Hydrochemistry and Water Quality Index of Kolong River: Analysis of drinking suitability of one of the most polluted rivers of India

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Abstract

"Thousands have lived without love, not one without water" (Auden, 2021). The increasing population of the globe and anthropogenic activities are adversely affecting the hydrochemistry of the rivers and made them polluted. Kolong river ofNagaon, Assam, India is categorized under 71 most polluted river of India (2013, Central pollution control board). This study assessed the hydrochemistry of the river. The Samaguri site was selected from upstream of the river; Nagaon town and Jagi bhakatgaon sites were selected from midstream and the Mayong kajalimukh site was selected from the downstream. Temperature, P^H, transperancy, total alkalinity, total hardness, conductivity, BOD, DO, COD, sulfate, magnesium, phosphate and chloride were selected as physico-chemical parameters. The physico-chemical parameters of Nagaon town site were not suitable for healthy survival of the biotic components of the river. The QWI assessment showed that the Nagaon town site is unfit for drinking in all seasons, during the study period. Other sites were also having very poor and poor status. Kolong river was once a vibrant river, but anthropogenic acts are degrading the ecological health of the river in a very terrifying way. Effective control measures should be taken to restore the polluted river to its original state.

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Keywords: Kolong River, Hydrochemistry, Water Quality Index, Pollution

Introduction

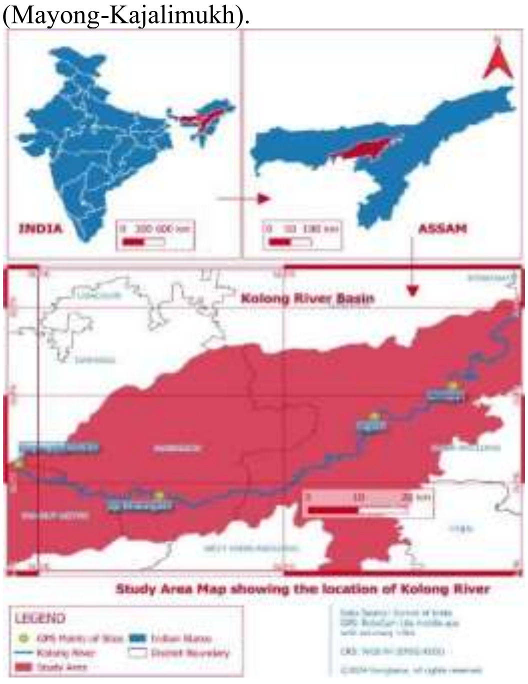
Rivers are considered as 'Mother'. The biotic components of the environment are dependent on riverine ecosystem. The Kolong river is a tributary of the mighty river Brahmaputra, a major south Asian trans boundary river. Kolong river diverts out from it in Hatimura region of Nagaon district, Assam, India and again meets it at Kajalimukh, near Guwahati (the capital of Assam). It is about 250 km in length. In British times, the river was used as a medium of transport. The people of Nagaon love to call themselves as Kolong-poriya (means who lives on the bank of Kolong river). During the rainy season, river creates havoc by flooding. But in winter season, the river dries. From few years, Kolong River is sleeping on its death bed in some areas. For its revival, North East Centre for Environmental Research and Development advocates the re-opening of the river mouth. The sluice gate must be installed at the mouth of the river at Hatimura.

The Kolong river is categorized under 71 most polluted rivers of India by Central pollution control board, 2013. Sewage and organic discharges thrown by anthropogenic activities induce pollution. Negligible self-purification capacity is an another cause of gradual degradation. The river receives huge amounts of point and non-point pollutants. Urbanization and industrialization are the major cause of surface water pollution (M Alam and J.K. Pathak, 2010). The hydrochemistry of the river requires regular monitoring for reliable estimation of the water quality (Singh KP et al., 2004). Water monitoring helps in evaluation of water pollution (Strobl and Robillard , 2008). Water Quality Index (WQI) was first describe by Horton (Horton , 1965). WQI is applied for both surface and ground water quality assessment. It helps in the assessment of status of a particular water body. In Indian rivers, numerous studies have been carried out on water quality assessment (Joshi, 2009; Samantray , 2009; Avnish and Suman , 2010; Jindal et al.,2014). Hazrika and Kalita, 2019 had assessed the water chemistry of Kolong river. They had found that the physico-chemical parameters were indicating pollution in Kolong river.

The historic Kolong river is kindred with the emotions of the people of Nagaon (Medhi and Hazarika, 2022) . The present study investigates the very recent hydrochemistry ofKolong river, one of the most polluted rivers of India to revitalize the river to its original state. Otherwise Kolong river will be lost with time, since it is already in death bed (Medhi et al., 2022).

Materials and Methods

Study Area: The Kolong river is located in the Nagaon district of Assam, India. It has a total length of about 230 k.m. and it is a tributary of mighty river Brahmaputra and flows through the districts of Nagaon, Morigaon and Kamrup. For this study, we had selected 4 different sites namely- Site I (Samoguri), Site 2 (Nagaon Town) , Site 3 (Jagi-bhakatgaion) and Site 4 (Mayong-Kajalimukh).



Figl. Maps showing the location of the study area (Medhi et al., 2023)

Sample collection: Water samples from each site (Samoguri, Nagaon town, Jagi-Bhakatgaon, Kajalimukh) in 4 study seasons -Pre-monsoon (PM), Monsoon (M), Retreating monsoon(RM) and Winter(W) were collected. The study was conducted from June 2022 to June 2023.

Sample analysis: Water samples in triplicate were collected by Grab sampling method and stored in pre rinsed 2L polyethylene terephthalate properly labeled bottles at 4^0C in dark. A total of 13 water quality parameters such as- temperature, pH, electrical conductivity (EC), Transparency, Dissolved oxygen (DO), Total hardness (TH), total alkalinity(TA),chloride (Cl), sulphate (S02), magnesium(Mg), phosphate (P04), biochemical oxygen demand (BOD) and chemical Oxygen demand (COD), were measured by following the guidelines of APHA, 2020 (51). Temperature, pH, conductivity and transparency were measured in situ using the Systronic water analyzer kit.

Water Quality Index (WQI): Total I I parameters namely- P^H, electrical conductivity (EC), total dissolved solid (TDS), total suspended solid (TSS), total hardness (TH), total alkalinity (TA), chloride, magnesium, sulfate, Dissolved oxygen (DO) and biological oxygen demand (BOD) were selected for building the WQI since these parameters play key role in water quality. Temperature plays a major role in biological activity and growth of the aquatic organisms. Higher the temperature, the higher are its biological activities and growth. Likewise, lower pH makes the water more corrosive. The amount of DO values also depends on temperature, microbial population and time of sampling.
The EC is used to represent the overall concentration of soluble salts in water (Gupta et al., 2008). A high concentration of conductivity implies a high level ofpollution from agricultural runoff, sewage disposal and waste disposal. The BOD and COD analysis helps in identification of contaminants with organic wastes.

WQI-
Determination of Water Quality Index (WQI):
WQI was calculated by the procedure mentioned by Maheswaran & Elangovan, (2014). Step
l: The unit weight (Wn) was calculated by following formula:
Sn
Where, K- Constant of proportionality
Sn- Standard value of the parameter
Step 2: The quality rating (Qu) was calculated as given below: Vn— Vid
$\_ \frac{Vn-Vid}{Sn-Vid}$
Where, Vn- Observed value ofthe n^{th} parameter; Vid- Ideal value of the n^{th} parameter (7 for pH, 14.6 for DO and 0 for all other parameters).
Step 3: The WQI was calculated by the following formula:
EQnwn
] * 100
EWn
Where, Qn- quality rating of the n^{th} parameter
Wn- Quality unit weight of the n^{th} parameter
The computed WQI values are classified according to the proposed categorization of Yadav et al.,2010. According to the scale, if the range ofWQI is 0—25, then the water quality is excellent, if it is 26—50, then the water quality is good, if it is 51—75, then the water quality is poor, if the range ofWQI is 76—100 then the water quality is very poor and if WQI is above 100 (>100) then the water is unsuitable for consumption (Maheswaran, and Elangovan, 2014).

Results and Discussion

Table 1. Physico-chemical parameters of site I in four different seasons

Water Parameters	Pre- Monsoon	Monsoon	Retreating Monsoon	Winter
Water temperature('C)	27.38 ± 0.02	29.41±0.01	23.79±0.01	20.93±0.01
PH	7.02±0.005	7±0.04	7.01±0.01	7.37±0.02
Transparency(cm)	47.19±0.01	44.29±0.	50.76±0.03	50.22±0.01
Total alkalinity (mg/L)	50.01±0.04	58.05±0.01	71.08±0.01	72.01±0.02
Total hardness (mg/l)	86.30±0.01	100.05±0.01	106.20±0.03	99.50±0.04
Conductivity (pmhos/cm)	158.02±0.01	153.03 ±0.04	150.45±0.02	150.27±0.02
Chloride (mg/l)	9.04±0.04	20.21±0.03	30.35±0.02	19.95±0.04

Magnesium (mg/l)	46.05±0.02	49.51±0.04	30.42±0.01	29.54±0.06
Phosphate (mg/l)	0.64±0.01	0.66±0.02	0.62±0.01	0.59±0.03
Sulfate (mg/l)	6.6±0.01	7.35±0.4	6.01±0.01	4.59±0.04
Dissolved Oxygen (mg/l)	5.06±0.03	5.15±0.04	5.95±0.03	6.03±.01
BOD (mg/l)	5.42±0.04	5.02±0.01	4.26±0.01	4.08±0.01
COD (mg/l)	12.05±0.01	14.03±0.03	11.05±0.04	10.22±0.01
TDS	251±0.03	233±0.05	192±0.01	180±0.01
TSS	68±0.02	121±0.05	65±0.06	58±0.01

Table 2. Ph sico-chemical arameters of site 2 in four different seasons

Water Parameters	Pre- Monsoon	Monsoon	Retreating Monsoon	Winter
Water temperature('C)	26.22±0.04	30.45±0.02	20.59±0.04	18.15±0.03
PH	6.03±0.03	6.01±0.01	6.33±0.01	6.45±0.01
Transparency(cm)	49.55±0.01	35.02±0.01	68.90±0.02	72.24±0.03
Total alkalinity (mg/l)	60.03±0.03	65.20±0.03	74.24±0.01	81.43±0.01
Total hardness (mg/l)	50.69±0.01	47.02±0.01	74.59±0.03	76.41±0.01
Conductivity (pmhos/cm)	222.73±0.02	160.07±0.03	189.15±0.05	177.40±0.03
Chloride (mg/l)	10.02±0.02	23.97±0.01	26.23±0.02	24.44±0.02
Magnesium (mg/l)	24.96±0.02	49.23±0.02	41.41±0.02	32.63±0.02
Phosphate (mg/l)	0.66±0.02	1.50±0.03	1.4±0.02	0.96±0.02
Sulphate (mg/l)	8.75±0.02	9.02±0.02	6.25±0.03	5.42±0.04
Dissolved Oxygen (mg/l)	4.04±0.03	3.86±0.03	3.45±0.03	4.96±0.02
BOD (mg/L)	6.28±0.04	5.57±0.03	6.45±0.02	7.65±0.01
COD (mg/l)	32.64±0.03	29.25±0.01	25.22±0.02	23.15±0.02
TDS	381.36±0.04	302.12±0.04	68.49±0.04	73.45±0.02
TSS	83.47±0.04	145.31±0.04	297.62±0.02	295.62±0.3

Table 3. Physico-chemical parameters of site 3 in four different seasons

Water Parameters	Pre- Monsoon	Monsoon	Retreating Monsoon	Winter

Water temperature('C)	26.20±0.02	29.82±0.01	22.27±0.03	17.97±0.02
PH	7.04±0.03	7.01±0.04	7.43±0.02	7.77±0.01
Transparency(cm)	43.20±0.02	35.22±0.02	53.07±0.02	56.10±0.02
Total alkalinity (mg/L)	52.15±0.03	51.95±0.01	88.26±.01	102.135±0.03
Total hardness (mg/l)	86.66±.01	74.96±0.02	97.15±0.01	100.21±0.01
Conductivity (pmhos/cm)	120.92±0.01	100.25±0.01	101.02±0.2	105.30±0.01
Chloride (mg/l)	8.60±0.01	14.50±0.01	16.14±0.02	25.94±0.04
Magnesium (mg/l)	58.09±0.01	65.13±0.01	37.44±0.02	28.83±0.01
Phosphate (mg/l)	0.68±0.01	0.63±0.02	1.62±0.01	1.07±0.02
Sulphate (mg/l)	19.5±0.01	9.99±0.01	7.79±0.03	2.95±0.01
Dissolved Oxygen (mg/l)	6.30±0.04	6.50±0.03	5.01±0.02	5.15±0.01
BOD (mg/l)	5.90±0.02	5.27±0.02	5.22±0.01	5.13±0.03
COD (mg/l)	8.16±0.03	12.20±0.02	11.37±0.02	10.34±0.01
TDS	345±0.03	247±0.04	176±0.03	159±0.04
TSS	74±0.04	151±0.01	55±0.02	62±0.04

Table 4. Physico-chemical parameters of site 4 in four different seasons

Water Parameters	Pre- Monsoon	Monsoon	Retreating Monsoon	Winter
Water temperatureC C)	27.02±0.03	29.22±0.02	28.66±0.02	16.99±0.01
PH	7.02±0.01	6.01±0.03	7.18±0.03	7.25±0.02
Transparency(cm)	51.03±0.01	42.01±0.03	70.02±0.01	71.41±0.03
Total alkalinity (mg/l)	50.03±0.01	53.12±0.02	72.21±0.03	81.18±0.02
Total hardness (mg/l)	50.65±0.01	45.04±0.03	64.04±0.4	68.12±0.03
Conductivity (pmhos/cm)	219.12±0.06	167.77±0.01	189.25±0.04	195.15±0.02
Chloride (mg/l)	8.81±0.04	25.20±0.04	26.33±0.01	28.25±0.01
Magnesium (mg/l)	30.02±0.02	39.14±0.02	36.23±0.01	33.374±0.02

Phosphate (mg/l)	0.68±0.02	1.02±0.01	1.24±0.01	0.92±0.01
Sulphate (mg/l)	9.10±0.02	7.51±0.03	6.72±0.02	4.30±0.02
Dissolved Oxygen (mg/l)	6.6±0.01	7.02±0.02	6.24±0.02	5.59±0.03
BOD (mg/l)	6.70±0.04	6.12±.02	6.99±0.01	7.11±0.04
COD (mg/l)	4.08±0.02	6.32±0.01	8.01±0.06	8.76±0.02
TDS	231±0.03	134±0.03	138±0.01	123±0.02
TSS	68±0.02	87±0.03	58±0.03	

Table 5. Correlation between physico-chemical parameters of the river

Correlat ion	Temper ature	PH	Transpa rency	TA	TH	Conduc tivity	Cl		P	S	Do	BOD	COD	TDs	TSS
Temper ature															
PH	0.35														
Transpa rency	0.13	o. 73													
TA	-0.93	o. 06	-0.24												
	0.06	o. 70	-0.97	o. oo											
Conduct ivity	0.31	o. 76	0.91	o. 52	o. 79										
Chlorid e	0.45	o. 67	0.86	o. 64	o. 71	0.99									
Magnesi um	-0.50	o. 63	-0.83	o. 70	o. 66	-0.97	1. oo								
Phospha te	-0.72	o. 56	0.51	o. 72	o. 70	0.19	o. 04	o. 03							
Sulfate	-0.66	o. 37	-0.42	o. 89	o. 17	-0.74	o. 82	o. 86	o. 50						
	0.71	o. 76	-o. 11	o. 39	o. 13	-0.21	o. 11	o. 08	o. 41	o. 06					
BOD	—O. 14	o. 66	0.93	o. 11	o. 99	0.70	o. 61	o. 55	o. 77	o. 04	o. 11				
COD	-0.70	o. 83	0.24	o. 38	o. 26	0.31	o. 20	0. 16	o. 49	o. 08	0. 99	0.2 4			

		29		58	76	-0.79	o. 82	o. 81	o. 10	o. 52	o. 40	0.7 1	0.2 9		
		o. 87	0.33	o. 44	o. 38	0.35	o. 22	o. 18	o. 61	o. 01	96	0.3 7	0.9 9	o. 21	

Water Quality Index (WQI)

Table 6. Water quality parameters with their standard value and unit weights

	Parameters	BIS	Unit weight (Wn)
1	pH	8.5	0.203784
2	EC	300	0.005774
3	TDS	500	0.003464
4	TSS	500	0.003464
5		300	0.005774
6		200	0.008661
7	Chloride	250	0.006929
8	Magnesium	30	0.057739
9		5	0.346432
10	BOD	5	0.346432
11	Sulphate	150	0.011548

Table 7. Categories of Water Quality Index

	Water Quality Index	Description
1	0-25	Excellent
2	26-50	Good
3	51-75	Poor
4	76-100	Very poor
	>100	Unfit for drinking

Table8. WQI and water quality status of four sites of Kolong river in four different seasons

	Site I				Site 2				Site 3				Site 4			
1	.1	21	67, 83	70. 96	100. 8	101. 40	103. 20	102. 76	83. 64	37	85	74	38	66	89. 08	92. 69
Water quality status	Very poor	Very poor	Poor	Poor	Unfit for drinking	Unfit for drinking	Unfit for drinking	Unfit for drinking	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor

It is mandatory to assess the hydrochemical dynamics of aquatic ecosystems to identify the recent ecological health status. Pollution is a burning problem of the society. P^H values of the water samples of site l, 3 and 4 were within desirable limit (Table 1, Table 3 and Table 4) but site 2 was showing low P^H(<6.5) in all seasons which is not suitable for icthyofaunal resources (Table 2). Transparency of site I and 3 was within desirable limit (<60 cm) indicating clear water in all the seasons but in winter season, site 2 was showing unclear water (Table 2). Site 4 was showing unclear water in retreating monsoon and winter (Table 4).

In table l, Alkalinity of water in site 1 in all the seasons were not in desirable limit (>75 mg/l). Samples of Site 2 were also not in desirable limit except in winter season (Table 2). Alkalinity values of site 3 were not in desirable limit except in retreating monsoon and winter (Table 3). Likewise, site 4 was showing alkalinity values in desirable limit in winter season but not in other seasons (Table 4). Total hardness values of site I were within desirable limit (75-200 mg/l) but in site 2, values were not desirable in pre-monsoon, monsoon and retreating monsoon (Table 2). Values of Site 3 were within desirable limit except in monsoon season (Table 3). But site 4 was not in desired range.

Conductivity of Kolong river water in all the sites was within optimum level which could support diverse aquatic lives (150-500 gs/cm). But that range in site3 was not in optimum range. Magnesium levels were within desirable limit (10-100 mg/l).

Sulfate levels were within desirable limit (<200 mg). Phosphate levels of site 2 (in monsoon and retreating monsoon), site 3(retreating monsoon and winter) and site 4 (Monsoon, retreating monsoon and winter) were not in desirable range (<1 mg/l). Chloride levels were within desirable limit in all the sites (<250 mg/l)

Dissolve oxygen level in site 2 (pre monsoon, retreating monsoon, winter) was not in desirable limit (<5 mg/l), indicating water pollution. BOD levels of all the sites were within 2-8 mg/l, which indicates moderate water pollution. But values of site 2 in retreating monsoon and winter (Table 2) and site 4 in all the seasons (Table 4) were not favorable for aquatic fauna (>6 mg/l). COD values of site 2 indicates water pollution (Table 2) since the values of that site were >20 mg/l.

From table 5, it can be concluded that correlation between transparency and TH was significantly negative. Correlation between conductivity and chloride was significantly positive. Likewise, a significant negative correlation had been found between conductivity and magnesium. Conductivity and chloride had shown significantly positive correlation. Hardness of the kolong river water showed significantly negative correlation with BOD. DO showed significantly negative correlation with COD and TSS. But COD and TSS showed significantly positive correlation.

The values of Water Quality Index (Table 8) showed that the site 2 (Nagaon town site) was unfit for drinking in all the seasons during the study period. During chath puja season, it is observed that a particular community of Nagaon town area drink Kolong river's water at the urban site as a ritual related to chath puja. Unfortunately, it is a very unhealthy practice if we consider this recent study. Other sites were showing poor and very poor water quality status (Table 8).

Hazarika and Kalita, 2019 found that the Nagaon town site was more polluted than other sites of the river. The present study also agreed with their study. But if we compare the physico-chemical parameters of the present study with their study, then it can be concluded that the river is degrading more and more from 2019 to 2023.

Conclusion

In this study, the existence of pollution has been confirmed by observing the physico-chemical parameters of Kolong river. Use of detergents while washing the cloths, hospital wastes, sewage, garbage dumping, agricultural runoff, substances used in religious activities, over fishing, synthetic colors used in furniture making etc. were observed during the study period. Growing human needs are disturbing the natural untouched ecosystem of the river. Once the river was in a very healthy state. Therefore, to restore the dynamic nature of the river, the anthropogenic interferences must be minimized. Public awareness should be generated for this to save one of the major rivers of North-East India.

Acknowledgement: Authors would like to thank the Central laboratory of "Pollution Control Board Assam".
Conflict Of Interest: The authors declare there is no conflict of interest.
Ethical Approval: Ethical approval for the present work is not required.
Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not for profit sector.
Data Availability Statement: The primaw data is available with the corresponding author and can be made available on reasonable request.

Author Contributions: This work was carried out in collaboration among all the authors. Author Kangkana Medhi was involved in designing the study. Author Arup Kumar Hazarika and Sasank Sekhar Ghosh did the experiments. Suraj Chetri and Bhanita Bora analyzed the data, finalized the results and prepared the draft of the manuscript. All authors read and approved the final manuscript.

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