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HYDROCHEMICAL INFLUENCE ON FISHERY POTENTIAL OF ONE OF THE MOST POLLUTED RIVERS OF INDIA: KOLONG RIVER, NAGAON, ASSAM

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ABSTRACT

Rivers are the priceless blessings for both nature and mankind. Specially, Indian people consider rivers as mother and Goddess. There is a saying that- "Every River of India is as sacred as river Ganga". The historic Kolong river, the tributary of the mighty river Brahmaputra was once a vibrant river, which is now struggling for pollution. The Central Pollution Control Board of India (2015) has categorized this river under the most polluted rivers of India. Therefore, it is important to analyze the recent hydrochemistry of the polluted ecosystem and identify the root causes of pollution. For commercial utilization of the river, we must know about the ecological strength of it. Though the contribution of the fishery sector of Assam to the State Gross Domestic Product is very high, but due to the lack of proper scientific skills, people are unable to utilize the aquatic resources of the state in commercial purpose. Day by day, pollution in some water bodies is becoming very alarming, but no properly planned measures and means have been taken to compensate the same.

This study aimed to explore the significant impact of hydrochemical dynamics on fishery potential of Kolong river. The study was conducted at four different sites (Samoguri, Nagaon town, Jagi bhakatgaon and Mayong Kajalimukh) of the river in four different seasons by following standard guidelines. The study documented the detrimental effect of water pollution in fishery potential of the river, particularly in Nagaon town site. pH and conductivity had significant negative impact on fish abundance. The undesirable values of alkalinity, Phosphate and Dissolve oxygen were recorded. Transparency values also indicated unclear water. As per the study, some important fish species were found to be totally absent in that site. However, presence of 32 different fish species (Critically endangered, Endangered, Nearly threatened) indicated a good sign from conservation point of view.

KEYWORDS: Kolong river, Hydrochemistry, Fishery potential, Pollution, Conservation.

INTRODUCTION

Rivers are the blessings of Mother Nature to mankind. The Kolong river, a tributary of the mighty river Brahmaputra was once a very vibrant river of India. But the river is currently struggling due to unsustainable anthropogenic activities. Some engineering approaches that had been taken to control flood hazards are also creating ecological issues.

The Kolong river originates at Kolongmukh, Jakhalabandha and passes through Nagaon, Morigaon, Kamrup metro (Medhi et al., 2023). It is going through a staid phase of degeneration as a result of human intervention, from the last century. This river was once an ecologically strong and culturally innovative river. From ancient times, the folks of Assam are emotionally attached with the river till now. But this river is now categorized under 275 most polluted rivers of India by Central pollution Control Board (2015). This is a much undesired outcome of pollution for such a vibrant natural resource. Therefore, it is necessary to monitor the ecological health of this river regularly, which is demanding sincere attention form mankind. The biotic and abiotic factors of water bodies determine the ecological status of them. The ecological health of a water body depends on the interplay between biotic and abiotic factors. Moreover, limnological studies estimate the productivity of a water body.

The economic survey of Fishery department, Government of Assam (2016-2017) revealed that the contribution of fishery sector to the State Gross Domestic Product is Rupees 47219 lakh. It is important to promote research on fisheries. Because, due to lack of proper scientific skill on fish culture among the people of Assam, fish production is comparatively low in the state. The fish diversity of Beki river of Assam had been studied by Goswami and Singha (2023). They noticed a significant decrease in freshwater fish due to excess anthropogenic pressure. Li et al. (2024) mentioned that Climate change influences river water quality. As far as the Kolong river has been concerned, previous researchers had studied the hydrochemical dynamics of the river. But literature is scanty regarding the effects of hydrochemistry on biotic factors of the river. Therefore, the present study aims to analyze the recent status of icthyofaunal resources and hydrochemistry of Kolong river, along with the impact of hydrochemical dynamics in fishery potential.

MATERIAL AND METHODOLOGY

Study Area:

Kolong River flows through Nagaon, Morigaon and Kamrup districts of Assam. The sampling sites selected from upstream, middle stream and downstream stretches of the river are listed in the Table 1.

Table 1: Geographical co-ordinates of the sampling sites

Sl. No.	Sampling sites	Co-ordinates
1	Samoguri (Site 1)	26.421772˚ N, 92.841883˚ E
2	Nagaon town (Site 2)	26.352373˚ N, 92.6819˚ E
3	Jagi-Bhakatgaon (Site 3)	26.17131˚ N, 92.246183˚ E
4	Mayong-Kajalimukh (Site 4)	26.245523˚ N, 91.958757 ˚ E

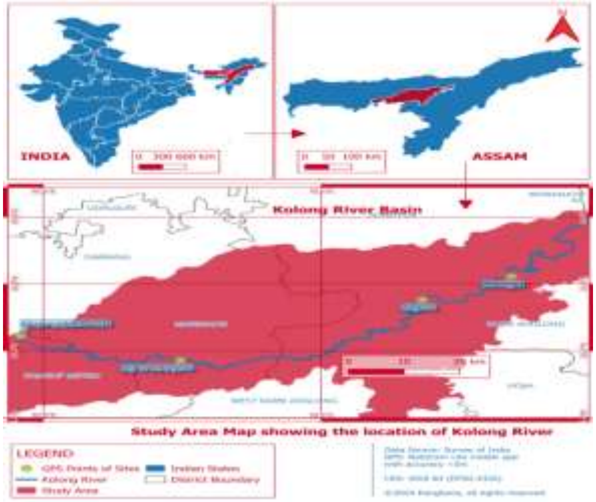

Figure 1- Map showing the locations of Study area in Kolong river

Study period:

The study had been conducted from 2022-2023. As per Barthakur (1986), the seasons had been classified as- . pre-monsoon, monsoon, retreating monsoon and winter.

Fish Sampling: From each sampling site (Table 1) of the river, adequate quantity of fish samples were randomly collected through experimental fishing methods in morning shift (from 6 am to 8 am) and afternoon shift (from 1 pm to 3 pm) with the permissions of the District Fishery officers of Nagaon District. Local fishermen were involved in fishing and fish collection. Fishes were identified by using standard keys given by Kar 2007 and Vishwanath et al. (2007).

Analysis of Physico-chemical factors: The guidelines of APHA (23rd edition, 2017) was followed for water quality parameter analysis.

Statistical analysis: SPSS and R software were used for statistical analysis.

RESULTS

Fishery potential of Kolong river:

Table 2: Number (Mean ± Standard deviation) of Fish species at the study sites during Pre-monsoon season in Kolong river

Sl. No.	Fish species	S1	S2	S3	S4
	Family- Notopteridae				
1	*Notopterus notopterus* (Pallas,1769)	2±0.3	0	3±0.4	3±0.6
2	*Chitala chitala* (Hamilton, 1822)	3±0.2	0	2±0.1	0
	Family- Clupeidae				
1	*Gudusia chapra* (Hamilton,1822)	0	0	1±0.5	1±0.5
	Family- Cyprinidae				
1	*Catla catla* (Hamilton, 1822)	5±0.2	2±0.2	3±0.1	4±0.5
2	*Labeo rohita* (Hamilton,1822)	4±0.2	2±01	1±0.5	3±0.2
3	*Labeo bata* (Hamilton, 1822)	2±0.4	0	3±0.2	3±0.4
4	*Labeo gonius* (Hamilton,1822)	4±0.1	2±0.1	5±0.3	0
5	*Labeo reba* (Hamilton,1822)	4±0.2	0	0	3±0.6
6	*Cirrhinus mrigala* (Hamilton,1822)	6±0.5	2±0.3	0	3±0.2

7	*Pethia ticto* (Hamilton, 1822)	5±0.1	3±0.4	3±0.4	4±0.2
8	*Amblypharyngodon mola* (Hamilton,1822)	6±0.2	2±0.3	2±0.1	4±0.5
9	*Cryprinus carpio* (Linnaeus,1758)	3±0.1	1±0.5	2±0.1	2±0.6
10	*Ctenopharyngodon idella* (Valenciennes,1844)	5±0.1	1±0.3	2±0.1	3±0.5
11	*Puntius sophore*(Hamilton,1822)	7±0.2	0	3±0.7	6±0.4
12	*Puntius chola* (Hamilton,1822)	3±0.2	0	0	2±0.1
	Family- Bagridae				
11	*Mystus cavasius*(Hamilton, 1822)	0	0	2±0.6	0
12	*Mystus tengara*(Hamilton, 1822)	0	0	0	1±0.5
	Family- Siluridae				
1	*Wallago attu* (Bloch & Schnelder,1801)	2±0.4	0	1±0.5	2±0.6
2	*Ompok pabda* (Hamilton, 1822)	2±0.1	0	0	1±0.5
	Family- Clariidae				
1	*Clarias batrachus* (Lineus,1758)	1±0.5	1±0.5	0	2±0.3
	Family- Heteropneustidae				
1	*Heteropneustes fossilis* (Bloch, 1974)	3±0.6	0	2±0.5	4±0.3
	Family- Belonidae				
1	*Xenentodon cancila* (Hamilton, 1822)	3±0.5	0	2±0.5	4±0.7
	Family- Synbranchidae				
1	*Monopterus cuchia* (Hamilton, 1822)	4±0.2	0	1±0.5	2±0.3
	Family- Mastacembelidae				
1	*Mastacembelus armatus*(Lacepede, 1800)	6±0.2	2±0.3	2±0.4	3±0.2
2	*Macrognathus aral* (Bloch & Schneider, 1801)	2±0.1	0	2±0.5	4±0.1
	Family- Anabantidae				
1	*Anabus testudinius*(Bloch,1792)	5±0.5	2±0.7	3±0.2	3±0.2
	Family- Osphronemidae				
1	*Trichogaster fasciata* (Bloch & Schneider, 1801)	6±0.2	1±0.5	2±0.5	5±0.3
	Family- Channidae				
1	*Channa punctata* (Bloch, 1793)	5±0.6	1±0.5	1±0.5	3±0.6
2	*Channa striata* (Bloch, 1793)	4±0.2	0	2±0.6	2±0.3
	Family- Tetraodontidae				
1	*Leiodon cutcutia* (Hamilton, 1822)	3±0.5	0	0	0
	Family- Botiidae				
1	*Botia Dario* (Hamilton, 1822)	2±0.1	0	0	1±0.5
	Family- Nandidae				
1	*Nandus nandus* (Hamilton, 1822)	5±0.8	0	2±0.5	3±0.1

Table 3: Number (Mean ± Standard deviation) of Fish species at the study sites during Monsoon season in Kolong river

Sl. No.	Fish species	S1	S2	S3	S4
	Family- Notopteridae				
1	*Notopterus notopterus* (Pallas, 1769)	5±0.4	0	6±0.5	7±0.3
2	*Chitala chitala* (Hamilton, 1822)	3±0.5	0	1±0.1	6±0.2
	Family- Clupeidae				
1	*Gudusia chapra* (Hamilton, 1822)	3±0.5	0	3±0.5	4±0.4
	Family- Cyprinidae				
1	*Catla catla* (Hamilton, 1822)	5±0.5	2±0.2	3±0.1	3±0.5
2	*Labeo rohita* (Hamilton, 1822)	8±0.3	2±0.5	8±0.6	9±0.2

3	*Labeo bata* (Hamilton, 1822)	6±0.2	2±0.4	3±0.5	7±0.3
4	*Labeo gonius* (Hamilton, 1822)	5±0.1	1±0.5	4±0.2	9±0.3
5	*Labeo reba* (Hamilton,1822)	5±0.2	0	0	0
6	*Cirrhinus mrigala* (Hamilton, 1822)	4±0.2	1±0.5	2±0.4	7±0.6
7	*Pethia ticto* (Hamilton, 1822)	16±0.8	3±0.5	10±0.2	11±0.8
8	*Amblypharyngodon mola* (Hamilton, 1822)	17±0.4	3±0.5	6±0.3	12±0.4
9	*Cryprinus carpio* (Linnaeus, 1758)	7±0.3	2±0.5	4±0.2	6±0.3
10	*Ctenopharyngodon idella* (Valenciennes, 1844)	4±0.2	1±0.5	3±0.6	6±0.2
11	*Puntius sophore* (Hamilton, 1822)	15±0.	4±0.2	10±0.5	13±0.5
12	*Puntius chola* (Hamilton, 1822)	5±0.3	0	5±0.5	0
	Family- Bagridae				
1	*Mystus cavasius* (Hamilton, 1822)	0	0	0	5±0.5
2	*Mystus tengara* (Hamilton, 1822)	3±0.5	0	0	5±0.5
	Family- Siluridae				
1	*Wallago attu* (Bloch & Schnelder, 1801)	6±0.3	3±0.5	7±0.5	9±0.5
2	*Ompok pabda* (Hamilton, 1822)	9±0.4	0	3±0.5	22±0.8
	Family- Clariidae				
1	*Clarias batrachus* (Lineus, 1758)	4±0.2	1±0.5	7±0.5	6±0.3
	Family- Heteropneustidae				
1	*Heteropneustes fossilis* (Bloch, 1974)	9±0.3	3±0.1	2±0.4	17±0.5
	Family- Belonidae				
1	*Xenentodon cancila* (Hamilton, 1822)	7±0.5	0	2±0.4	3±0.5
	Family- Synbranchidae				
1	*Monopterus cuchia* (Hamilton, 1822)	5±0.1	3±0.1	2±0.3	4±0.3
	Family- Mastacembelidae				
1	*Mastacembelus armatus* (Lacepede, 1800)	12±0.6	3±0.5	4±0.9	8±0.6
2	*Macrognathus aral* (Bloch & Schneider, 1801)	6±0.3	2±0.5	5±0.5	16±0.6
	Family- Anabantidae				
1	*Anabus testudinius* (Bloch, 1792)	17±0.8	0	8±0.4	16±0.3
	Family- Osphronemidae				
1	*Trichogaster fasciata* (Bloch & Schneider, 1801)	19±0.3	1±0.5	18±0.3	16±0.8
	Family- Channidae				
1	*Channa punctata* (Bloch, 1793)	21±0.5	2±0.4	11±0.5	12±0.4
2	*Channa striata* (Bloch, 1793)	9±0.3	0	10±0.5	2±0.1
	Family- Tetraodontidae				
1	*Leiodon cutcutia* (Hamilton, 1822)	7±0.5	0	7±0.6	10±0.4
	Family- Botiidae				
1	*Botia Dario* (Hamilton,1822)	3±0.7	0	3±0.1	6±0.5
	Family- Nandidae				
1	*Nandus nandus* (Hamilton, 1822)	7±0.5	0	4±0.6	9±0.8

Table 4: Number (Mean ± Standard deviation) of Fish species at the study sites during Retreating monsoon season in Kolong river

Sl. No.	Fish species	S1	S2	S3	S4
	Family- Notopteridae				
1	*Notopterus notopterus* (Pallas, 1769)	0	0	2±0.6	3±0.5
2	*Chitala chitala* (Hamilton, 1822)	1±0.5	0	2±0.5	2±0.6
	Family- Clupeidae				

1	*Gudusia chapra* (Hamilton, 1822)	0	0	0	1±0.5
	Family- Cyprinidae				
1	*Labeo catla* (Hamilton, 1822)	5±0.3	1±0.5	2±0.5	2±0.5
2	*Labeo rohita* (Hamilton, 1822)	7±0.3	3±0.6	5±0.5	5±0.3
3	*Labeo bata* (Hamilton, 1822)	9±0.4	1±0.5	3±0.5	5±0.6
4	*Labeo gonius* (Hamilton, 1822)	8±0.6	3±0.1	5±0.3	6±0.3
5	*Cirrhinus reba* (Hamilton, 1822)	3±0.2	0	1±0.5	2±0.4
6	*Cirrhinus mrigala* (Hamilton, 1822)	12±0.8	2±0.5	3±0.1	8±0.6
7	*Pethia ticto* (Hamilton, 1822)	10±0.8	4±0.2	7±0.8	9±0.6
8	*Amblypharyngodon mola* (Hamilton, 1822)	9±0.6	0	4±0.2	9±0.6
9	*Cryprinus carpio* (Linnaeus, 1758)	0	0	2±0.6	1±0.5
10	*Ctenopharyngodon idella* (Valenciennes, 1844)	2±0.4	0	2±0.6	3±0.4
11	*Puntius sophore* (Hamilton, 1822)	6±0.6	2±0.4	3±0.8	6±0.3
12	*Puntius chola* (Hamilton, 1822)	4±0.8	0	0	0
	Family- Bagridae				
1	*Mystus cavasius* (Hamilton, 1822)	3±0.2	0	1±0.5	1±0.5
2	*Mystus tengara* (Hamilton, 1822)	1±0.5	0	0	2±0.6
	Family- Siluridae				
1	*Wallago attu* (Bloch & Schnelder, 1801)	5±0.6	0	2±0.1	3±0.4
2	*Ompok pabda* (Hamilton, 1822)	0	0	0	2±0.3
	Family- Clariidae				
1	*Clarias batrachus* (Lineus, 1758)	2±0.1	1±0.5	4±.0.2	5±0.1
	Family- Heteropneustidae				
1	*Heteropneustes fossili*s (Bloch, 1974)	4±0.2	1±0.5	0	2±0.1
	Family -Belonidae				
1	*Xenentodon cancila* (Hamilton, 1822)	5±0.1	0	2±0.6	4±0.8
	Family- Synbranchidae				
1	*Monopterus cuchia* (Hamilton, 1822)	4±0.2	1±0.5	1±0.5	2±0.6
	Family- Mastacembelidae				
1	*Mastacembelus armatus* (Lacepede, 1800)	5±0.8	1±0.5	2±0.4	6±0.8
2	*Macrognathus aral* (Bloch & Schneider, 1801)	1±0.5	0	0	3±0.6
	Family- Anabantidae				
1	*Anabus testudinius* (Bloch, 1792)	7±0.3	3±0.8	4±0.2	5±0.1
	Family- Osphronemidae				
1	*Trichogaster fasciata* (Bloch & Schneider, 1801)	9±0.8	2±0.2	4±0.2	6±0.4
	Family- Channidae				
1	*Channa punctata* (Bloch, 1793)	6±0.3	0	2±0.4	4±0.6
2	*Channa striata* (Bloch, 1793)	6±0.8	0	4±0.3	4±0.3
	Family- Tetraodontidae				
1	*Leiodon cutcutia* (Hamilton, 1822)	2±0.3	0	0	0
	Family- Botiidae				
31	*Botia Dario* (Hamilton,1822)	0	0	2±0.4	0
	Family- Nandidae				
32	*Nandus nandus* (Hamilton, 1822)	3±0.6	0	1±0.5	0

Table 5: Number (Mean ± Standard deviation) of Fish species at the study sites during Winter season in Kolong river

Sl. No.	Fish species	S1	S2	S3	S4
	Family -Notopteridae				
1	*Notopterus notopterus* (Pallas, 1769)	0	0	1±0.5	3±0.2
2	*Chitala chitala* (Hamilton, 1822)	2±0.3	0	2±0.3	2±0.8
	Family- Clupeidae				
1	*Gudusia chapra* (Hamilton, 1822)	0	0	0	1±0.5
	Family- Cyprinidae				
1	*Labeo catla* (Hamilton, 1822)	3±0.8	0	0	1±0.5
2	*Labeo rohita* (Hamilton, 1822)	3±0.8	2±0.6	0	2±0.4
3	*Labeo bata* (Hamilton, 1822)	2±0.3	3±0.6	0	2±0.8
4	*Labeo gonius* (Hamilton, 1822)	4±0.3	0	0	1±0.5
5	*Cirrhinus reba* (Hamilton, 1822)	3±0.1	0	1±0.5	2±0.3
6	*Cirrhinus mrigala* (Hamilton, 1822)	8±0.6	0	3±0.2	6±0.1
7	*Pethia ticto* (Hamilton, 1822)	5±0.3	1±0.5	0	7±0.2
8	*Amblypharyngodon mola* (Hamilton, 1822)	7±0.6	0	4±0.2	1±0.5
9	*Cryprinus carpio* (Linnaeus, 1758)	3±0.2	1±0.5	0	8±0.6
10	*Ctenopharyngodon idella* (Valenciennes, 1844)	3±0.2	2±0.6	3±0.1	4±0.2
11	*Puntius sophore* (Hamilton, 1822)	3±0.1	1±0.5	5±0.1	6±0.3
12	*Puntius chola* (Hamilton, 1822)	6±0.1	2±0.1	3±0.2	2±0.4
	Family- Bagridae				
1	*Mystus cavasius* (Hamilton, 1822)	2±0.1	1±0.5	3±0.6	4±0.9
2	*Mystus tengara* (Hamilton, 1822)	2±0.3	0	2±0.3	4±0.2
	Family -Siluridae				
1	*Wallago attu* (Bloch & Schnelder, 1801)	3±0.1	0	0	3±0.1
2	*Ompok pabda* (Hamilton, 1822)	2±0.4	0	1±0.5	3±0.5
	Family- Clariidae				
1	*Clarias batrachus* (Lineus, 1758)	4±0.8	1±0.5	6±0.3	3±0.8
	Family- Heteropneustidae				
1	*Heteropneustes fossilis* (Bloch, 1974)	5±0.6	0	1±0.5	3±0.6
	Family- Belonidae				
1	*Xenentodon cancila* (Hamilton, 1822)	3±0.5	0	2±0.6	6±0.2
	Family- Synbranchidae				
1	*Monopterus cuchia* (Hamilton, 1822)	4±0.3	0	2±0.4	3±0.6
	Family- Mastacembelidae				
1	*Mastacembelus armatus* (Lacepede, 1800)	3±0.6	1±0.5	5±0.2	6±0.8
2	*Macrognathus aral* (Bloch & Schneider, 1801)	0	0	4±0.2	6±0.8
	Family- Anabantidae				
1	*Anabus testudinius* (Bloch, 1792)	3±0.1	2±0.1	5±0.6	6±0.2
	Family- Osphronemidae				
1	*Trichogaster fasciata* (Bloch & Schneider, 1801)	2±0.3	0	3±0.1	7±0.8
	Family- Channidae				
1	*Channa punctata* (Bloch, 1793)	5±0.2	1±0.5	6±0.3	6±0.3
2	*Channa striata* (Bloch, 1793)	8±0.3	0	3±0.2	0
	Family- Tetraodontidae				
1	*Leiodon cutcutia* (Hamilton, 1822)	4±0.1	0	2±0.3	0
	Family- Botiidae				
1	*Botia Dario* (Hamilton,1822)	0	0	1±0.5	0
	Family- Nandidae				
1	*Nandus nandus* (Hamilton, 1822)	0	0	0	0

The study revealed the presence of 32 species of fishes (25 genera and 16 families). The Cyprinidae family was found to be dominant (Table 2,3,4 and 5). A total of 12 species were found (38% of total families observed).

Site 1 showed greater fish diversity and site 2 showed lesser fish count as compared to the other sites of the river. Monsoon season showed greater fish diversity in the present study.

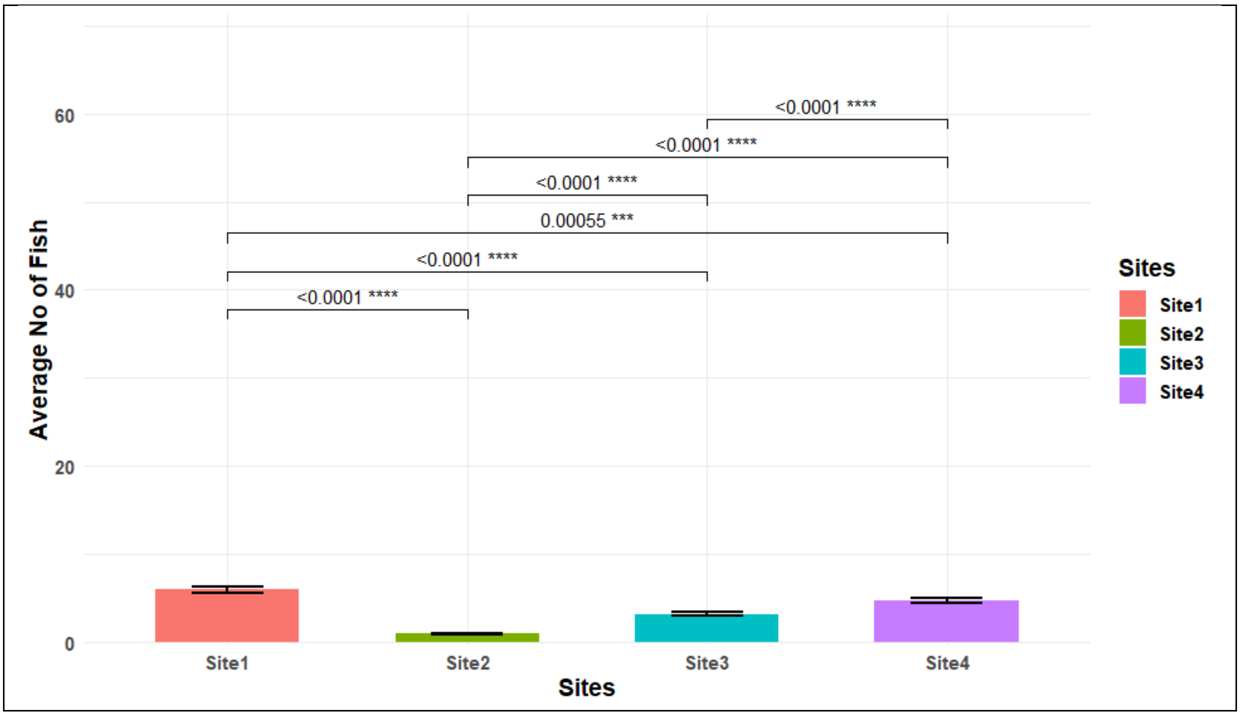

Figure 2- Result of One way ANOVA test for overall site wise distribution of fishes in four sites of Kolong river

The abundance of fishes varied from site to site. Site 1 showed significant difference in fish abundance with site 2, site 3 and site 4. On the other hand, Site 2 had shown significant difference with site 3 and site 4 (Figure 2).

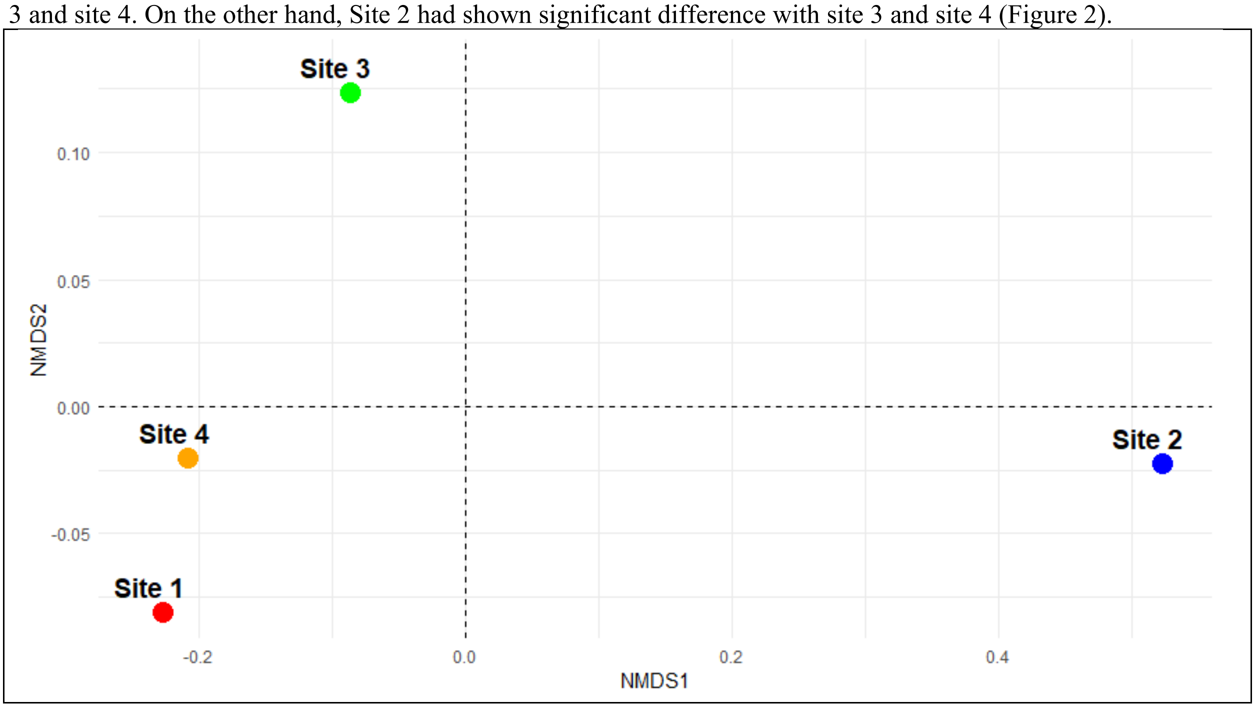

Figure 3- Non-metric Multidimensional Scaling (NMDS) analysis of fish abundance of the study sites of Kolong river

The abundance of fishes in Site 2 and Site 3 were significantly dissimilar than the other two sites, while the Site 1 and the Site 4 were less similar (Figure 3).

physico-chemical parameters of Kolong river:

Table 6: Values of Physico-chemical parameters (Mean ± Standard deviation) of Kolong river in site 1 during four different seasons

Water Parameters	Pre- Monsoon	Monsoon	Retreating Monsoon	Winter
Water temperature(˚C)	26.38 ± 0.02	29.41±0.01	23.72±0.02	20.93±0.01
pH	7.04±0.005	7.01±0.03	7.05±0.01	7.30±0.02
Transparency(cm)	46.19±0.01	44.29±0.01	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	101.05±0.01	106.20±0.03	98.50±0.04
Conductivity (µmhos/cm)	158.02±0.01	154.03 ±0.04	150.45 ±0.03	150.27±0.02
Chloride (mg/l)	9.04 ±0.04	20.22±0.03	30.35±0.02	19.95±0.04
Magnesium (mg/l)	46.05±0.02	49.51±0.04	31.42±0.01	29.54±0.06
Phosphate (mg/l)	0.64±0.01	0.66±0.02	0.63±0.01	0.59±0.03
Sulfate (mg/l)	6.6±0.02	7.35±0.4	6.01±0.01	4.59±0.04
DO (mg/l)	5.05±0.03	5.15±0.04	5.95±0.03	6.05±.01
BOD (mg/l)	5.42±0.03	5.03±0.01	4.26±0.01	4.05±0.01
COD (mg/l)	12.06±0.01	14.03±0.03	11.05±0.04	10.23±0.01

Table 7: Values of Physico-chemical parameters (Mean ± Standard deviation) of Kolong river in site 2 during four different seasons

Water Parameters	Pre-Monsoon	Monsoon	Retreating Monsoon	Winter
Water temperature(˚C)	26.22±0.03	30.44±0.02	20.59±0.04	18.15±0.03
pH	4.75±0.03	4.70±0.02	4.94±0.02	5.03±0.01
Transparency(cm)	49.54±0.01	35.02±0.01	68.91±0.02	67.25±0.03
Total alkalinity (mg/l)	60.03±0.03	65.20±0.03	74.23±0.01	81.43±0.01
Total hardness (mg/l)	50.69±0.01	47.02±0.01	74.60±0.03	76.41±0.01
Conductivity (µmhos/cm)	222.73±0.02	160.07±0.03	188.15±0.05	177.40±0.03
Chloride (mg/l)	10.02±0.02	23.92±0.01	26.23±0.02	24.44±0.02
Magnesium (mg/l)	24.96±0.03	49.24±0.02	41.41±0.02	32.63±0.02
Phosphate (mg/l)	0.66±0.02	1.50±0.03	1.48±0.02	0.96±0.02

Sulphate (mg/l)	6.5±0.02	8.97±0.02	6.25±0.03	4.01±0.04
DO (mg/l)	4.09±0.03	5.43±0.03	4.34±0.03	4.15±0.02
BOD (mg/l)	5.05±0.04	4.87±0.03	6.13±0.02	7.01±0.01
COD (mg/l)	32.64±0.03	29.25±0.01	25.23±0.02	23.15±0.02

Table 8: Values of Physico-chemical parameters (Mean ± Standard deviation) of Kolong river in site 3 during four different seasons

Water Parameters	Pre- Monsoon	Monsoon	Retreating Monsoon	Winter
Water temperature(˚C)	26.22±0.02	29.82±0.02	22.27±0.03	17.97±0.02
pH	5.08±0.01	4.46±0.01	5.20±0.01	5.61±0.02
Transparency(cm)	43.25±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	88.27±.01	102.135±0.03
Total hardness (mg/l)	86.66±.02	74.96±0.02	97.16±0.01	100.21±0.01
Conductivity (µmhos/cm)	120.92±0.01	100.28±0.01	101.02±0.2	105.30±0.01
Chloride (mg/l)	8.60±0.01	14.55±0.01	16.14±0.02	25.94±0.04
Magnesium (mg/l)	58.09±0.02	65.16±0.01	37.44±0.02	28.83±0.01
Phosphate (mg/l)	0.68±0.02	0.63±0.02	1.63±0.01	1.07±0.02
Sulphate (mg/l)	19.5±0.02	9.98±0.01	7.79±0.03	2.95±0.01
DO (mg/l)	6.30±0.04	6.50±0.04	5.01±0.02	5.15±0.01
BOD (mg/l)	5.90±0.02	5.29±0.02	5.22±0.01	5.13±0.03
COD (mg/l)	8.16±0.03	12.25±0.02	11.37±0.02	10.34±0.01

Table 9: Values of Physico-chemical parameters (Mean ± Standard deviation) of Kolong river in site 4 during four different seasons

Water Parameters	Pre- Monsoon	Monsoon	Retreating Monsoon	Winter
Water temperature(˚C)	27.02±0.04	29.23±0.02	27.62±0.02	16.99±0.01
pH	6.63±0.02	6.71±0.04	7.02±0.03	7.05±0.02
Transparency(cm)	51.03±0.02	42.01±0.03	70.02±0.02	71.41±0.03
Total alkalinity (mg/l)	50.03±0.01	53.13±0.02	72.21±0.03	81.18±0.02
Total hardness (mg/l)	50.65±0.01	45.05±0.03	64.05±0.4	68.12±0.03
Conductivity (µmhos/cm)	219.12±0.06	167.78±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	39.15±0.02	36.23±0.01	33.374±0.02
Phosphate (mg/l)	0.68±0.02	1.02±0.01	1.26±0.01	0.92±0.01
Sulphate (mg/l)	9.10±0.02	7.51±0.03	6.725±0.02	4.30±0.02
DO (mg/l)	6.6±0.02	7.04±0.02	6.24±0.02	5.59±0.03
BOD (mg/l)	6.70±0.04	6.12±.02	6.97±0.02	7.11±0.04
COD (mg/l)	4.08±0.03	6.32±0.01	8.01±0.06	8.76±0.01

As per the study, the temperature was recorded highest in site 2 and lowest value (16.99 ˚C) was observed in site 4. In site 2, the pH values did not fall within desirable limit (< 4.71). Minimum value was recorded in site 3 in monsoon season. The transparency values of all the sites indicated unclear water (< 60 cm), except in site 4 for some seasons. Likewise, the alkalinity values of site 2 were not within desirable limit (<75 mg/l), as per the study. The values of total hardness in all the sites were almost within the desirable limit (75-200 mg/l). Conductivity was within optimum limit (150-500 µmhos/cm). But the amount of Chloride in all the sites did not follow the same (98-107 mg/l). Magnesium levels were within the desirable limit (10-100 mg/l) throughout the study period. Monsoon and retreating monsoon seasons had shown undesirable phosphate values (Limit should be ≤1 mg/l) in site 2, site 3 and site 4. In Site 2, DO levels were less than 5 mg/l, indicating water pollution. In site 2, BOD level was higher. Maximum values of COD throughout the study period was recorded in site 2 and minimum value was recorded in site 4. The results depicted the present hydrochemical scenario of the river (Table 6, 7, 8 and 9).

Table 10: Coefficients for multiple linear regression model to predict fish abundance based on physico-chemical parameters of Kolong river

	Fish		
Predictors	**Estimates**	**CI**	**p**
BOD (mg/l)	2.11	-15.82 – 20.04	0.805
Chloride (mg/l)	0.07	-0.42 – 0.57	0.750
COD (mg/l)	-0.88	-3.90 – 2.14	0.542
Conductivity (µmhos/cm)	-0.68 **	-1.07 – -0.29	0.002
Dissolved Oxygen (mg/l)	12.05	-10.33 – 34.43	0.269
Magnesium (mg/l)	-1.24	-3.95 – 1.47	0.344
pH	35.00 **	14.55 – 55.45	0.002
Phosphate (mg/l)	0.74	-0.90 – 2.38	0.353
Pre-Monsoon	Reference		
Monsoon	110.99 **	51.59 – 170.39	0.001
Retreating Monsoon	-36.20	-95.96 – 23.56	0.216
Winter	-92.80 *	-173.10 – -12.50	0.026
Sulphate (mg/l)	-3.25	-11.09 – 4.60	0.392
Total alkalinity (mg/l)	-0.67	-2.02 – 0.67	0.301

Total hardness (mg/l)	0.31	-0.35 – 0.96	0.338
Transparency(cm)	1.70	-1.00 – 4.41	0.199
Water temperature(˚C)	-2.83	-11.24 – 5.58	0.484
Observations	32		
R2 / R2 adjusted	0.912 / 0.818		
* p<0.05 ** p<0.01 *** p<0.001			

The multiple linear regression model examined the relationship between various physico-chemical parameters and fish abundance in a site. Conductivity (μmhos/cm) and pH were found (Table 10) to have statistically significant effects on fish abundance, with coefficients of -0.68 and 35.00, respectively ($p < 0.01$). For every one-unit increase in conductivity, fish abundance is expected to decrease by 0.68, and for every one-unit increase in pH, fish abundance is expected to increase by 35.00. During the Monsoon season, fish abundance significantly increased by 110.99 units compared to the Pre-Monsoon season ($p < 0.001$). But during the winter season, fish abundance significantly decreased by 92.80 units ($p < 0.05$). BOD, Chloride, COD, Magnesium, Phosphate, Sulphate, Total alkalinity, Total hardness, Transparency and Water temperature did not show statistically significant effects on fish abundance. The overall model fit was strong, explaining approximately 91.2% of the variance in fish abundance of Kolong river (R^2 = 0.912), with an adjusted R^2 of 0.818.

DISCUSSION

The fishery potential of the polluted Kolong river was quite significant with the presence of 32 different species of fish, indicating a certain level of adaptability employed by these fishes in response to pollution. Samoguri site and Mayong Kajalimukh site were rich in fish abundance. These two sites were somewhat free from excessive anthropogenic utilization. Nagaon urban site showed lesser fish diversity and abundance. Anthropogenic pressure was maximum in that site. Bora and Goswami (2017) also concluded that Nagaon town was the most polluted site. In the present study, some species like- *Xenentodon cancila*, *Ompak pabda* and *Leiodon cutcutia* were found to be totally absent in this site during 2022-2023. This could be a matter of discussion for the future researchers. Interestingly, the presence of two critically endangered species, one endangered species and two nearly threatened species in such a disturbed ecosystem indicated a good sign from conservation point of view. Nagaon town site was significantly different from all the other sites in case of fish abunance as per ANOVA results. NMDS analysis in the present study also recorded dissimilarities between all the sites in case of fish abundance. Every site has different hydrochemistry and different anthropogenic utilization. Ronganodi river of Assam is also listed as a polluted river, but a study by Dohutia et al. (2023) had found the presence of 76 numbers of fish species in the river. This clearly portraits the alarming condition of the recent ecology of Kolong river.

As regards the physico-chemical parameters, it is noteworthy that almost all the sites showed unfavorable values of pH, transparency, chloride and phosphate values for fish survival. Addressing the primary source of the escalating pollution level is imperative to maintain the ecological equilibrium necessary for sustaining the fishery potential of Kolong river. Highest temperature was recorded in site 2 (Urban area) during monsoon season. Organisms can survive in an optimum temperature that nature had set to them, though some species have thermoregulation mechanism. Durham et al. (2006) reported that 5 fish species had died due to high water temperature (38˚C) on 9 July, 2002 in North Fork Ninnescah river. pH levels of Nagaon town site and Jagi-Bhakatgaon site not lie within optimum limit in the present study. Roberts and Palmeiro (2008) noted that fluctuations on water pH results in stress, lethargy, skin irritations, corneal edema, increased mucous production and mortality in fish. In the present study, transparency values also did not lie within desirable limit. Chapman et al. (2014) noted that a higher water transparency has a negative impact on feeding behaviour of fish. But, lower feed consumption had been noticed by Hasenbein et al. (2013) in fish that reside in very clear water. Chloride values indicate pollution in a water body. Higher amount of chlorides in water reacts with sodium and thereby increasing salinity total dissolved solid of water. Elevated phosphate level causes algal blooms, resulting in poor environment for fish. The BOD values of water best describe organic pollution. BOD values were found to be comparatively higher in Nagaon town site. This finding agrees with the findings of Kalita and hazarika (2019). Overall, the undesirable values of physico-chemical parameters in Nagaon town site indicate extreme anthropogenic pressure. It is important to analyze the impact of abiotic parameters on biotic parameters of water bodies. Therefore the present study documented the effects of hydrochemistry of Kolong river on its icthyofaunal resources. The Statistics confirmed that Conductivity and pH affected the fish abundance of Kolong River. Earlier, Smith et al. (1987) also concluded that elevated conductivity levels decreased the fish abundance of a polluted river. Fluctuation in pH also can affect the behavior, reproductive capability and even survival of fish.

Continuous assessment of the water chemistry of Kolong river is essential to ensure long term sustainability of its fish population. Therefore, the present study emphasizes the need of management of water quality to ensure the same. The alterations in physico-chemical parameters are indicative of environmental changes brought about by pollution. These changes have the potential to disturb the equilibrium of the Kolong river ecosystem. We have the opportunity to work together towards a future where polluted rivers like Kolong can once again thrive, showing the balance between nature and mankind. This is a legacy we can leave for the future generations.

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Conflict of Interest
The authors declare there is no conflict of interest.

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