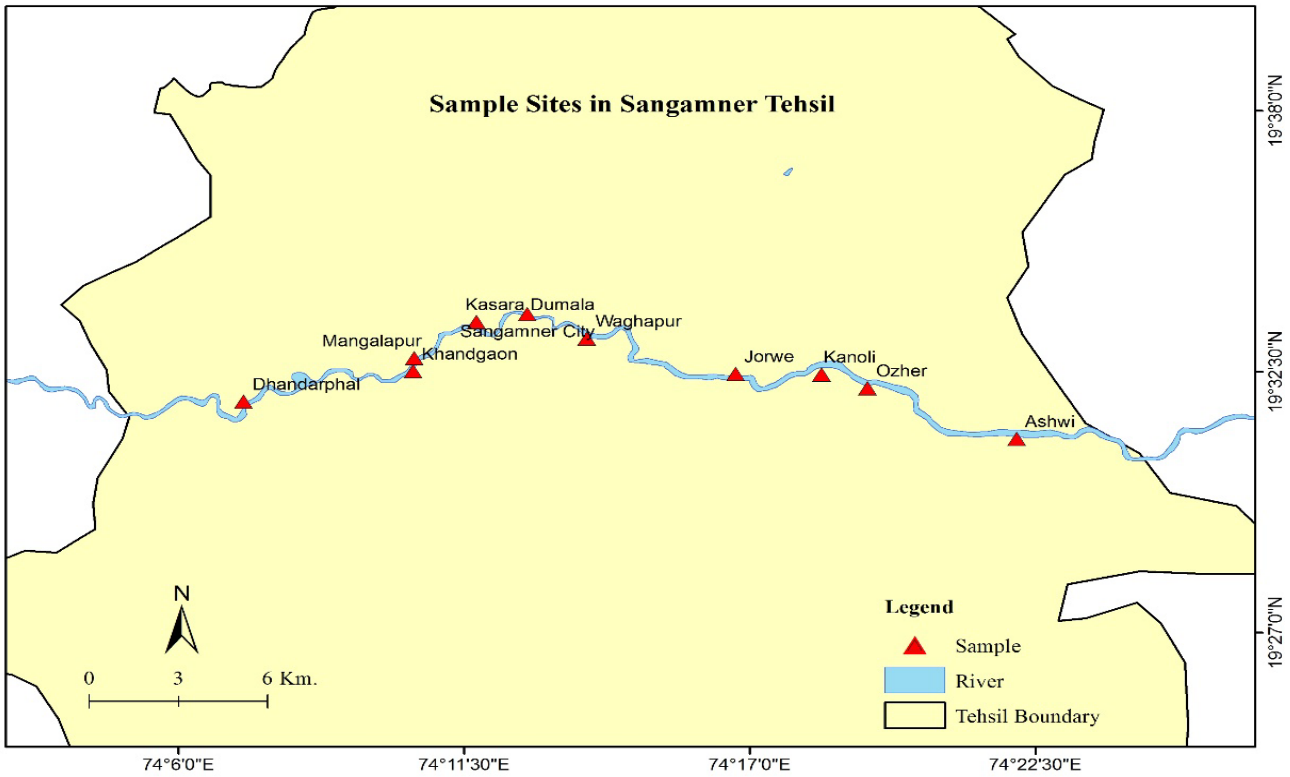

Figure 1. Location Map of Study Area

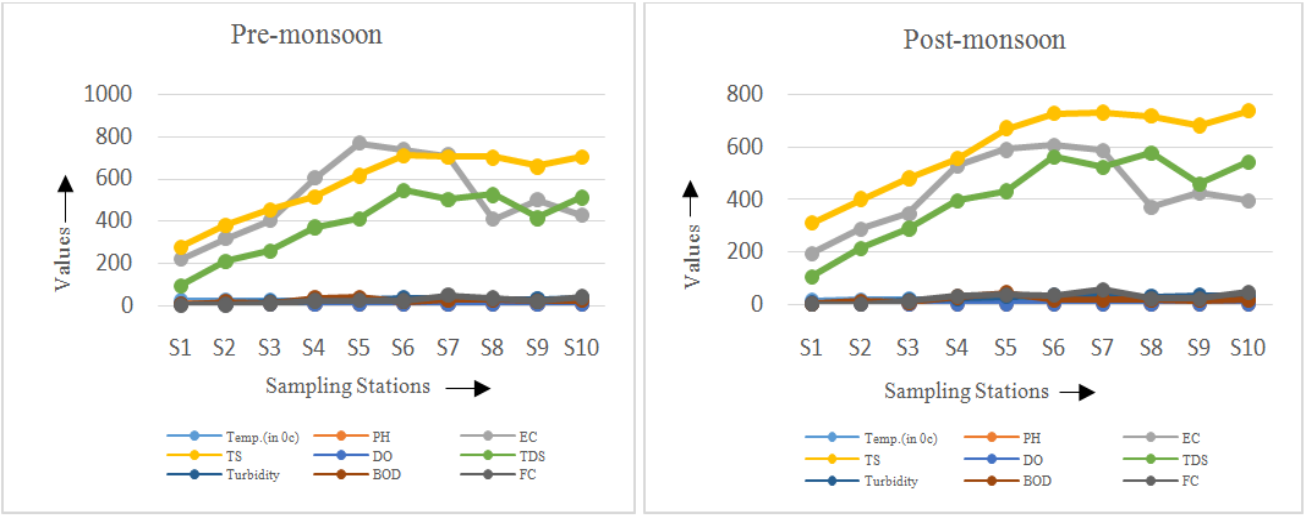

Figure 2. Physico-chemical analysis of Pravara River

3. Materials and Methods

For furture study 10 sampling stations within Sangamner Tehsil have been selected. Selection of sampling stations is based on types of human activities and their intensity. For water quality analysis water samples have been collected from the surface water along river during the pre-monsoon (April 2019) and post-monsoon (November 2019) period (Table 4). Temperature and pH of samples have been measured at in the field during collection. The water samples were analyzed at Water Quality Laboratory level- II, Nashik under Hydrology Project, Water resources department, Government of Maharashtra. The analysis was carried out in the laboratory as per BIS standard methods. Various Physio-chemical parameters like Electrical conductivity (EC), Total solids (TS), Total dissolved solids (TDS), Dissolved oxygen (DO), Biological Oxygen demand (B.O.D.), and turbidity were analyzed for the evaluate the impact of human activities on water quality. The Karl Pearson correlation matrix has been established for examine relationship between the water quality parameters for that an average value of individual parameter was calculated for different sites with the help of Microsoft Excel worksheet. It all information summarize and analyzed with the help of graphs. The data was analyze for water quality status and for that water quality index was determined by the formula developed by NSF (National Sanitation Foundation) and modified by CPCB (Central Pollution Control Board) [17]. The modified weights as per CPCB are given in Table No. 1 and the equations used to determine the sub index values are given Table 2. Determining the Water Quality Index, the water quality is described for easy understanding and interpretation. The classification and the description of the water quality Index [17] are given in Table 3 which depicts the water quality in simple and easy way. It all information summarize and analyzed with the help of graphs.

$$WQI = \sum_{i=1}^{P} Wili$$

Where;
Ii= sub index for water quality parameter
Wi= weight (in terms of importance) associated with water quality parameter
P= number of water quality parameters.

Table 1. Modified weights for computation of WQI based on DO, FC, pH and BOD

Sr. No.	Parameters	Weight
1	Dissolved Oxygen	0.31
2	pH	0.28
3	BOD	0.22
4	Fecal coli	0.19
	∑ Wi	1.00

Table 2. Sub index equation used to calculate NSF WQI for DO, FC, pH and BOD

Water Quality Parameters (Units)	Range Applicable	Equation
Dissolved Oxygen (DO) (% Saturation)	0-40	0.18 + 0.66 X % Saturation DO
	40-100	(-13.55) + 1.17 X % Saturation DO
	100-140	163.34 - 0.62 X % Saturation DO
Fecal Coliform (FC) (counts/100ml)	$1\text{-}10^3$	97.2-26.6*log FC
	$10^3\text{-}10^5$	42.33-7.75*log FC
	$>10^5$	2
pH	02-05	16.1+7.35*(pH)
	05-7.3	(-142.67)+33.5*(pH)
	7.3-10	316.96-29.85*pH
	10-12	96.17-8*pH
	<2, >12	0
BOD (mg/l)	0-10	96.67-7*BOD
	10-30	38.9-1.23*BOD
	>30	2

Table 3. Water Quality classification and best designated use

Sr. No.	WQI	Class by CPCB	Remarks	Colour Code
1	63-100	A	Non Polluted	
2	50-63	B	Non Polluted	
3	38-50	C	Polluted	
4	38 and less	D,E	Heavily Polluted	

4. Results and Discussions

The seasonal analysis report of sample sites has been carried out as per BIS limits [18], which are given in the Table 4 and Table 5.

pH- It is an indicator of concentration of hydrogen ions in water, pH value of normal water which fit for drinking is between 6.5 to 7.5 [18]. Human activies relies on the river responsible for contamination which can change the hydrogen ion concentration (pH) and it become alkaline. The present study shows that water in pre-monsoon and post monsoon season is found to fluctuates between slightly acidic to slightly alkaline. The arithmetic mean value is 7.25 during pre-monsoon and 6.75 during post-monsoon. The pH values has been higher at S_5 due to high concentration domestic activities which contaminates bicarbonates and phosphate in the water.

Table 4. The Parameters Of The Pravara River In Sangamner Tehsil (April, 2019)

Station No.	Location	Temp.(in °C)	PH	EC	TS	DO	TDS	Turbidity	BOD	FC
S1	Dhandharphal Bk.	20.8	7.1	220	278	6	94	5.3	4.8	1.5
S2	Manglapur	22.2	7.3	318	380	5.4	210	8.4	16	2.5
S3	Khandgaon	23.1	7.3	402	452	5.5	259	15.5	10.7	7.9
S4	Kasara Dumala	24	7.5	603	516	5	370	24	34	20
S5	Sangamner	25.8	7.8	768	616	4.6	410	30.8	37	24
S6	Waghapur	25.5	7.2	740	709	4.8	544	35.5	18	22
S7	Jorve	26.3	7.4	710	702	4.9	501	34.9	26	47
S8	Kanoli	24.2	7.2	410	701	5.9	524	31.8	24	32
S9	Ozher	25	7.4	501	658	5.8	414	32	19.5	19
S10	Ashwi	27.4	7.3	428	705	5.6	511	33.6	21.5	38

(Required desirable limits- As per standards prescribed For Drinking Water by Bureau of Indian Standards, 2002 (BIS) limits, 2012).

Table 5. The Parameters Of The Pravara River In Sangamner Tehsil (November, 2018)

Station No.	Location	Temp.(in °C)	PH	EC	TS	DO	TDS	Turbidity	BOD	FC
S1	Dhandharphal Bk.	14.4	6.9	198	312	7	109	5.5	4.1	3
S2	Manglapur	18.1	7.1	291	402	5.9	217	8.6	14.2	4
S3	Khandgaon	20.9	7	350	481	6	291	15.8	9.9	15
S4	Kasara Dumala	23.1	7.2	528	556	5.8	396	26.6	29	35
S5	Sangamner	23.8	7.7	590	671	6.1	433	32	46	38
S6	Waghapur	23.9	6.3	607	729	5.7	563	36	19	36
S7	Jorve	24.9	7	587	730	5.8	524	35.8	20	58
S8	Kanoli	22.8	6.8	372	718	6.6	577	32	18	25
S9	Ozher	24.1	6.6	429	681	6.4	462	34	17.1	24
S10	Ashwi	26.1	7	398	737	6.1	545	34.1	19	47

Turbidity- Turbidity is description of the optical proporties of water which is calculated by amount of light emitted and absorbed by particles in the water [14], it is measure of degree to which the water loses its transparency due to presence of suspended particles. Turbidity of water is found to range between 5.3 to 35.5 in pre-monsoon season with mean 20.4 NTU. It is between 5.5 to 36.0 NTU in post-monsoon with mean value 20.75 NTU. Increase in turbidity at S_6 and S_7 is due to instream sand mining, Brick kilns in pre-monsoon.

BOD- It is measure of dissolved oxygen that is used by aerobic micro-organisms when decomposing organic matters in water. The value of BOD vary between 4.8 to 37 mg/l with arithmetic mean of 19.4 in pre-monsoon whereas 4.1 to 46 mg/l in post-monsoon with mean of 25.05 BOD is found highest at S_5 in both season it may due urban waste contamination, vehicle washing etc. [19]

EC- EC is the measurement of various dissolved solids present in the water. It is found that value of EC ranges between 220-768 µmhos/cm with mean value of 494. In the post-monsoon it ranges from 198-587 µmhos/cm it may be due to dilution of river water during rainy season and concentration of metal ions during summer.

DO- Dissolved Oxygen in the water is important index in determining purity of water. It gives nature of organic matter present in water and essential to the metabolism of all aquatic organism [2]. The DO has been ranged between in 4.6 to 6.0 mg/l in pre-monsoon and 5.7 to 7 mg/l in post-monsoon. In the study area S_5 (pre-monsoon) and S_6 (post-monsoon) shows lower values and deplection of DO indicates that river become polluted due to different types of human interventions.

TDS- Total Dissolved Solids are measured as inorganic salts and tiny quantities of the organic substance existing in the water and it is one among various key aspects as a standard of potable water [2]. TDS is ranged between 94 to 544 mg./l in pre-monsoon and 109 to 577 mg/l in post-monsoon. Heighest values has been found at S_6 in pre-monsoon and at S_8 in post-monsoon it may discharged inorganic substance like phosphate containing detergents through domestic activities. High concentration of TDS decreases the palatability of water and may cause Gastro intentional irritation [18].

TS- Total solids are disssolved solids in the water including suspended and settleable solids. Total solids ranged between 278 to 709 mg/l in pre-monsoon and 312 to 737 mg/l in post-monsoon. TS suddenly increased from S_5, it is due to instream sand mining sites.

Correlation

Simple correlation coefficient (R^2) is used to shows the degree of linear correlation between any two parameters for water quality measurement. In the present analysis following classifications were used

$R^2=1$	=	Perfectly correlated
$\pm 0.9< R^2$	=	Very strongly correlated
$\pm 0.7<R^2$	=	Strongly correlated
$\pm 0.5<R^2$	=	Moderately correlated
$R^{2<}\pm 0.5$	=	Poorly correlated

Table 7 and Table 8 shows pH is moderately correlated with other parameter in pre-monsoon and poorly correlated in post-monsoon. TDS is strongly correlated with TS and Turbidity in post-monsoon due to contamination. TS is strongly correlated with Turbidity in pre-monsoon same phenomena seen about correlation of TDS with TS. Ec is moderately correlated with other parameter in pre-monsoon and strongly correlated in post-monsoon.

Table 6. Statistical Summary Of Physico-Chemical Parameters

	Pre-monsoon				Post-monsoon			
Parameters	Max.	Min.	Mean	Sum	Max.	Min.	Mean	Sum
Temperature	27.4	20.8	29.25	292.5	26.1	14.4	24.8	248.2
pH	7.8	7.1	8.87	88.7	7.2	6.3	8.2	82.5
EC	768	220	608.8	6088	607	198	51.5	5155
TS	709	278	670.4	6704	737	312	70.6	7066
DO	6	4.6	6.4	64.1	7	5.7	7.4	74.1
TDS	544	94	447.5	4475	577	109	48.0	4803
Turbidity	35.5	5.3	29.2	292.6	36	5.5	30.1	301.9
BOD	37	4.8	25.3	253.3	46	4.1	24.6	246.4
FC	47	1.5	21.3	213.9	58	03	28.5	285

(Max.-Maximum, Min.-Minimum).

Table 7. Karl Pearson Correlation Matrix For Water Samples Of Pravara River Water In Sangamner Tehsil (April 2019, Pre-monsoon)

Parameters	pH	EC	TS	DO	TDS	Turbidity	BOD
pH	1.0						
EC	0.479072	1.0					
TS	0.299319	0.658665	1.0				
DO	-0.31913	-0.88005	-0.32013	1.0			
TDS	0.203662	1.341879	1.970782	-0.36867	1.0		
Turbidity	0.376312	0.742039	1.969935	-0.39942	0.969145	1.0	
BOD	0.598082	0.729981	0.543758	-0.65017	0.571147	0.609615	1.0

Table 8. Karl Pearson Correlation Matrix For Water Samples Of Pravara River Water In Sangamner Tehsil (November 2019, Post -monsoon)

Parameters	pH	EC	TS	DO	TDS	Turbidity	BOD
pH	1						
EC	-0.1825	1					
TS	-0.3636	0.734445	1				
DO	-0.0698	-0.68109	-0.35287	1			
TDS	-0.38493	0.697862	0.983514	-0.3617	1		
Turbidity	-0.36329	0.799442	0.982963	-0.36303	0.959312	1	
BOD	0.263999	0.726291	0.483472	-0.38464	0.419247	0.535662	1

Table 9. WQI rating of selected sampling sites of Pravara River

Sr. No.	Stations	WQI (Pre-monsoon)	Colour Code	WQI (Post-monsoon)	Colour Code
1	Dhandharphal Bk.	78.92		76.13	
2	Manglapur	70.74		71.98	
3	Khandgaon	66.6		62.3	
4	Kasara Dumala	55.25		57.96	
5	Sangamner	37.52		43.2	
6	Waghapur	49.78		47.23	
7	Jorve	38.00		50.07	
8	Kanoli	61.82		59.03	
9	Ozher	62.38		60.35	
10	Ashwi	49.71		47.10	

WQI gives a single number that expresses overall quality of water sample at given location for specific time. The WQI is developed in order to simplified complex water quality parameter data into single number which is easy to understand. The WQI is based on important parameters which are indicators of water quality e.g., DO, pH, and BOD. Given the parameters monitored in India under the NWMP and to maintain the uniformity while comparing the WQI across the nation, the NSF WQI has been modified and relative weights been assigned by CPCB [17]. It is clearly seen that (Table 9) in the study area S_1, S_2 and S_3 appears non polluted in both season due to less intervented stream. It is also may be due to the location of stations are in the rural areas with less population but as stream entered in the urban area (S_5 and S_7) the human activities also has been enhanced [10] and

river become polluted (WQI 37.5 to 38) during pre-monsoon. As S_8, S_9 and S_{10} are located in the rural areas but identified for indiscriminate instream sand mining as well as instream brick kilns also affects on water quality. At S_{10} due to existence of aquatic plants quality of water deteriorates hence value of WQI decline (<50). WQI values of these stations indicate that water quality deteriorates as river flow from rural to urban area.

5. Conclusions

Water Quality Index is an easy tool which helpful in the assessment of water quality. The present investigation represents the water quality status of Pravara River in Sangamner Tehsil. The water quality Index values of Pravara River shows that due to domestic activities, instream sand mining and brick making activities and urban waste WQI get declin. Status of WQI shows non-polluted water at upper stream in the study area, but as it enters in city considerable changes in WQI were observed and water become polluted (S_6 & S_{10}) to heavily polluted (S_5 & S_7). In spite of all efforts made by government authorities, local people and entrepreneur not aware about river pollution. From the above analysis, it has been concluded that the acceleration of population increases the human interventions along the river which deteriorate the water quality. Hence the suggested measures would help to minimize human interventions in and along the River Pravara. It's also helpful to minimize negative consequences of such impacts in the future and conserve the water resource.

Conflict of Interest

There is no conflict of interest.

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