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Rewatkar SB
Mohsinbhai Zaweri College, Desaiganj (Wadsa), District Gadchiroli, Maharashtra, India

MIM Siddique
Institute of Science, Nagpur, Maharashtra, India

Gourkar AR
Shivaji Science College, Gadchiroli, District Gadchiroli, Maharashtra, India

Correspondence
Rewatkar SB
Mohsinbhai Zaweri College, Desaiganj (Wadsa), District Gadchiroli, Maharashtra, India

Assessment of water quality index of Kathani River, Gadchiroli, Maharashtra, India

Rewatkar SB, MIM Siddique and Gourkar AR

Abstract
Present study deserves a critical assessment of the water quality of Kathani River water, Gadchiroli, Maharashtra in terms of physico-chemical parameters and determining its water quality index. Water quality index (WQI) aims at giving a single value to the water quality of a source, reducing great amount of parameters into a simple expression. In the present investigation, water samples were collected from four sites of Kathani River, once in every month from June 2013 to May 2015 and were analyzed in the laboratory as per APHA standard methods (2012). WQI was calculated by using WHO standards of drinking Water quality and the Weighted Arithmetic Index method.
The higher values of most of the hydrological parameters during rainy season had resulted the higher WQI during rainy season. The least values of WQI during winter are also supported by the magnitudes of hydrological parameters which are relatively lower during winter. The annual values of WQI of all sampling sites during study period reported the range of WQI from 56.29 to 67.77 thereby showing the overall poor water quality of Kathani River. During both the years of investigation, it was observed that the extent of pollution had increased at every site from 2013-14 to 2014-15.

Keywords: Water quality index, Kathani River, Gadchiroli

1. Introduction
Needless to say that 'Water is Life'. It is the most important natural resource, the basic human need and a top priority national asset. The surface water bodies, which are the most important sources of water are unfortunately under severe environmental stress as a consequence of developmental activities and no wonder that in the nearest future we will strive for even a drop of secured water to drink.
Surface water quality thus is a sensitive issue, which in turn is influenced by several factors, such as atmospheric chemistry, the underlying geology, the vegetation and anthropogenic agents [1]. It is with this concern, present study deserves a critical assessment of the water quality of Kathani River water, Gadchiroli, Maharashtra in terms of physico-chemical parameters and determining its water quality index. Kathani River, a tributary of Wainganga River, flows west about 4 km from Gadchiroli town, embrasses the town and empties into river Wainganga near Bormala village about 4.5 km from Gadchiroli.
Water quality index summarises large amount of water quality data into simple terms in terms of number. Water quality index aims at giving a single value to the water quality of a source, reducing great amount of parameters into a simpler expression and enabling easy interpretation of monitoring data.

2. Materials and Methods
2.1 Study Area
Gadchiroli is the District headquarter and is confined to the eastern Vidarbha of Maharashtra State and is located at 20.1823N latitude and 80.003E longitude. The district stretches over an area of 14412 square km constituting 4.68% of the total geographical area of Maharashtra State. The Kathani River under investigation for physico-chemical parameters and water quality index, originates in the Dhanora-Pendhri hills, flows about 4 km away from Gadchiroli westwards and merges with Wainganga River, near Bormala village.

Kathani River is the main tributary of Wainganga River and often gets flooded during rainy season and overflow of Gosikhurd Dam project on Wainganga. The south-west monsoon arrives over the district by the second week of June. The rainfall during the period from June to September constitutes about 90% of the annual rainfall.

2.2 Methodology

Water samples were collected from four sites of Kathani River, once in every month on the second Sunday from June 2013 to May 2015. The water samples were analyzed for the physico-chemical parameters in the laboratory, as per APHA standard methods (2012) [2]. The values of hydrological parameters obtained were used for the calculation of WQI values for two years of investigation. WQI has been calculated by using the standards of drinking water quality recommended by WHO. The Weighted Arithmetic Index method [3] has been used for the calculation of WQI of the Kathani River water. The quality rating (q_n) was calculated using following expression,

$q_n = 100[Vn - Vid] / Vs - Vid$

where q_n = Quality rating

V_n = Observed value of parameter

V_s = Standard value of parameter

V_{id} = Ideal value of parameter

Unit weight was calculated by a value inversely proportional to the recommended standard value V_s of the corresponding parameter.

$Wn = K/V_s$

Where Wn = Unit weight for the n^{th} parameter

V_s = Standard value for n^{th} parameter

K = Constant of proportionality

Table 1: Water Quality Index and Status of Water Quality (Chatterji and Raziuddin, 2002) [4]

WQI Level	Water Quality Status
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very poor
>100	Unsuitable for drinking

3. Results and Discussion

Average values of physico-chemical parameters to assign WQI value from four sampling sites during study period have been used in the present study and are presented in table 2 and 3. Table 4 and 5 demonstrate the calculation of annual WQI in the years 2013-14 and 2014-15 respectively while Table 6 and 7 depict the seasonal WQI during both the years of investigation.

The evaluation of overall water quality is not an easy task, especially when it is applied to a water source with complex physico-chemical process and the influence of human activities [5]. From the results, it is observed that overall WQI during 2013-14 is 60.94 whereas that during 2014-15 is 63.65. WQI of sampling site K_1 are 61.73 and 63.81 during 2013-14 and 2014-15 respectively. WQI of site K_2 are 61.82 and 64.62 during 2013-14 and 2014-15 respectively. Similarly site K_3 reported WQI values as 63.10 and 67.77 whereas site K_4 as 57.18 and 56.29 respectively during 2013-14 and 2014-15. The annual values of WQI of all sampling sites during study period reported the range of WQI from 56.29 to 67.77 thereby showing the overall poor water quality of Kathani River [4].

The higher values of most of the hydrological parameters during rainy season had resulted the higher WQI during rainy season. Therefore the status of river water during this season is eutrophic and it is unsuitable for human consumption. The least values of WQI during winter are also supported by the magnitudes of hydrological parameters which are relatively lower during winter. High organic load and sewage as well as domestic wastes in a flooded situation might run down streams, showing maximum WQI at site K_1 near confluence especially in rainy season. Each sampling site exhibited hike in WQI from 2013-14 to 2014-15, showing increasing extent of pollution. Estimated higher values of parameters and calculated WQI values suggest the similar findings, thereby proving assessment of water quality by WQI calculation, useful and effective tool. On the basis of above discussion, it may be concluded that, the surface water of Kathani River at almost all the sites is of poor quality and it is severely contaminated especially during rainy season.

Table 2 : Monthly Mean Values of Physico-chemical Parameters of Kathani River water during 2013-2014

Month	Temp	pH	EC	TDS	TA	TH	CaH	MgH	CO	DO	BOD	COD	Fe^{+2}	Cl^{-}	F^{-}	NO_3^{-}	SO_4^{-2}	PO_4^{-3}
Jun-13	28.20	7.90	212	156.3	60.5	121.5	66.0	56.1	3.68	6.0	2.40	9.94	0.58	23.6	0.69	2.91	6.9	0.095
Jul-13	25.25	7.99	192	137.8	69.5	126.1	73.3	52.7	3.89	5.8	2.34	9.32	0.42	19.3	0.64	1.81	6.2	0.066
Aug-13	23.75	8.26	139	103.9	46.5	67.5	40.0	31.5	3.07	6.0	2.36	10.8	0.92	17.6	0.61	2.12	5.8	0.072
Sep-13	24.62	8.18	136	101.3	65.5	60.2	38.0	22.1	3.57	5.2	2.35	9.66	0.58	18.0	0.62	2.34	5.4	0.066
Oct-13	25.32	7.81	127	90.6	68.8	47.3	28.4	18.9	6.09	7.2	2.15	4.82	0.06	12.2	0.33	2.14	3.2	0.049
Nov-13	24.98	7.70	123	81.6	72.8	53.1	32.9	20.2	5.87	7.6	2.07	4.69	0.05	11.0	0.27	1.32	2.8	0.037
Dec-13	21.75	7.75	125	94.2	93.8	65.0	38.4	26.6	5.85	7.8	1.99	4.80	0.08	10.4	0.25	1.14	2.7	0.036
Jan-14	22.50	7.75	146	97.9	87.2	77.2	44.7	32.5	5.86	7.0	2.00	4.90	0.07	9.9	0.31	1.22	2.80	0.032
Feb-14	23.50	7.31	200	124.6	68.1	94.5	63.4	31.1	8.01	6.8	2.60	9.18	0.09	13.9	0.60	1.82	3.1	0.042
Mar-14	26.30	7.49	209	132.8	59.5	101.8	65.2	36.6	7.06	6.6	2.70	9.26	0.14	12.8	0.38	0.82	2.9	0.043
Apr-14	28.30	7.50	239	142.9	61.8	114.3	67.6	46.8	7.07	6.5	2.71	11.59	0.12	13.4	0.37	0.69	3.0	0.048
May-14	29.40	7.74	308	199.4	53.2	129.1	70.7	58.4	8.25	6.9	2.91	12.10	0.12	9.0	0.36	0.30	3.2	0.052
Mean	25.32	7.78	180	121.94	67.267	88.1	52.4	36.1	5.69	6.6	2.38	8.42	0.27	14.3	0.45	1.55	4.0	0.053

Table 3 : Monthly Mean Values of Physico-chemical Parameters of Kathani River water,Gadchiroli during 2014-2015

Month	Temp	pH	EC	TDS	TA	TH	CaH	MgH	CO_2	DO	BOD	COD	Cl^-	SO_4^{-2}	PO_4^{-3}	NO_3^-	Fe^{+2}	F^-
Jun-14	27.35	8.08	184.2	156.3	68.8	120.7	64.8	55.9	3.70	6.2	2.43	9.19	17.7	6.0	0.062	1.62	0.35	0.56
Jul-14	25.22	8.14	181.8	126.3	55.2	134.2	76.6	57.6	3.44	5.5	2.32	9.10	22.7	7.1	0.105	3.10	0.62	0.70
Aug-14	24.65	8.18	115.5	98.7	43.5	54.2	33.6	20.5	3.44	6.1	2.39	11.43	19.8	5.8	0.072	2.17	0.94	0.63
Sep-14	25.22	8.02	126.2	96.5	63.2	53.5	36.8	16.8	3.16	4.9	2.38	9.10	15.0	4.5	0.076	2.46	0.54	0.62
Oct-14	24.35	7.93	115.2	88.1	67.5	47.1	29.5	17.6	5.19	6.8	2.14	4.49	11.7	2.7	0.054	2.16	0.08	0.35
Nov-14	22.35	7.80	114.0	82.1	73.0	53.9	32.9	21.0	5.87	7.2	1.92	4.87	10.5	2.7	0.042	1.29	0.04	0.30
Dec-14	21.48	7.89	123.5	92.7	96.8	65.1	38.8	26.3	5.27	7.4	2.01	5.04	10.0	2.9	0.043	1.02	0.11	0.26
Jan-15	23.18	7.76	145.8	96.6	92.2	74.6	45.2	29.4	5.31	7.5	1.97	5.14	9.2	2.8	0.032	1.08	0.08	0.27
Feb-15	24.38	7.57	202.0	134.1	67.2	97.8	63.7	34.2	7.89	6.6	2.61	9.64	14.2	4.4	0.048	1.24	0.11	0.55
Mar-15	26.70	7.29	215.8	146.8	58.0	108.0	66.4	41.6	7.62	6.6	2.71	9.62	13.0	3.8	0.048	0.84	0.10	0.42
Apr-15	27.35	7.29	242.0	158.2	61.0	122.3	71.9	50.4	7.50	6.7	2.77	11.72	13.4	3.3	0.046	0.64	0.11	0.38
May-15	34.32	7.34	287.0	195.8	48.2	135.1	78.8	56.3	8.08	6.7	3.00	12.50	9.8	3.4	0.050	0.39	0.14	0.34
Mean	25.55	7.77	171.1	122.7	66.2	88.9	53.3	35.6	5.54	6.5	2.39	8.49	13.9	4.1	0.057	1.50	0.27	0.45

Table 4: Water Quality Index (WQI) of Kathani River water Gadchiroli (M.S.) during (2013-14)

Parameters	Actual measured values (Vn)	WHO Standard values (Vs)	Unit Weight (Wn)	Quality rating (qn)	Weighted Values Wn qn
Temp	25.3	40.0	0.0017	63.25	0.108
pH	7.78	8.50	0.008	52.00	0.416
EC	180	300	0.0002	60.00	0.012
TDS	121.9	500	0.0001	24.38	0.002
TA	67.27	200	0.0003	33.64	0.010
TH	88.1	300	0.0002	29.37	0.006
Ca^{2+}	52.4	75	0.0009	69.87	0.063
Mg^{2+}	36.1	30	0.0023	120.33	0.277
DO	6.6	6.0	0.0113	93.02	1.051
BOD	2.38	10.0	0.0068	23.80	0.162
COD	8.42	10.0	0.0068	84.20	0.573
Cl^-	14.3	250	0.0003	5.72	0.002
SO_4^{2-}	4.0	250	0.0003	1.60	0.0005
PO_4^{3-}	0.053	0.1	0.6800	53.00	36.04
NO_3^-	1.55	50	0.0014	3.10	0.004
Fe^{2+}	0.27	0.30	0.2267	90.00	20.403
F^-	0.45	1.50	0.0453	30.00	1.359
Free CO_2	5.7	10.0	0.0068	57.00	0.388
			∑Wn = 0.9990		∑Wn qn=60.876
WQI 60.94					

Table 5: Water Quality Index (WQI) of Kathani River water Gadchiroli (M.S.) during (2014-15)

Parameters	Actual measured values (Vn)	WHO Standard values (Vs)	Unit Weight (Wn)	Quality rating (qn)	Weighted Values Wn qn
Temp	25.6	40.0	0.0017	63.90	0.109
pH	7.75	8.50	0.0080	50.00	0.400
EC	178	300	0.0002	59.33	0.012
TDS	122.7	500	0.0001	24.54	0.002
TA	66.2	200	0.0003	33.10	0.010
TH	88.9	300	0.0002	29.63	0.006
Ca^{2+}	53.3	75	0.0009	71.07	0.064
Mg^{2+}	3.56	30	0.0023	118.67	0.273
DO	6.5	6.0	0.0113	94.19	1.064
BOD	2.40	10.0	0.0068	24.00	0.163
COD	8.49	10.0	0.0068	84.90	0.577
Cl^-	13.9	250	0.0003	5.56	0.002
SO_4^{2-}	4.1	250	0.0003	1.64	0.0005
PO_4^{3-}	0.057	0.1	0.6800	57.00	38.76
NO_3^-	1.50	50	0.0014	3.00	0.004
Fe^{2+}	0.27	0.30	0.2267	90.00	20.403

F^-	0.45	1.50	0.0453	30.00	1.359
Free CO_2	5.54	10.0	0.0068	55.40	0.377
			∑Wn = 0.9990		∑Wn qn=63.586
WQI 63.65					

Table 6: Seasonal water quality index (WQI) of Kathani River water, Gadchiroli at sampling sites during (2013-2014).

Sampling site	Year	Season	WQI
K_1	2013-14	Rainy	113.73
	2013-14	Winter	30.01
	2013-14	Summer	42.18
	2013-14	Annual	61.73
K_2	2013-14	Rainy	107.98
	2013-14	Winter	32.43
	2013-14	Summer	46.40
	2013-14	Annual	61.82
K_3	2013-14	Rainy	104.11
	2013-14	Winter	38.70
	2013-14	Summer	46.54
	2013-14	Annual	63.10
K_4	2013-14	Rainy	89.96
	2013-14	Winter	37.21
	2013-14	Summer	45.03
	2013-14	Annual	57.18

Table 7: Seasonal water quality index (WQI) of Kathani River water Gadchiroli at sampling sites during (2014-2015).

Sampling site	Year	Season	WQI
K_1	2013-14	Rainy	117.28
	2013-14	Winter	30.79
	2013-14	Summer	43.35
	2013-14	Annual	63.81
K_2	2013-14	Rainy	106.32
	2013-14	Winter	39.41
	2013-14	Summer	44.40
	2013-14	Annual	64.62
K_3	2013-14	Rainy	110.88
	2013-14	Winter	46.41
	2013-14	Summer	46.39
	2013-14	Annual	67.77
K_4	2013-14	Rainy	83.97
	2013-14	Winter	35.65
	2013-14	Summer	48.22
	2013-14	Annual	56.29

4. Conclusion

WQI has been computed to assess the suitability of surface water of Kathani River, Gadchiroli by using weighted Arithmetic Index method. In this study, surface water from four sites each during 2013-14 and 2014-15 were collected month wise and analyzed during the period between June 2013 and May 2015. For simplicity, average values of all parameters for 12 months are taken into consideration. It is concluded from the discussion that, water quality status of Kathani River is eutrophic especially during rainy season. Sites K_2 and K_4 had reported overall higher values of parameters but influence of rainy season resulted into higher WQI of site K_1, due to high organic load flowing down streams towards confluence with Wainganga River. During both the years of investigation, it was observed that the extent of pollution had increased at every site from 2013-14 to 2014-15.

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