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Assessment of Water Quality Index of the Kolong River of Nagaon District of Assam, India

Bhaswati Dutta[1], Bibhash Sarma[2]
[1]M.E. Student, Civil Engineering Department, Assam Engineering College, Guwahati-781013, Assam, India
[2]Associate Professor, Civil Engineering Department, Assam Engineering College, Guwahati-781013, Assam, India
Corresponding auther: Bhaswati Dutta

ABSTRACT - The objective of the study is to analyze the Water Quality Index (WQI) and analysis of variations of Water Quality Index parameters along the Kolong River,Nagaon, Assam, after the breaching of Hatimura dyke in 2017. WQI provides a single number that expresses overall water quality at a certain location and time based on several water quality parameters.The objective of a WQI is to turn complex water quality data into information that is understandable and useable by the public.Kolong River flows through the heart of the Nagaon urban area dividing the town into Nagaon and Haiborgaon in Assam.The blockage of the river flow was adopted as a flood control measure to protect its riparian areas, especially the Nagaon town, from flood hazard. So, Hatimura dyke was constructed across the river's take-off point near Hatimura in 1964. The river, once a blooming distributary of the mighty Brahmaputra, had high navigability and rich riparian biodiversity with agriculturally productive watershed. However, the present status of Kolong River is highly wretched as a consequence of the post-dam effects thus leaving it as stagnant pools of polluted waterwith negligible socio-economic and ecological value. But in August 2017, due to heavy flood the Hatimura dyke was breached and the breach allowed floodwaters to flow in through Kolongriver. In this study, river samples were collected and analyzed from twelve different study sites during March 2018 to April 2018, i.e. in pre monsoon period covering the entire river to study the after effect of floodwater in the Kolong river. The physico-chemical parameter of water such as Iron, Nitrate, Manganese, Fluoride,pH, Turbidity, Alkalinity, Total Hardness, Chloride, Dissolve oxygen, Total Dissolve Solids, Ammonia and Bacteria were analyzed. The calculation of Water Quality Index was done by using Weighted Arithmetic Index Method. The WQI value of these samples ranges from 58.87-216.53, which shows that water in all the sites are unsuitable for drinking. Thus, river needs proper treatment to conserve this water body from future contamination and pollutions.
Key Words: Assam, Kolongriver, Nagaon, Water Quality Index, Physico- Chemical Parameters, Weighted Arithmetic Index Method.

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I. INTRODUCTION

Rivers are the most important resources in the world in general and in India in particular, great civilization developed along the bank of rivers and even today most of development has taken place in the cities located near the rivers.The rivers provide water for industries, agriculture, aquaculture, commercial and domestic purposes.Unfortunately, during the last few decades these natural resources are continuously being tainted all around the world for the sake of development and flood hazard mitigation. However, north-east India is blessed enough to have bounty of accessible freshwater sources in the form of various rivers, streams, lakes, swamps, marshes, etc., with the mighty Brahmaputra river along with its numerous tributaries.

Until recently, rivers of north-eastern region of India were in pristine free-flowing and unpolluted condition. However, during the last few decades in the pursuit to cope up with rest of the world in terms of development, our freshwater resources are continuously being tainted and deteriorated to an inconceivable stage.Out of various negative anthropogenic acts being perpetuated over our rivers those requiring special mention are water pollution from various point and non-point sources, dams both for hydroelectricity generation as well as flood control, over abstraction and human encroachment.It affects their physico-chemical characteristics and microbiological quality (Koshy and Nayar, 1999). Increasing numbers and amounts of industrial, agriculture and commercial chemicals discharge into the aquatic environment has led to the various deleterious effects on aquatic organisms. In some aquatic organisms, including fish, accumulate pollutants directly from contaminated water and indirectly via the food chain. Prevention of river pollution requires effective monitoring of physico-chemical and microbiological parameters.

The Kolong River is a tributary which diverts out from the Brahamputra river in Hatimura region of Jakhalabandha (Nagaon district, Assam, India), and meets the same at Kajalichaki (near Chandrapur, Guwahati, Assam) in a joint channel with the Kopili Rivera major south bank tributary of Brahmaputra that flows into Kolong near Jagibhakatgaon of Morigaon district. The tributary is about 250 kilometres long, about 77 km upstream of Nagaon, and flows through the heart of the Nagaon urban area dividing the town into Nagaon and Haiborgaon and other districts of Morigaon and Kamrup.On the way several streams Diju, Misa, Kopili, Digaru, Haria and others meet the Kolong River. Kolong River of Nagaon district in Assam is an appropriate example of human intervention which is facing the gripe for the past fifty years. The Kolong River is presently gasping on its death-bed because of the ruthless act perpetrated on it in the name of engineering solution to the increasing flood hazard attributed to it in the aftermath of the great Assam earthquake of 1950.

During the years preceding 1964, primarily as a consequence of the great Assam earthquake of 1950, this region experienced repetition of large floods mainly due to raised bed level of the Brahmaputra as well as Kolongthrough massive aggradation leading thereby to its higher flood levels inundating adjoining low-lying areas like Nagaon. Mainly as a response to the increasing food hazard faced by the district administrative headquarter, i.e., the Nagaon town, an ad hoc flood control measure was undertaken by constructing an earthen embankment, known as Hatimura dyke, across the river's take-off point near Hatimura in the year 1964. This drastic human intervention has end up in converting the once free flowing river into a string of alternating dry stretches and stagnant pools during the decades. The river in the present scenario with negligible self-purification capacity is facing severe anthropogenic pressure and acts as the receiver of huge amount of point and non-point pollutants. Consequently, the Kolong River is listed among the 275 most polluted rivers of India by the Central Pollution Control Board (CPCB 2015). But in August, 2017,due to heavy flood the Hatimura dyke was breached and the breach allowed floodwaters to flow in through Kolongriver. Thus the Kolong river was washed off with the floodwater although the dyke is now again under construction.

Thus, the overall aim of the present investigation is to finalize the prevailing water quality inventory of the Kolong River after breaching of Hatimura dyke based on WQI and then to propose measures to revitalize the Kolong River by restoring it to its natural state, while allowing the river system to continue to support flood management, landscape development and recreational activities.

A water quality index (WQI) helps in understanding the general water quality status of a water source and hence it has been applied for both surface and ground water quality assessment all around the world since the last few decades. The main purpose of developing a WQI is to transform a complex set of water quality data into lucid and exploitable information by which a layman can know the status of the water source (Akoteyon et al. 2011; Balan et al. 2012). WQI aims at giving a single value to the water quality of a source by translating the list of parameters and their concentrations present in a sample into a single value, which in turn provides an extensive interpretation of the quality of water and its suitability for various purposes like drinking, irrigation, fishing etc. (Abbasi 2002). Although, water pollution is a chief matter of apprehension in regard to Kolong River, the water quality issue of the river has not yet got its due importance.

Ironically, literature survey revealed the fact that some work on WQI has been carried out for Kolong River before Hatimura dyke was damaged. Hence, in continuation of (Bora and Goswami 2014, 2015) and (Sarma, Das Saikia and Bormudoi 2017) the present investigation is carried out as after effect of the damage of Hatimura dyke, to establish the general pollution trend of the river and to determine the aptness of the water for various purposes based on a set of observed water quality parameters. In this context, an attempt has been made to assess and evaluate various water samples collected along Kolong River of different study sites of up and downstream course, using the 'weighted arithmetic index method' given by Brown et al. (1972).

II. MATERIALS AND METHODS

For the assessment of river water quality the present work was divided into three parts, as initial field survey was carried out for identifying water collection sampling station. Secondly, as field work twelve sampling sites had been selected from up and down streams of the river, covering the whole tributary. Lastly collected samples were analyzed in Nagaon Public Health Engineering Department.

Sampling Sites

Water samples were collected from twelve sampling sites viz.(1) Hatimura, Brahmaputra, (2) Hatimura, Kolong, (3) Hatbor, Kaliabor, (4) Borbhogia, (5) Missamukh, (6)Samoguri, (7) Puranigudam, (8) Near Girls college, Nagaon town,

(9) ADP College, Bhuyanpatty, (10) Hariamukh, (11) Jagibhakatgaon and (12) Kajalimukhduring pre-monsoon season over a period of two months, i.e., from March 2018 to April 2018. The distance between the sampling points were irregular and were selected based on accessibility and development of small towns.The details of sampling sites are shown in Figure 1.

TABLE 1: Sample numbers and sampling locations

Sample No.	Pinpoint location	Latitude (N) in degrees	Longitude (E) in degrees
1	Hatimura, Brahmaputra	26.612250	92.988466
2	Hatimura, Kolong	26.590613	92.976653
3	Hatbor, Kaliabor	26.570698	92.963537
4	Barbhogia	26.522546	92.951880
5	Missamukh	26.489189	92.934972
6	Samaguri	26.410997	92.830937
7	Puranigudam	26.342922	92.726139
8	Near Girls College, Nagaon town	26.356731	92.686654
9	ADP College Bhuyanpatty	26.342781	92.676995
10	Hariamukh	26.217223	92.540526
11	Jagibhakatgaon	26.178589	92.253150
12	Kajalimukh	26.247633	91.958739

FIG.1: Map showing sampling sites

Sampling

Water samples were collected by using plastic bottle from study sites of Kolong River. Two samples were collected from each location. These bottles were properly washed, dried and labeled and again rinsed with the river water to be sampled just prior to sampling. The samples were taken from the sampling points 1 foot below the surface of the river. Once the bottles were filled, they were securely sealed. Precautions were taken during sampling to avoid aeration. Once collected, the samples were warily transported to the laboratory and analysis was done instantaneously.

TABLE 2: Water quality parameters of the Kolong River

Parameter	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12
Fe	0.23	0.50	0.45	0.60	0.47	0.79	0.43	0.62	0.54	0.41	1.18	0.23
NO_3	3	2.9	2.2	1.9	4.6	2.3	2.1	1.6	1.8	2	2.1	2.1
Mn	0.46	0.69	0.56	0.57	0.52	0.67	0.53	0.27	0.50	0.34	0.87	0.50
F	0	0	0	0	0	0	0	0.09	0.07	0	0.18	0
pH	6.5	7	7	7.5	7.5	7	7	7.5	7.3	7.2	7	6.5
DO	12.16	12.57	7.91	9.53	7.7	6.08	8.51	6.28	3.44	7.5	8.1	7.7
Turbidity	18	15	11	15	15	10	14	4	5	8	41	9
Alkalinity	60	90	90	140	130	90	120	90	128	140	120	60
Total Hardness	80	80	110	140	130	90	88	110	125	105	110	65
Chloride	20	20	20	20	18	20	20	15	20	15	15	10
TDS	192	228	264	360	324	240	264	258	328	312	294	162
Ammonia	0	0	0	0	0	0	0	0	1	0	0	0
Phosphate	0	0	0	0	0	0	0	0	0	0	0	0
Bacteria	absent	absent	absent	absent	absent	present	absent	absent	absent	present	absent	absent

Calculation of Water Quality Index (WQI)

Various physico-chemical parameters of the water samples were analyzed by following the standard methods. Asetof fourteen most commonly used water quality parameters namely iron (Fe), nitrate (NO_3), manganese (Mn), fluoride (F), pH, turbidity,alkalinity,total hardness (TH), chloride, dissolved oxygen (DO), total dissolved solids (TDS), ammonia, phosphate and bacteria test which together, reflect the overall water quality of the Kolong River were selected forgenerating the water quality index (WQI).

Calculation of WQI was carried out by following the 'weighted arithmetic index method' (Brown et al. 1970), using the equation:

$WQI = \sum W_i X\ q_i / \sum W_i$

Where, W_i is the unit weight of nth water quality parameter, q_i isthequality rating ofnth water qualityparameter.

Unit weight (W_i) is calculated using the formula

$W_i = k/Vs$

Where, k is the constant of proportionality and it is calculated using the equation:

$k = [1/ \sum 1/Vs= 1, 2,\ldots..,n]$

The quality rating q_i is calculated using the equation:

$q_i = 100\ [(V_i – V_{id})/(S_i – V_{id})]$

Where, Vi = Observed value

Si = Standard permissible value

Vid = Ideal value

All the ideal values are taken as zero for drinking water expect pH and dissolved oxygen (Triphaty and Sahu, 2005). For pH, the normal value is 7.0 (for natural/pure water) and a permissible value is 8.5 (for polluted water)and for DO, the value is 14.6 mg/l. Therefore, the quality rating for pH and DO is calculated from the following equation:

$q_{pH} = 100\ [(V_{pH} - 7.0)/(8.5-7.0)]$
$q_{DO} = 100\ [(V_{DO} - 14.6)/(6-14.6)]$
Table 3 below shows a classification of water quality, based on its quality index of Brown et al. (1972).

TABLE 3: Classification of Water Quality Index based on weighted arithmetic WQI method

WQI	STATUS	POSSIBLE USAGE
0-25	Excellent	Drinking, irrigation and industrial
26-50	Good	Drinking, irrigation and industrial
51-75	Poor	Irrigation and industrial
76-100	Very Poor	Irrigation
Above100	Unsuitable for Drinking	Proper treatment required before use

III. RESULTS AND DISCUSSIONS

In this study, first of all analysis and variations of Water Quality Index Parametersalong the Kolong river are observed then we find out the Water Quality Index (WQI) of Kolongriver.

TABLE 4: Statistics for the Water quality parameters of the Kolong River

Parameters	Mean	Standard deviation (SD)
Fe (mg/l)	0.54	0.255
NO_3 (mg/l)	2.38	0.808
Mn (mg/l)	0.54	0.158
F (mg/l)	0.03	0.057
pH	7.08	0.343
DO (mg/l)	8.12	2.495
Turbidity (NTU)	13.75	9.602
Alkalinity (mg/l)	104.83	28.61
Total Hardness (mg/l)	102.08	23.204
Chloride (mg/l)	17.08	3.965
TDS (mg/l)	268.83	58.256
Ammonia (mg/l)	0.08	0.289

Iron (Fe)-Human bodies require iron to function properly, but iron, like many substances, is toxic at high dosages. Fe isconsidered as a secondary contaminant, which means it does not have a direct impact on health.In this study at maximum sites the presence of Fe is above permissible limit 0.3 mg/l.

The iron value ranges from 0.23 mg/l to 1.18 mg/l which is the maximum value comparing to the other sites. Presence of iron at site 11, Jagibhaktgaon is maximum. The mean iron value along the river is 0.54 mg/l which is within the permissible limit.

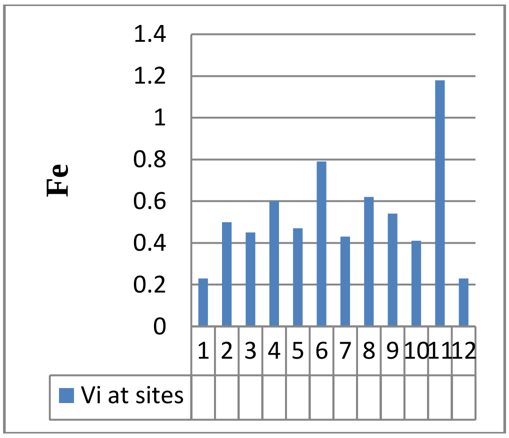

FIG.2: Variation of Iron value along the river

NITRATE(NO_3)-It is a common nitrogenous compound due to natural processes of the nitrogen cycle, anthropogenic sources have greatly increased the nitrate concentration. The largest anthropogenic sources are septic tanks, application of nitrogen-rich fertilizers, and agricultural processes.Nitrates are an essential source of nitrogen (N) for plants. When nitrogen fertilizers are used to enrich soils, nitrates may be carried by rain, irrigation and other surface waters through the soil into ground water. Elevated nitrate levels may suggest the possible presence of other contaminants such as disease-causing organisms, pesticides, or other inorganic and organic compounds that could cause health problems. In this study at all sites the presence of nitrate is in permissible limit 45 mg/l.

The nitrate value ranges from 1.6 mg/l to 4.6 mg/l. The minimum value is 1.6 mg/l at site 8, near Girls College Nagaon town and maximum at site 5,Missamukh, because of fertilizers used to enrich soils. The mean value of nitrate is 2.38 mg/l which is under the permissible limit.

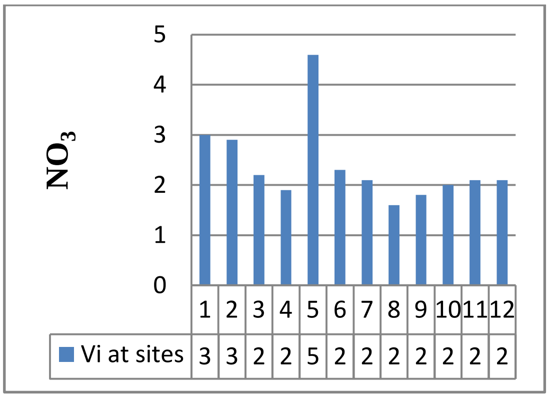

FIG.3: Variation of Nitrate value along the river

MANGANESE (Mn)-Mnoccurs naturally because of geology in many surface water and groundwater sources, particularly in anaerobic or low oxidation conditions.In this study at most of the sites the presence of Mn is above permissible limit 0.5 mg/l.

Manganese value ranges from 0.27 mg /l to 0.87 mg/l. The minimum value is 0.27 mg/l at site 8, near Girls College Nagaon town and maximum at site 11,Jagibhaktgaon because ofstagnant water. The mean value of Mn is 0.54 mg/l which is more than the permissible limit.

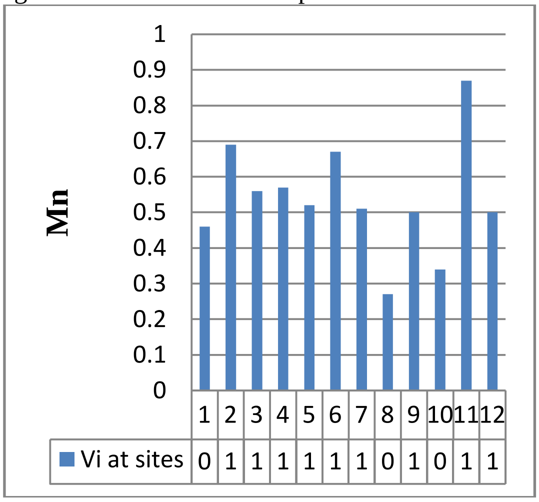

FIG.4: Variation of Manganese value along the river

FLUORIDE (F)- F is one of the very few chemicals that have been shown to cause significant effects in people through drinking water. In all the sites fluoride is in permissible limit 1.5 mg/l and in most of the sites it was found absent.

Fluoride value ranges from 0.07 mg/l to 0.18 mg/l.

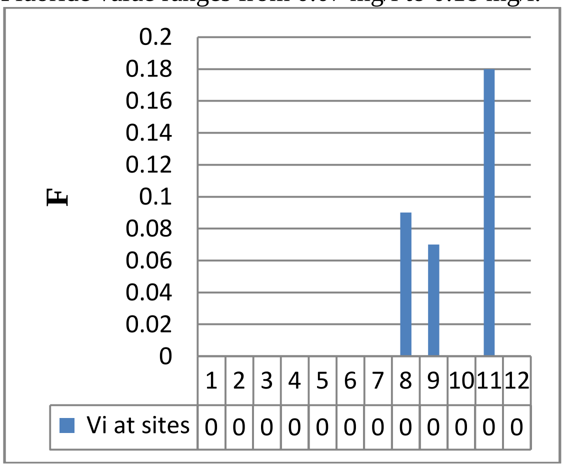

FIG.5: Variation of Fluoride value along the river

pH-pH generally signifies the degree of acidity or alkalinity of a water sample. The pH of water ranges from 6.5 to 7.5.

The mean pH values along the Kolongriver is 7.08 that means the water is alkaline in nature. The difference in the pH values depend upon the source of contamination and growth of algae also increases the pH level. Use of water hyacinth and its root mats for controlling algal concentrations can be taken as remedial measures in high pH sites.

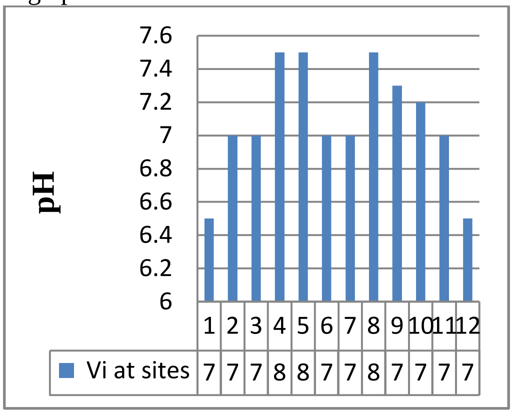

FIG.6: pH variation along the river

DISSOLVE OXYGEN (DO)-Amount of total oxygen dissolved in a water body is termed as dissolved oxygen (DO) and its concentration depend on physical, chemical and biological activities of the water body. Estimation of DO is very much essential in water pollution control. A DO level of 4–6 mg/l is optimum range for a good water quality sustaining aquatic life. Water sample with DO concentration below this optimum range is expected to be polluted. The primary cause of oxygen depletion in a water body is from excessive algae and phytoplankton growth driven by high levels of phosphorus and nitrogen.

DO value ranges from 3.44 mg /l to 12.6 mg/l. The minimum value is 3.44 mg/l at site 9, near ADP College,Bhuyanpatty,attributed chiefly by the high stagnancy of the water source and waste discharge of the Nagaon town and maximum at site 2,Hatimura, Kolong. The mean value of DO is 8.12 mg/l which is more than the permissible limit.

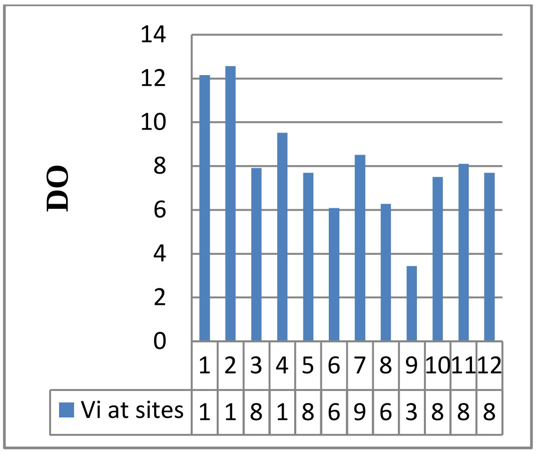

FIG.7: DO variation along the river

TURBIDITY- Turbidity is the cloudiness or haziness of a fluid caused by suspended solids that are usually invisible to the naked eye. The measurement of Turbidity is an important test when trying to determine the quality of water. It is an aggregate optical property of the water and does not identify individual substances. The permissible limit of turbidity is 5 NTU.

Turbidity of water ranges from 4 NTU to 41 NTU which is significantly high as shown in figure. High turbidity levels recorded at site 11, Jagibhaktgaon due to high erosion of the land and direct discharge from storm water drains and the lowest value of turbidity is recorded at site 8, near Girls College Nagaon. The mean turbidity level is 13.75 NTU which is not under the permissible limit.

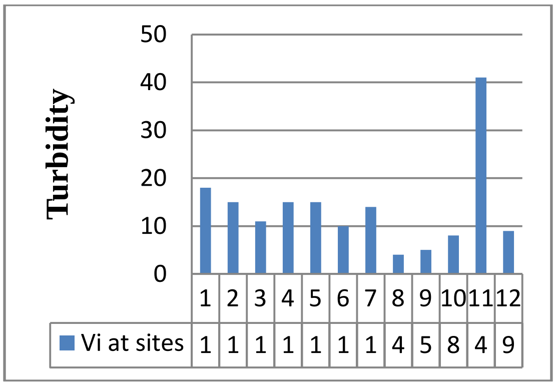

FIG.8: Turbidity variation along the river

ALKALINITY- It is the capability of an aqueous solution to neutralize an acid. Alkalinity is due to the various carbonate, bicarbonate and hydroxide ions present in water. Thepermissible limit of alkalinity is 200 mg/l.
Alkalinity of water ranges from 60 mg/l to 140 mg/l.The mean alkalinitylevel is 104.83 mg/l which is under the permissible limit.

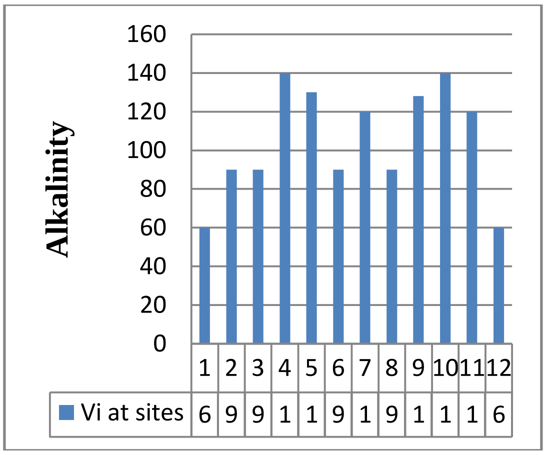

FIG.9: Alkalinity variation along the river

TOTAL HARDNESS(TH)-Hardness implies the lather forming capacity of a water sample and the two cations mainly responsible for hardness of water are calcium and magnesium. Thepermissible limit of TH is 300 mg/l.Based on the hardness values, Kolong River water generally falls under moderately hard (60-120 mg/l) to hard (120-180 mg/l) water category.

The total hardness values ranges from 65 mg/l to 140 mg/l. The minimum value of 65 mg/l is at site 12, Kajalimukh and maximum 140 mg/l at site 4 Borbhogia, Kaliabor. The mean TH of water is 102.08 mg/l which is under the permissible limit.

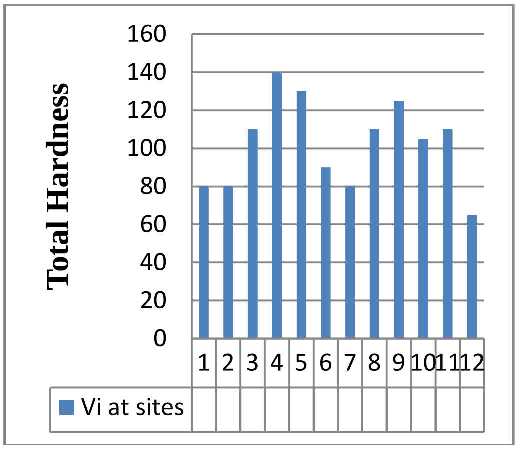

FIG.10: Total Hardness of water variation along the river

CHLORIDE (Cl)-Chloride is one of the important parameter and is widely distributed in nature in the form of salts of sodium(NaCl), potassium (KCl) and calcium ($CaCl_2$). Various sources contributing chloride in water are leaching from various rocks by the process of weathering, surface run-off from inorganic fertilizers dependent agricultural fields, irrigation discharge, animal feeds, etc. Thepermissible limit of Chloride is 250 mg/l.
Chloride value ranges from 10 mg/l to 20 mg/l. The maximum value is 20 mg/l and it is due to highly discharge of industrial waste. The mean value of Chloride is 17.08 mg/l which is under the permissible limit.

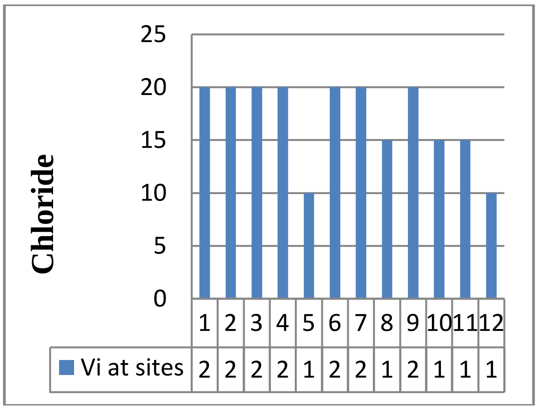

FIG.11: Chloride variation along the river

TOTAL DISSOLVED SOLIDS(TDS)-TDS is organic as well as inorganic in nature.TDS in water supplies originate from natural sources, sewage, urban run-off, industrial wastewater, and chemicals used in the water treatment process. TDS affects the ionic strength of water, dissolved oxygen concentration, the growth and decay of aquatic life and also influences the ability of a water body to assimilate wastes. The permissible limit is 500 mg/l.

The TDS values ranges from 162 mg/l to 360 mg/l. The minimum value of 162 mg/l is at site 12, Kajalimukh and maximum 140 mg/l at site 4, Borbhogia, Kaliabor. The mean TDS of water is 268.83 mg/l which is under the permissible limit.

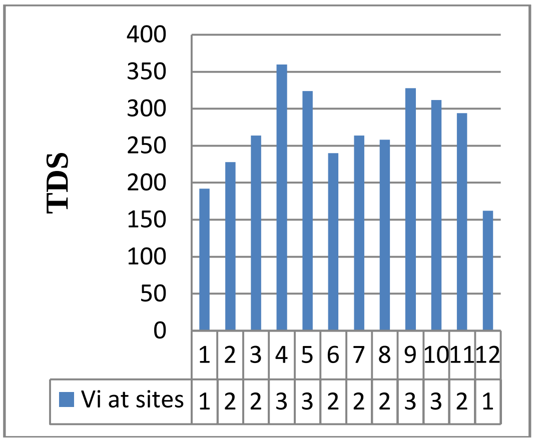

FIG.12: TDS variation along the river

AMMONIA- Ammonia is a compound of nitrogen and hydrogen with the formula NH_3. It is a colour less gas with a characteristic pungent smell.

The ammonia values ranges from 0 mg/l to 1 mg/l. Trace of ammonia is found in site 9, ADP College, Bhuyanpatty mainly because of discharge of urine and sewage directly into the river without any treatment but in other sites it is absent. The permissible limit is 0.5 mg/l.

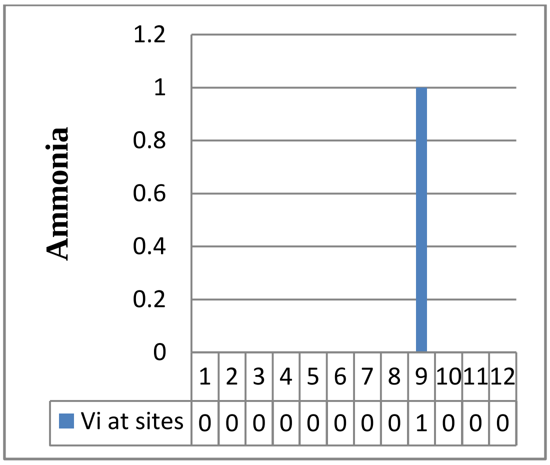

FIG.13: Ammonia variation along the river

WQI analysis

The first step in calculation of WQI 'weighted arithmetic index' method involves the estimation of 'unit weight' assigned to each physico-chemical parameter considered for the calculation. By assigning unit-weights, all the concerned parameters of different units and dimensions are transformed to a common scale. Table below shows BIS\ IS:2296standards for surface water and the unitweights assigned to each parameter used for calculating the WQI.

TABLE 5: Relative weights of the parameters used for WQI determination

Parameter	BIS\IS:2296 standard (V_s)	Unit weight (W_i)
Fe	0.3	0.3913
NO_3	45	0.0026
Mn	0.5	0.2348
F	1.5	0.0783
pH	6.5-8.5	0.0138
DO	6	0.0196
Turbidity	5	0.0235
Alkalinity	200	0.00059
Total Hardness	300	0.00039
Chloride	250	0.00047
TDS	500	0.00023
Ammonia	0.5	0.2348

$\sum W_i = 1.0004 = 1$

All the parameters are in mg/l except pH and turbidity in NTU.

TABLE 6: Calculations of Water Quality Index

Parameter	Sites	Observed values (V_i)	Standard values (S_i)	Unit weight (W_i)	Quality rating (q_i)	Weighted value (W_iq_i)
Fe	1	0.23	0.3	0.3913	76.67	30
	2	0.5	0.3	0.3913	166.67	65.22
	3	0.45	0.3	0.3913	150	58.7
	4	0.6	0.3	0.3913	200	78.26
	5	0.47	0.3	0.3913	156.67	61.30
	6	0.79	0.3	0.3913	263.33	103.04
	7	0.43	0.3	0.3913	143.33	56.08
	8	0.62	0.3	0.3913	206.67	80.87
	9	0.54	0.3	0.3913	180	70.43
	10	0.41	0.3	0.3913	136.67	53.48
	11	1.18	0.3	0.3913	393.33	153.91
	12	0.23	0.3	0.3913	76.67	30

Parameter	Sites	Observed values (V_i)	Standard values (S_i)	Unit weight (W_i)	Quality rating (q_i)	Weighted value (W_iq_i)
NO_3	1	3	45	0.0026	6.67	0.0173
	2	2.9	45	0.0026	6.44	0.0167
	3	2.2	45	0.0026	4.89	0.0127
	4	1.9	45	0.0026	4.22	0.011
	5	4.6	45	0.0026	10.22	0.0266
	6	2.3	45	0.0026	5.11	0.0133
	7	2.1	45	0.0026	4.67	0.0121
	8	1.6	45	0.0026	3.56	0.0092
	9	1.8	45	0.0026	4	0.0104
	10	2	45	0.0026	4.44	0.0115
	11	2.1	45	0.0026	4.67	0.0121
	12	2.1	45	0.0026	4.67	0.0121

Parameter	Sites	Observed values (V_i)	Standard values (S_i)	Unit weight (W_i)	Quality rating (q_i)	Weighted value (W_iq_i)
Mn	1	0.46	0.5	0.2348	92	21.60
	2	0.69	0.5	0.2348	138	32.40
	3	0.56	0.5	0.2348	112	26.30
	4	0.57	0.5	0.2348	114	26.77
	5	0.52	0.5	0.2348	104	24.42
	6	0.67	0.5	0.2348	134	31.46
	7	0.51	0.5	0.2348	102	23.95
	8	0.27	0.5	0.2348	54	12.68
	9	0.50	0.5	0.2348	100	23.48
	10	0.34	0.5	0.2348	68	15.97
	11	0.87	0.5	0.2348	174	40.86
	12	0.50	0.5	0.2348	100	23.48

Parameter	Sites	Observed values (V_i)	Standard values (S_i)	Unit weight (W_i)	Quality rating (q_i)	Weighted value (W_iq_i)
F	1	0	1.5	0.0783	0	0
	2	0	1.5	0.0783	0	0
	3	0	1.5	0.0783	0	0
	4	0	1.5	0.0783	0	0
	5	0	1.5	0.0783	0	0
	6	0	1.5	0.0783	0	0
	7	0	1.5	0.0783	0	0
	8	0.09	1.5	0.0783	6	0.4698
	9	0.07	1.5	0.0783	4.67	0.3657
	10	0	1.5	0.0783	0	0
	11	0.18	1.5	0.0783	12	0.9396
	12	0	1.5	0.0783	0	0

Parameter	Sites	Observed values (V_i)	Standard values (S_i)	Unit weight (W_i)	Quality rating (q_i)	Weighted value (W_iq_i)	V_{id}
pH	1	6.5	8.5	0.0138	-33.33	-0.46	7
	2	7	8.5	0.0138	0	0	7
	3	7	8.5	0.0138	0	0	7
	4	7.5	8.5	0.0138	33.33	0.46	7
	5	7.5	8.5	0.0138	33.33	0.46	7
	6	7	8.5	0.0138	0	0	7
	7	7	8.5	0.0138	0	0	7
	8	7.5	8.5	0.0138	33.33	0.46	7
	9	7.3	8.5	0.0138	20	0.28	7
	10	7.2	8.5	0.0138	13.33	0.18	7
	11	7	8.5	0.0138	0	0	7
	12	6.5	8.5	0.0138	-33.33	-0.46	7

Parameter	Sites	Observed values (V_i)	Standard values (S_i)	Unit weight (W_i)	Quality rating (q_i)	Weighted value (W_iq_i)	V_{id}
DO	1	12.16	6	0.0196	28.37	0.56	14.6
	2	12.57	6	0.0196	23.60	0.46	14.6
	3	7.91	6	0.0196	77.79	1.52	14.6
	4	9.53	6	0.0196	58.95	1.16	14.6
	5	7.7	6	0.0196	80.23	1.57	14.6
	6	6.08	6	0.0196	99.07	1.94	14.6
	7	8.51	6	0.0196	70.81	1.39	14.6
	8	6.28	6	0.0196	96.74	1.90	14.6
	9	3.44	6	0.0196	129.77	2.54	14.6
	10	7.5	6	0.0196	82.56	1.62	14.6
	11	8.1	6	0.0196	75.58	1.48	14.6
	12	7.7	6	0.0196	80.23	1.57	14.6

Parameter	Sites	Observed values (V_i)	Standard values (S_i)	Unit weight (W_i)	Quality rating (q_i)	Weighted value (W_iq_i)
Turbidity	1	18	5	0.0235	360	8.46
	2	15	5	0.0235	300	7.05
	3	11	5	0.0235	220	5.17
	4	15	5	0.0235	300	7.05
	5	15	5	0.0235	300	7.05
	6	10	5	0.0235	200	4.7
	7	14	5	0.0235	280	6.58
	8	4	5	0.0235	80	1.88
	9	5	5	0.0235	100	2.35
	10	8	5	0.0235	160	3.76
	11	41	5	0.0235	820	19.27
	12	9	5	0.0235	180	4.23

Parameter	Sites	Observed values (V_i)	Standard values (S_i)	Unit weight (W_i)	Quality rating (q_i)	Weighted value (W_iq_i)
Alkalinity	1	60	200	0.00059	30	0.0177
	2	90	200	0.00059	45	0.0266
	3	90	200	0.00059	45	0.0266
	4	140	200	0.00059	70	0.0413
	5	130	200	0.00059	65	0.0384
	6	90	200	0.00059	45	0.0266
	7	120	200	0.00059	60	0.0354
	8	90	200	0.00059	45	0.0266
	9	128	200	0.00059	64	0.0378
	10	140	200	0.00059	70	0.0413
	11	120	200	0.00059	60	0.0354
	12	60	200	0.00059	30	0.0177

Parameter	Sites	Observed values (V_i)	Standard values (S_i)	Unit weight (W_i)	Quality rating (q_i)	Weighted value (W_iq_i)
Total Hardness	1	80	300	0.00039	26.67	0.0104
	2	80	300	0.00039	26.67	0.0104
	3	110	300	0.00039	36.67	0.0143
	4	140	300	0.00039	46.67	0.0182
	5	130	300	0.00039	43.33	0.0169
	6	90	300	0.00039	30	0.0117
	7	80	300	0.00039	26.67	0.0104
	8	110	300	0.00039	36.67	0.0143
	9	125	300	0.00039	41.67	0.0162
	10	105	300	0.00039	35	0.0136
	11	110	300	0.00039	36.67	0.0143
	12	65	300	0.00039	21.67	0.0084

Parameter	Sites	Observed values (V_i)	Standard values (S_i)	Unit weight (W_i)	Quality rating (q_i)	Weighted value (W_iq_i)
Chloride	1	20	250	0.00047	8	0.0038
	2	20	250	0.00047	8	0.0038
	3	20	250	0.00047	8	0.0038
	4	20	250	0.00047	8	0.0038
	5	10	250	0.00047	4	0.0019
	6	20	250	0.00047	8	0.0038
	7	20	250	0.00047	8	0.0038
	8	15	250	0.00047	6	0.0028
	9	20	250	0.00047	8	0.0038
	10	15	250	0.00047	6	0.0028
	11	15	250	0.00047	6	0.0028
	12	10	250	0.00047	4	0.0019

Parameter	Sites	Observed values (V_i)	Standard values (S_i)	Unit weight (W_i)	Quality rating (q_i)	Weighted value (W_iq_i)
TDS	1	192	500	0.00023	38.4	0.0088
	2	228	500	0.00023	45.6	0.0102
	3	264	500	0.00023	52.8	0.0121
	4	360	500	0.00023	72	0.0166
	5	324	500	0.00023	64.8	0.0149
	6	240	500	0.00023	48	0.011
	7	264	500	0.00023	52.8	0.0121
	8	258	500	0.00023	51.6	0.0119
	9	328	500	0.00023	65.6	0.0151
	10	312	500	0.00023	62.4	0.0144
	11	294	500	0.00023	58.8	0.0135
	12	162	500	0.00023	32.4	0.0074

Parameter	Sites	Observed values (V_i)	Standard values (S_i)	Unit weight (W_i)	Quality rating (q_i)	Weighted value (W_iq_i)
Ammonia	1	0	0.5	0.2348	0	0
	2	0	0.5	0.2348	0	0
	3	0	0.5	0.2348	0	0
	4	0	0.5	0.2348	0	0
	5	0	0.5	0.2348	0	0
	6	0	0.5	0.2348	0	0
	7	0	0.5	0.2348	0	0
	8	0	0.5	0.2348	0	0
	9	1	0.5	0.2348	200	46.96
	10	0	0.5	0.2348	0	0
	11	0	0.5	0.2348	0	0
	12	0	0.5	0.2348	0	0

TABLE 7: Classification of WQI based on weighted arithmetic WQI method

Sites	$\sum W_iq_i$	WQI $=\sum W_iq_i/\sum W_i$	WQI STATUS
1	60.22	60.22	Poor
2	105.20	105.20	Unsuitable for Drinking
3	91.76	91.76	Very Poor
4	113.78	113.78	Unsuitable for Drinking
5	94.90	94.90	Very Poor
6	141.21	141.21	Unsuitable for Drinking
7	88.06	88.06	Very Poor
8	98.32	98.32	Very Poor
9	146.49	146.49	Unsuitable for Drinking
10	75.09	75.09	Very Poor
11	216.53	216.53	Unsuitable for Drinking
12	58.87	58.87	Poor

The summary of WQI values of the water samples from all the twelve sampling sites are presented in Table 6. The results showed that majority of the water sample fall under very poor (75<WQI<100) and unsuitable for drinking water category (WQI>100). WQI were recorded with values ranging from a low of 58.87 at site 12 to a high of 216.53 at site 11 with an average WQI value 107.54. The WQI analysis unveiled the fact that site 2,4,6,9,11 were the most polluted sites along the entire reach of the KolongRiver. The WQI values of above sites specified the fact that the water was unsuitable for any use including drinking, fish culture and irrigation.In addition to domestic sewage disposal and eutrophication of the water body, the reason behind high pollution level of site 2,4 and 6 is the lack of sufficient flow leading to the stagnancy of the water, which in turn reduced the self-assimilation capacity of the riverine ecosystem. Similarly, site 6 i.e. Samoguri is also polluted because of urban settlements and development.And site 9, i.e., ADP College, Bhuyanpatty, Nagaon town, the most populated urban agglomeration along Kolong River also witnessed a highly deteriorated water quality mainly contributed by huge demographic as well as socio-economic pressure in the form of river bed encroachment and river water exploitation from direct disposal of waste and sewarage. Thus, site 9 acquired unfit for drinking water quality status as indicated by the WQI values. It is clear from above Tables Fe, Mn, Turbidity and DO were the deciding parameters exhibiting the maximum influence in WQI calculation. The Kolong River water samples experienced lower DO concentration at some sites signifying high organic pollution load. The WQI values of site 11, i.e., near Jagibhakatgaon,was the most polluted studied sites, the high WQI scores are contributed mainly by various anthropogenic activities like the inflow of direct sewerage from residential, agricultural run-off and unabated dumping of solid wastes by the communities residing alongside the river, etc. The water in this study site was very turbid that was attributed by increased surface run-off from the adjacent river banks and direct discharge from storm water drains along roads adjacent to the river which resulted in muddy water and since it was pre monsoon so the river in this site also narrowed to a thin channel.

The WQI value of site 12, i.e., Kajalimukh was comparatively better among all the studied sites. The comparatively improved water quality condition at site 12 are mainly because of the dilution of the polluted Kolong River water with less polluted Kopili River water, besides the absence of any major urban agglomeration and similarly at site 1 i.e., Hatimura, Brahmaputra WQI value is better because it is the WQI of the river Brahmaputra just before the Hatimura dyke indicating less pollution of river Brahmaputra than its tributary Kolong.

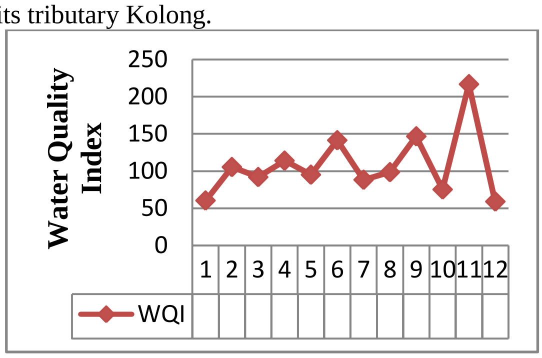

FIG.14: WQI rating of various sampling sites of Kolong River

There is abrupt raise and fall in pollution level downstream of the river starting from site 1 justified by the demographic as well as commercialpressure and urban settlement at the respective sites. Site 9 again rendered an increased pollution level when compared to its immediate upstream sampling site, i.e., site 8, mainly supported by the fact that site 9 is located near an urban agglomeration dominated by a market place and slum area, though both the sites are in the Nagaon town itself site 8 is comparatively better mainly because of proper drain and sanitation system.. While the raise in graph at site 11, is supported by the fact about thelack of sufficient flow in addition to increased organic pollution load. The graph at site 1 and site 12 are the least indicating less pollution at river Brahmaputra before the mouth closure of Kolong and at the downstream after dilution with the Kopiliriver respectively.

IV. CONCLUSION

Water quality index is helpful in assessment and management of water quality. The case study provides valuable insight into the status of overall suitability of the Kolong River water based on WQI values. It highlights the salient features of various important physico-chemical parameters acting upon the general water quality of the river.Again there are also variations in water quality in twelve different sampling sites distributed along the river channel. The baseline data generated in this investigation and their analysis and interpretation will help in understanding about the status of water quality of the Kolong River and the factors affecting the overall quality of its water. The study has both academic value and practical significance. Based on observed WQI results it can be concluded that the Kolong river water is not fit for direct consumption, but might be used for transportation, irrigation and agricultural purposes and must therefore be treated before use to avoid related diseases. This quality of river water may cause harm to the sensitive aquatic life and aqua-environment. The effective treatment measures are urgently required to augment the river water quality by defining an appropriate water quality management plan which will support any future plan for sustainable river restoration. Water quality of the river needs to be restored by adopting measures like restricting inflows of raw sewerage from residential/commercial areas, limiting direct discharge from storm water drains into the river and preventing dumping of solid waste by communities residing along the river. Besides, desilting measures to improve the carrying capacity of the river channel needs to be adopted and infrastructural development should be removed.The Kolong River also needs regular monitoring of water quality in order to detect the changes in physico-chemical parameters. Thus, the river water must be subjected to continuous monitoring and pollution reduction measures to reduce pollution so that the river water can be used for drinking, domestic and agricultural purposes.

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