Comparative Analysis of Water Quality Index (WQI) of River Erai and Zarpat of Chandrapur City, Maharashtra

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Abstract

A water quality indexis a mathematical tool which provides a single value or number that expresses overall water quality at a certain location and time. The objective of the present study wasto assess the Water Quality Indexof river Erai and Zarapat to carry the comparative analysis in order to obtain information that is understandable and useable by the general public. In the currentstudy water quality parameters viz.Temperature, pH, Conductivity, DO, Alkalinity, Acidity, TDS, Total hardness, Calcium and Magnesium hardness were evaluated during the period of July, 2015 to February, 2016. The current study revealed that potability of Erai River was more near to the standard of BIS and ICMR as compared to Zarpat River. Water quality of both the river is deteriorated due to discharge of domestic sewage from rural and urban population in the vicinity of river bank. Our results proved the same with the help of comparing WQI of these rivers. Water Quality Index and the river Erai was observed to be 91.424 which indicate very poor quality and WQI of river Zarpat was observed to be 133.373which indicate unsuitability for drinking purpose and proper treatment required before use. According to these indices both the rivers are polluted and not suitable for drinking purpose during the study period and ZarpatRiver is more polluted than Erai River.

Keywords: Water quality index, physico-chemical parameter, Chandrapur

I Introduction

Earth is the Blue Planet because 71% of Earth's surface is covered with water and 0.3% of which is usable by humanity. Therefore water is limited and valuable resource which is to be planned, developed, conserved and managed such as and on an integrated and environmentally sound basis. The fresh water supply is not evenly distributed (National Water Policy, 2000). After green revolution the average use of water for irrigation became very high in India (Ingole N., 2019).A study on quality of natural resources is undertaken all over the world because of contamination of these resources by various factors.Major concern in India is deteriorating of water quality of river. This is mainly true for rivers being used as drinking water resources (Shrivastava A., 2014).Rivers play important role in human life cycle and development of Nation and sustenance of life, which are being polluted due to civilization, rapid industrialization and various developmental activities (Mandal*et al.*, 2012; Aalam and Pathak, 2010; Mandal and Das, 2011). Rivers have vital role in the form of providing drinking water, making land fertile and serving as a medium for transportation for human development. Since centuries, the ecosystem services are being provided by rivers and human being have been enjoying without understanding how the river ecosystem functions and maintains its importance (Naiman, 1992).

Chandrapur city is rich in these surface water resources. Erai and Zarpat are the two important rivers of the city. Erai and Zarpat River flows through the western and eastern part of the Chandrapur city respectively. Erai River is a main tributary of Wardha River in Chandrapur district and Zarpat River is a tributary of Erai River. Erai River is considered as life line of Chandrapur. It is main source of irrigation, drinking and industrial purposes etc. But Erai and Zarpat River water is deteriorated due to anthropogenic activities like discharge of domestic sewage from rural and urban population in the near of river bank. Effluent from industries like CSTPS, MEL and WCL open and underground mines are the major contributors of industrial pollution load and also agriculture and sewage discharges rapidly polluting the river. These two rivers now become sewer carrying drains of Chandrapur city (Erai and Zarpat River Action Plan).Erai River which is the vital source of drinking water is also getting deteriorated due to various anthropogenic activities. Zarpat River flows through the city and during Mahakali yatra and Navaratri many people uses this water various purpose and spiritually attached (Raipurkar K.S., 2012).

To conserve these fresh water resources there is need to check the root causes of the degradation. For the same periodic physico-chemical assessment should be done to check the pollution.For a lay man understanding physico-chemical analysis and their interpretation is a tedious job. Hence an understandable figure which shows the pollution level is to be sorted. This problem can be solved by using a single figure i.e. Water Quality Index.Water Quality Index provides a single number that indicate water quality at a certain point and based on several water quality parameters. The objective of water quality index is to provide the water quality data into information that is understandable and usable by the general public. Water quality cannot be understood by single parameter but more number of parametersis also to be considered and covered in water quality index. By inclusion of some of the principal parameters in water quality index gives a simple indicator of water quality (Yogendra and Puttaiah, 2008).In this context there is a need to check all those sources which are responsible for pollution of these rivers. For the same a study was carried out to determine the pollutional strength of these water resources by using Water Quality Index.

II Material and Method

The Study area

Chandrapur is located in the eastern edge of Maharashtra in Vidarbha region. It is located between 19.30’N to 20.45’N Latitude and 78.46’E Longitude. Physiographically, the district is situated within the Wainganga and Wardha basins, respectively flowing on the eastern and western boundaries of the district which are the tributaries of Godavari River (MPCB, 2006). Several types of industries exist in the nearby city and the domestic and industrial waste of this major city is responsible for degrading the quality of river Erai and Zarpat.

Sample Collection and Preservation

The water samples were collected from five different sites during the whole year 2015-2016. Samples were collected in clean polythene bottles without any air bubbles. The bottles were rinsed before sampling and tightly sealed after collection and labelled itself in the field. The in-situ parameter like temperature was measured in the field itself and DO was fixed at the time of sample collection. After sampling the samples were preserved in refrigerator maintained at 4^0C to avoid any further degradation.

Water Analysis

Analysis was carried out for various water quality of physico-chemical parameters such as Temperature, pH, Conductivity, DO, Alkalinity, Acidity, TDS, Total hardness, Calcium and Magnesium hardness etc. were estimated by following methods prescribed by Standard Methods for Examination of Water and Waste Water 18^{th} Edition 1992, American Public Health Association (APHA) andAmerican Water Works Association (AWWA) and National Environmental Engineering Research Institute (NEERI) manual.

Calculating Water Quality Index

In general, a specific and intended use of water is known as WQI. The WQI was considered for human consumption or uses (Bhutani*et al*., 2018). Complex water quality data is simplified into information by calculating water quality index and it is made understandable and useable by the global people. Hence WQI is functional and systematic method providing a simple indicator of water quality which is based on some of very important parameters. Water Quality Index (WQI) was calculated by using the weighted Arithmetic Index method as described by Cude, 2001, Brwon*et al*., 1970 (shown in table no.1). In this framework, different water quality components are multiplied by a weighting factor and are then aggregated using simple arithmetic mean. Quality rating for each parameter is calculated by using the following equation;

$$Qi = [(V_{observed} – V_{ideal})/ (V_{standard} – V_{ideal})] \times 100$$

Where,

Qi = Quality rating of i^{th} parameter for a total of n thwater quality parameters.

$V_{observed}$ = Actual value of the water quality parameter obtained from laboratory analysis

V_{ideal} = ideal value of that quality parameter can be obtained from the standard tables.

V_{ideal} for pH = 7 and for other parameters it is equating to zero and DO V_{ideal} = 14.6 mg / L

$V_{standard}$ = Recommended WHO standard of the water quality parameter.

Calculation of Unit weight (Wi):

Unit weight was calculated by a value inversely proportional to the recommended standard (Si) for the corresponding parameter using the following expression;

$$Wi = K/ Si$$

Where,

Wi = Unit weight for n^{th} parameter,

Si = Standard permissible value for n^{th} parameter

K = proportionality constant, For the sake of simplicity, K is assumed as 1,

The overall WQI was calculated by aggregating the quality rating with unit weight linearly using the following equation

$$WQI = \frac{\Sigma WiQi}{\Sigma Wi}$$

Where, Qi = quality rating,

WI = Unit weight

Table: 1 Water Quality Index, status and possible usage of the water

Water Quality Index Level	Water Quality Status	Possible Usages
0-25	Excellent water quality	Drinking, irrigation and industrial
26-50	Good water quality	Drinking, irrigation and industrial
51-75	Poor water quality	Drinking and industrial
76-100	Very poor water quality	Irrigation
>100	Unsuitable for drinking	Proper treatment required before use

Source: Brown *et al.*, (1972),Chatterji and Raziuddin (2002)

III Results and Discussion

Table: 2 Physico-chemical Characteristics of Erai River water (July to Feb 2015-16)

Parameter	Sampling Location										Average
	Site 1		Site 2		Site 3		Site 4		Site 5		
pH	6.92	7.57	7.11	8.21	7.02	8.02	7.03	8.25	7.11	7.50	7.47
Temperature (^oC)	27	26	26	26	27	26	26	27	25	27	26.3
Conductivity (mmhos cm^{-1})	0.52	0.62	0.51	0.62	0.55	0.59	0.52	0.59	0.54	0.60	0.56

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Dissolved Oxygen (mg L^{-1})	4.5	7.6	6.5	8	4.2	7	4.1	8	4.2	7.8	6.19
Alkalinity (mg L^{-1})	207	220	208	230	210	220	205	210	209	230	214.9
Acidity (mg L^{-1})	230	190	220	220	200	240	230	250	220	200	220
TDS (mg L^{-1})	320	360	540	380	420	360	430	360	440	370	398
Total Hardness (mg L^{-1})	144	190	132	290	138	190	142	230	134	250	184
Calcium Hardness (mg L^{-1})	92	100	108	110	98	110	102	50	100	100	97
Magnesium Hardness (mg L^{-1})	52	90	24	180	48	80	32	180	35	80	80.1

Table: 3 Physico-chemical Characteristics of Zarpat River water (July to Feb 2015-16)

Parameter	Sampling Location										Average
	Site 1		Site 2		Site 3		Site 4		Site 5		
pH	9.2	7.35	7.1	7.26	7.2	7.32	9.2	7.54	8.1	7.30	7.75
Temperature (^oC)	26	28	25	27	26	28	24	27	27	28	26.6
Conductivity (mmhos cm^{-1})	0.71	0.81	0.68	0.74	0.74	0.76	0.74	0.78	0.70	0.75	0.74
Dissolved Oxygen (mg L^{-1})	4.1	2	3.9	3	4.0	3	4.2	2.5	3.8	2	3.25
Alkalinity (mg L^{-1})	200	300	190	340	210	320	220	330	180	310	260
Acidity (mg L^{-1})	104	150	110	170	112	160	108	140	108	130	129.2
TDS (mg L^{-1})	690	510	720	460	730	480	700	470	710	500	597
Total Hardness (mg L^{-1})	213	310	211	340	212	320	211	310	213	300	264
Calcium Hardness (mg L^{-1})	151	150	151	100	154	130	152	140	151	100	137.9
Magnesium Hardness (mg L^{-1})	62	160	60	240	58	180	59	220	62	200	130.1

Table: 4 Water Quality Index of Erai River water

Parameters	Observed values (Vo)	Standard values (Si)	Unit Weight (Wi)	Quality rating (Qi)	Weighted values (WiQi)
pH	7.47	8.5	0.1176	31.33	3.6844
Temperature (^oC)	26.3	------	------	--------	-----------
Conductivity (mmhos cm^{-1})	0.56	300	0.0033	0.1866	0.00061
Dissolved Oxygen (mg L^{-1})	6.19	6	0.1666	97.79	16.2918
Alkalinity (mg L^{-1})	214.9	200	0.005	107.47	0.5373
Acidity (mg L^{-1})	220	------	-------	----------	----------
TDS (mg L^{-1})	398	500	0.002	79.6	0.1592
Total Hardness (mg L^{-1})	184	300	0.0033	61.33	0.2023
Calcium Hardness (mg L^{-1})	97	75	0.0133	129.33	1.7200
Magnesium Hardness (mg L^{-1})	80.1	30	0.0333	267.0	8.8911

			∑Wi=0.3444		∑WiQi= 31.4867
Water Quality Index (WQI) = ∑ WiQi/ ∑Wi = 91.42479					

Table: 5 Water Quality Index of Zarpat River water

Parameters	Observed values (Vo)	Standard values (Si)	Unit Weight (Wi)	Quality rating (Qi)	Weighted values (WiQi)
pH	7.75	8.5	0.1176	50	5.88
Temperature (^{o}C)	26.6	------	------	---------	--------
Conductivity (mmhos cm^{-1})	0.74	300	0.0033	0.2466	0.000813
Dissolved Oxygen (mg L^{-1})	3.25	6	0.1666	131.9767	21.98731
Alkalinity (mg L^{-1})	260	200	0.005	130	0.65
Acidity (mg L^{-1})	129.2	------	-------	-------	-------
TDS (mg L^{-1})	597	500	0.002	119.4	0.2388
Total Hardness (mg L^{-1})	264	300	0.0033	88	0.2904
Calcium Hardness (mg L^{-1})	137.9	75	0.0133	183.866	2.44541
Magnesium Hardness (mg L^{-1})	130.1	30	0.0333	433.666	14.44107
			∑Wi=0.3444		∑WiQi = 45.933803
Water Quality Index (WQI) = ∑ WiQi/ ∑Wi = 133.3734					

Table: 6 Comparative analysis of Water Quality Index of Erai and Zarapt River

Sr. No.	Name of River	Water Quality Index	Water Quality Status
1.	Erai River	91.424	Very poor water quality
2.	Zarpat River	133.373	Unsuitable for drinking

Table: 7 Drinking Water Standards (ICMR, 1975), BIS Standards (IS 10500:2012)

Sr. No.	**Parameters**	**Standards**	**Recommended Agencies**
1.	pH	6.5-8.5	ICMR/BIS
2.	Electrical Conductivity(µmhos/cm2)	300	ICMR
3.	Dissolved Oxygen (mg/l)	5.00	ICMR
4.	Alkalinity(mg/l)	200	BIS
5.	Acidity(mg/l)	-	-
6.	TDS(mg/l)	500	ICMR/BIS
7.	Total Hardness(mg/l)	200	BIS
8.	Calcium Hardness(mg/l)	75	BIS
9.	Magnesium Hardness (mg/l)	30	BIS

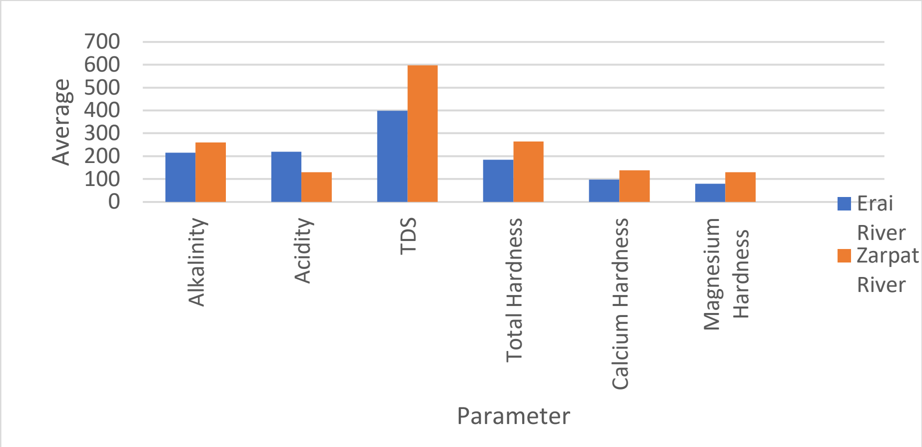

Fig1: Comparative analysis of physico-chemical parameters of Erai and ZarpatRiver

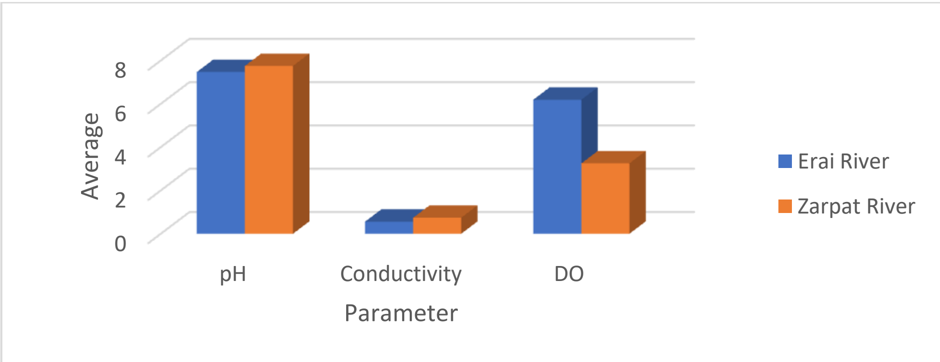

Fig2: Comparative analysis of physico-chemical parameters of Erai and ZarpatRiver

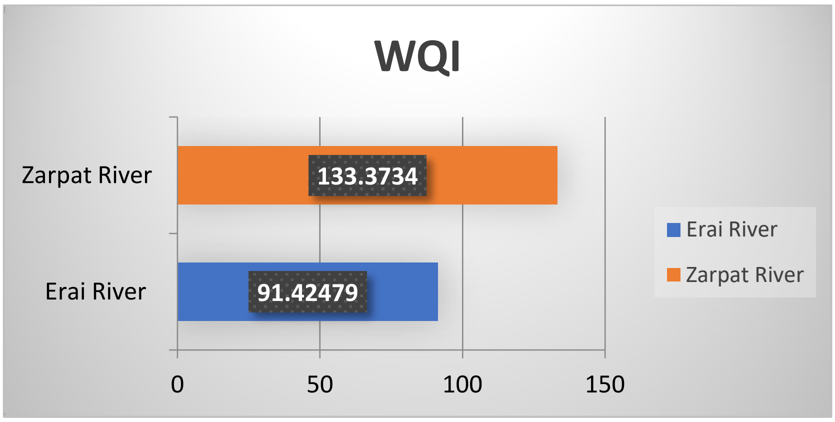

Fig3: Comparative analysis of Water Quality Index of Erai and ZarpatRiver

Erai and Zarpat rivers receives waste water in large quantity and vulnerable to changes in water quality of river during the study period. The physico-chemical parameters of Erai and ZarpatRiver were analysed and results obtained are shown in table no. 2 and 3. The Water Quality Index was calculated using various physico-chemical parameters and are shown in table no. 4 and 6.

pH: In the present study, pH of Erai and Zarpat river water was recorded as 7.47 and 7.75 respectively.The pH of natural water varies from 6.0 to 8.5 and the presence of pollutants can be indicated by changes in pH which is concerned with conductivity of water body (Dwivedi and Santoshi, 2004). The lower value of pH below 4 produces sour taste and a higher value above 8.5 gives an alkaline taste, however pH as such has no adverse effect on health (Choudhary *et al.*, 2014).During the current study Zarpat river water has more pH value as compared to Erai river. Alkaline nature of water is generally more prone to eutrophication of water body.

Temperature: During the study of Erai and Zarpat River, the temperature was noted 26.3^{0}C and 26.6^{0}C respectively. WHO (1993) did not recommended any definite temperature value for drinking water.

Conductivity: Capacity of water to conduct electrical current is electrical conductivity. Presence of dissolved salt and minerals in water is responsible for electrical current (Upadhyayand Chandrakala, 2017). The conductivity of Erai and Zarpat River was found in the study period 0.56 and 0.74 mmhos cm^{-1} respectively.

Dissolved Oxygen: Dissolved oxygen is one the most important indicators of the water quality. In the present study DO of Erai and Zarpat river was recorded as 6.19 and 3.25 mg/L respectively. As per the IS and ICMR standard DO of Erai river was near to standard but DO of Zarpat river showed that it was very less. This may be because of more human activities and excess growth of eutrophication. Organic pollution in the river is increased due to rapid fall in DO (Shah and Joshi, 2017).

Alkalinity: Alkalinity is the capacity of water to neutralize the acids. Carbonates, bicarbonates and hydroxide present in water gives alkalinity to water (UpadhyayandChandrakla, 2017). The ISI has set standard as200 mg/l for alkalinity. During the study period alkalinity of Erai and Zarpat River was found to be 214.9 and 260 mg/l respectively.

Total Dissolved Solids: The aggregate of all the dissolved solids present in the water which is equal to Total Dissolved Solids. The amount of Total Dissolved Solids of Erai and Zarpat River was reported as 398 and 597 mg/L. The ISI standard for TDS is 500mg/L.TDS level of water above 500 mg/L is unsuitable for flora and tastes unpleasant to drink (Choudhary P. *et al*., 2014).

Total Hardness: The soap consuming capacity of water is called a Hardness of water. The presence of bicarbonate, sulphate, chloride and nitrates of calcium and magnesium are indicated of Total hardness of water (Kumar *et al*., 2010). Total hardness of Erai and Zarpat River was reported as 184 and 264 mg/l respectively. ISI standard for hardness is 200mg/L. If hardness exceeds of ISI standard the tolerance limit may lead to serious illness.

Calcium Hardness: The presence of lime stone, gypsum dolomite and gypsi-ferrous material are indicated occurrence of Calcium hardness in water (Upadhyay A and Chandrakala, 2017). During the study period of Erai and Zarpat River the values of calcium carbonate was found to be 97 and 137.1mg/l respectively, which is very high concentration for drinking water.

Magnesium Hardness: Hardness in the water due to the presence of Magnesium ions. The formation of scale and sludge is due to presence of magnesium hardness (Upadhya A and Chandrakala, 2017). During the study period of Erai and Zarpat River, the yearly values of magnesium hardness were found to be 80.1 and 130.1 mg/l respectively, which is very high concentration for drinking water.

Water Quality Index: Water Quality Index allows for a general analysis of water quality on many levels that affect a water body of ecosystems and whether the overall quality of water bodies cause a future threat to various uses of water (Akkaraboyina and Raju, 2012). From Table 4, 5 and 6, the WQI of the Erai River was found to be 91.42479 which indicate the very poor water quality and WQI of the Zarpat River was calculated as 133.3734 which indicate the unsuitability for drinking purpose and indicated that river water was seriously polluted during the study period. Similar results were observed by Bhutani*et al*., 2018 for water quality of river Malin using Water Quality Index at Najibabad, Bijnor (UP) India.

IV Conclusion

Erai and Zarpat River are deteriorated due to rural and urban settlements. Both the rivers are suffocated due to unwanted growth of Echornia plant. From the comparative studies Zarpat River was more deteriorated than Erai River due to dense population around Zarpat River. The responsible factors for eutrophication are mainly the localized human activities in the form of cloth washing, bathing, cattle wading, sewage, industrial effluents and runoff. From the above study it can be concluded that both Erai and Zarpat River are seriously polluted. Eutrophication is the major problem of Zarpat River. Water hydrophytes like Eccornia are now reached to the Erai River which is the main drinking water resource of Chandrapur city. The point sources contributing to river Zarpat have very high organic load as compared to Erai River. The water quality of river Erai is very poor and river Zarpat is unsuitable for drinking purpose. Most of the parameters were found above the standard limits of WHO and BIS for Zarpat River, as compared to Erai River. On the basis of WQI both rivers are more polluted and not suitable for drinking purpose. Hence attempt should be made to adopt efficient and effective management practices for these important resources.

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