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A study on seasonal and temporal variation in physico-chemical and hydrological characteristics of River Kolong at Nagaon Town, Assam, India

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ABSTRACT

Healthy natural ecosystem is an indispensable prerequisite of a hale and hearty society. Although the socio-economic, cultural as well as the political well-being of a region is directly correlated to a healthy and sustainable ecosystem, the mankind has relentlessly been tampering with these valued assets of nature for their comfort. Moreover, out of all the existing ecosystems it is a fact that aquatic ecosystem is the most imperiled one. Thus, it is the need of the hour to take some stern and state-of-the-art actions towards upholding the aquatic ecosystems of our environment. Like many other rivers of the world, the Kolong River of Assam is also going through a staid phase of degeneration as a result of human intervention, for the last half century. The objective of the present study is to reveal the ailing condition of the Kolong River along Nagaon town and to assess the change in the trend of its water quality parameters for a time interval of twenty years (i.e. 1992 to 2013). The results revealed that river discharge has diminished with time except for the peak monsoonal period. Similarly, few water quality parameters viz. Conductivity, total alkalinity, BOD, total hardness, calcium, magnesium and chloride has shown an increasing trend while pH, DO and phosphate evidenced a decreasing trend, which in turn highlighted the elevated level of pollution in the river. Thus, the temporal variations of water quality and hydrological variables have led to the escalating focus on work of river restoration and rejuvenation.

Keywords: natural ecosystem, aquatic ecosystem, Kolong River, human intervention, water quality

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INTRODUCTION

Previously, the socio-economic, political and cultural development has largely been related to the availability and distribution of freshwater riverine systems [1, 2]. In the recent years, in order to meet the needs of the swelling population, the freshwater ecosystems have been affected at an alarming rate all over the world. Centuries of over extraction, damming, diversion and pollution have reduced most of our rivers to meager phantom of their natural identity. We are now faced with the harsh reality that many of our rivers are in a very bad shape and a few of them already on the verge of extinction. Studies reflecting the impacts of land use, urbanization, or other development on riverine environment within rural, urban and industrial areas are being conducted globally from time to time [3, 4, 5, 6]. Currently, water quality management is one of the most exigent environmental issues in India. In order to develop and implement sustainable water-use management strategies, it is significant to draw information regarding quality of water and their probable pollution sources [7, 8, 9].

In the present study, river Kolong is selected for water quality evaluation as it is a preeminent example of a degraded river of Northeast India. Kolong, a by-channel of river Brahmaputra with a total length of about 250 km , originates from a place near Jakhalabandha(Nagaon district, Assam) in between two hills viz. Hatimura and Barjhap at latitude 26˚36'3"N and longitude 93˚5'7" E. It flows through the district of Nagaon and Morigaon and meets the Kopili River (a major south bank tributary of the Brahmaputra) near a village called Jagibhakatgaon and finally pours into the mighty Brahmaputra at Kajalimukh. The principal tributaries of Kolong are *Misa, Dizu, Haria* and *Digaru*. All these tributary channels are drawing runoff from the southern part of the basin (Figure 1). During the colonial period, Kolong River was the lifeline of the rural dwellers of its banks. Role played by Kolong River in determining the economy of the region is highlighted in Hunter's '*Statistical Account of Assam*' [10] (Hunter 1879) which mentions the sailing of ships through the heart of Kolong River between Silghat to Raha, thus serving as a vital economic link.

Unfortunately, as an aftermath of the 1950 Great Assam earthquake, there were topographical changes of river bed and its surroundings and as a result, the surrounding villages of the basin were subjected to flood inundation upto 1963. In 1963, a major part of Nagaon town itself as well as the Kolong Basin remained under flood water for about two months.

In order to mitigate the suffering of the people from the flood hazard, an emergency scheme in the name of *Nagaon town Protection* was taken up and completed in 1964 at the off take point of river Kolong in which an earthen dyke was constructed along south bank of Brahmaputra River between Hatimura hill and Barjhap hill across the mouth of the Kolong river. Consequently, the river is altered into a dead stream with trifling flow, especially in the upstream stretch up to Nagaon town, where the river flows only during the monsoon months. Although, the flood problem of the Kolong river basin after the construction of the above dyke was minimized but it has given rise to subsequent problems as mentioned below:

i. As the entry of water to Kolong River, was stopped by the dyke stated above, the flow in the lower reach of Kolong River was greatly hampered. As such, the rain water collected in the paddy fields on either side used to escape and channelize through Kolong. As a result, the cultivators in the basin suffer every year.
ii. In the past, Kolong river water was used for different purposes by a large section of rural population of the district. After the closure of the mouth of the Kolong River, the water became dirty and the villagers had to use the available dirty and contaminated water for their day to day use.
iii. The migration of fishes from Brahmaputra through Kolong was entirely stopped thus disturbing the auto-stocking capacity of the water-bodies, leading to low fish productivity.
iv. A river is a natural gift to the people of the surrounding areas, though it sometimes becomes cause of sorrow. Prior to 1963, the people of Kolong basin were economically developed having a rich cultural heritage. But due to closure of Kolong, the people of the basin have been deprived of the benefits of economic and cultural development.

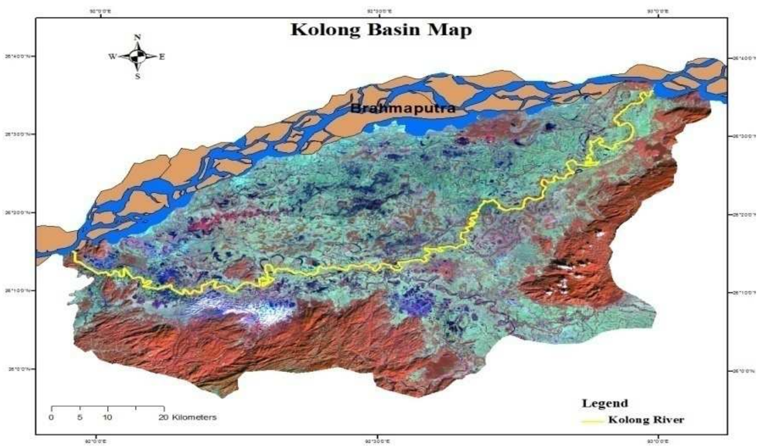

Figure1 Catchment Area of Kolong River

Presently, the Kolong River is semi-perennial in nature. Over the past fifty years, the river has dried, shallowed and polluted, reducing it to little more than an urban drain with negligible ecological value. Mounting demand of water for human consumption and irrigation has impacted the water quality of the river due to its moribund flow. Moreover, according to a study conducted by the Central Pollution Control Board during 1993 [11], the Kolong River is among the 71 most polluted rivers of India. The credible sources of pollution that have been identified among others are discharge of untreated waste water (both domestic as well as industrial) to the river at various places, floodplain surface run-off and direct dumping of solid waste into the river and its banks. Some of the prior studies have exposed the fact that, water-bodies especially freshwater reservoirs like rivers are most adversely affected by the wanton disposal of wastes into the ambient environment rendering them infertile and unproductive. An added reason for the river being slowly turned into a derelict channel by the public is the lack of basic civil amenities along the river bank. on one hand, the municipal corporation at-large is inept to treat the increasing load of municipal sewage flowing into the river, while on the other hand the receiving water body does not have sufficient water for their dilution.

Water quality of various rivers has been monitored from time to time and a worldwide deterioration of surface water quality has been observed which has been attributed to both natural and anthropogenic processes [12, 13, 14]. There are several studies relating to assessment of water quality of rivers in India as well [15, 16, 17] (Chetia et al. 2011; Haloi and Sarma 2011; Saikia and Gupta 2012). [18, 19, 20, 21, 22]Saikia and Sarma (2011); Khan and Hazarika (2012); Barbaruah et al. (2012); Bora and Goswami (2014) and Bora (2014) etc have conducted studies related to physico-chemical parameters of Kolong River from time to time. However, extensive studies pertaining to hydrological parameters of Kolong River are still lacking and in view of this, an attempt has been made here to explore this component.

In the present study, the river stretch which flows through the heart of Nagaon town is under consideration as this portion is the most significant economic and political centre of the catchment and the exclusive reason for blocking the river at source is to shield this region against flood hazard. Besides, the aforementioned region is the most exploited and polluted stretch of the entire river, which suffers acute environmental degradation due to tremendous demographic pressure as well as lack of sufficient flow and thus continues to impact the health and hygiene of the populace in the adjoining area. The objective of the present study is to assess variation in physico-chemical and hydrological quality of the river within a time-period of about two decades (i.e. 1991 to 2013), in order to determine its changing trend.

MATERIALS AND METHODS

The present study is based on primary as well as secondary datasets of consecutive years from 1991 to 2013. The river stretch near the old RCC Bridge at Nagaon Town was selected as the sampling station and sampling was done for pre-monsoon, monsoon and post monsoon seasons. Historical data regarding physico-chemical parameters were collected from a report of Central Pollution Control Board (CPCB, 1993), whereas historical river discharge data were collected from Kaliabor and Integrated Kolong Division, Irrigation Department, Govt. of Assam. Based on the availability of historical data, comparative study was conducted between values of pre-monsoon and monsoon seasons only in case of physico-chemical parameters whereas in case of hydrological parameters, values for the complete year was considered .Current observed values of water quality parameters viz. temperature, pH, electrical conductivity, chloride, alkalinity, total hardness, calcium, magnesium, DO, BOD, sulphate and phosphate were analyzed as per standard techniques following the procedure of APHA (2005) [23] and Trivedy and Goel (1986) [24].

The size of a river is signified by few hydrological parameters like river width, river depth, cross-sectional area and river flow. Cross-sectional area of a river channel at a particular section is the area craved out by the river to accommodate its flow, while flow of a river is the overall volume of water that fully occupies the channel. These measures of river size are linked up by a common equation known as the *continuity equation*, based on which discharge is measured. Discharge of the Kolong River was measured using the continuity equation which states that

$$Q = w \times d \times v$$

Where
Q= Discharge (measured in m^3s^{-1} or cumec)
w= Width of the channel (measured in meters, m)
d= Average depth of the channel (measured in meters, m)
v= mean velocity of flow through the channel cross-section (in ms^{-1}).

The observed values of various physico-chemical and hydrological parameters alongwith the historical data are tabulated. Finally, in order to determine the changing trend of river water quality, comparison is done among the present and past values and subsequently the results are shown in the form of graphs.

RESULTS AND DISCUSSION

The physico-chemical and hydrological dynamics of the river was studied and the results are presented in the form of tables and graphs given below:

1.1. Physico-chemical analysis: The concentrations of few commonly determined mineral constituents both anion and cations and other inorganic constituents of the river water of Kolong within the study site are summarized in Table 1 based on laboratory analytical data as well as historical data and are subsequently plotted in line graph.

Table 1 Seasonal and temporal variation of Physico-chemical parameters of Kolong River

Parameters	Pre-monsoon		Monsoon	
	1992	2013	1992	2013
pH	7.8	7.47	7.1	6.6
Conductivity (µS)	100	191	98	188.5
Temperature (˚C)	25	23	25	25
DO (mg/l)	6.1	6.08	5	0.81081
BOD (mg/l)	1.7	7.5	0.2	5.5
Total Alkalinity (mg/l)	60	300	48	220
Total Hardness (mg/l)	52	128	40	288
Calcium (mg/l)	9.6	24.048	12	27.2544
Magnesium (mg/l)	6.7	113.348	2.4	271.57
Chloride (mg/l)	4	96.56	6	53.96
Phosphate (mg/l)	7.6	0.0269	1.7	1.23
Sulphate (mg/l)	12	6.6395	17	27

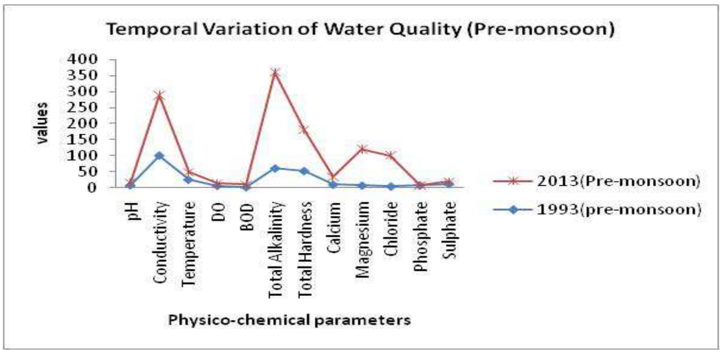

Figure2 Temporal Variation of Water Quality of Kolong River during pre-monsoon (1993 and 2013)

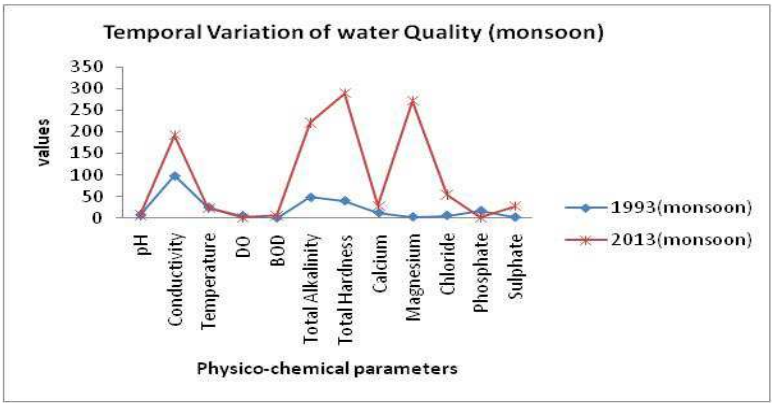

Figure3 Temporal Variation of Water Quality of Kolong River during monsoon (1993 and 2013)

1.2. Hydrological analysis: Total volume of water carried by a river varies from month to month. Flow rate of the river as a function of time at a given location on the stream is shown on a graph known as *discharge hydrograph* and a discharge hydrograph showing the change in river discharge throughout a year is termed as an annual hydrograph. The variability of discharge over the course of various years is represented by hydrographs for the respective years with mean monthly discharge plotted over the annual time scale as shown in Figure 4.

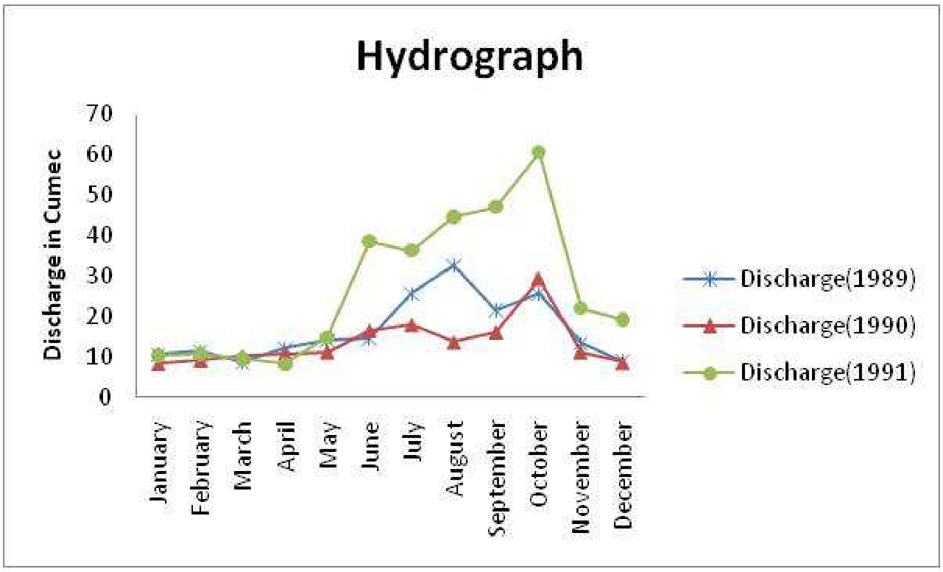

Figure4 Discharge Hydrograph of the Kolong River (1989, 1990, 1991 & 2013)

The results of physico-chemical as well as hydrological parameters are highly heterogeneous in temporal scale. It has already been mentioned that the mouth of the river at source has been closed by the State Flood Control Department in 1964, and consequently there is no direct link of the river with the mainstream of the Brahmaputra. Thus, the main source of runoff has been thwarted. There is a systematic fluctuation in seasonal rainfall in the region which in turn affects the river flow. The present discharge of the river Kolong is dependent partially on storm water and mainly on the tributaries of Misa, Dizu and Haria. Significant rainfall during pre-monsoon and monsoon (more than 70% of total annual rainfall) and alternate dryness during the lean seasons are the special features of the runoff and the hydrologic regime of the river. Hydrographs of different years depicts almost similar pattern (Figure 4), with feeble flow in the river up to the month of May and with the onset of monsoon stream flow increases markedly and again cease altogether during the post-monsoon season. During the monsoon season (May-October), the river gains its peak discharge in all the studied years with a maximum discharge value of 60.51 cumec recorded during October month of the year 1991.

It has been found from Figure 4 that in comparison to the previous years, pre-monsoonal discharge all through 2013 is quite low while the sample station experienced an enhanced monsoonal discharge with a peak discharge of 55.672 cumec during September 2013. This may be attributed to the fact that, discharge depends on both the depth and width of a stream channel, or more precisely, on the cross-sectional area of the channel. With time, the Kolong river bed has been silted and encroached with vegetation thus reducing the storage capacity of the river with rapid runoff, which is evident in the flow regime of the river, which experiences minimal flow during lean season (Jan-April and Nov-Dec) with sufficient peak discharge during monsoon (May-Oct) in the recent years in comparison to the early years (Figure 5).

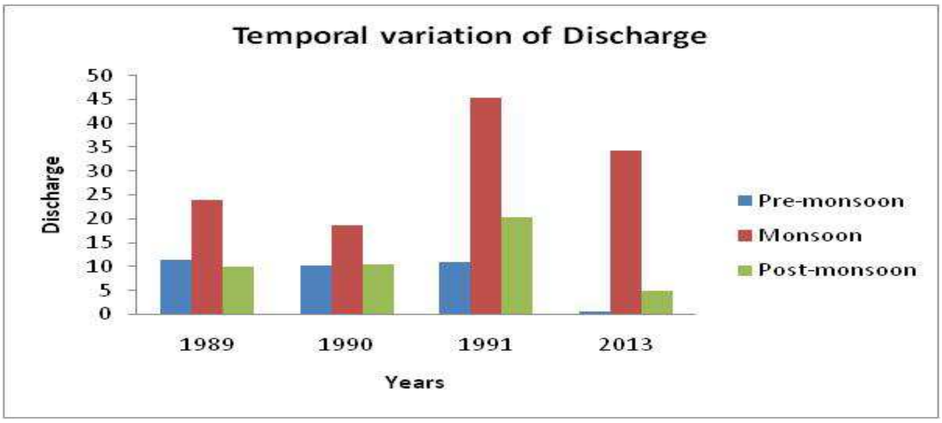

Figure5 Temporal variation of Discharge in Kolong River

Physico-chemical parameters have also shown a peculiar trend with time. It is evident from Table 1 that Physico-chemical parameters viz. conductivity, total alkalinity, total hardness, magnesium and chloride show enormous temporal variation in both the seasons.

a. **pH**: The pH was within permissible range of potable water, 6.5–8.5 (WHO, 1996) [25] in the study site during the study period. pH values ranged from 6.6 to 7.8.

b. **Conductivity**: The conductivity of water is a measure of capacity of a solution to conduct electrical current through it and depends on the concentration of ions and load of nutrients. As most of the salts in water are present in ionic forms, they make water capable for conducting current. The conductance of stream water is indirectly proportional to the river discharge. This has been shown by the fact that during pre-monsoon season the conductance values show higher concentration rates and during monsoon the values have declined, which means that during monsoon the stream might have been added with additional storm-water and thus caused dilution of the mineral concentration.

c. **Temperature**: Temperature range is almost equal in both the seasons for both the years. The uniform temperature range of 25˚C is quite convenient for better assimilation of wastes.

d. **DO**: Almost all plants and animals require oxygen to breathe and live. This is true for aquatic species as well, and oxygen is present in water in a dissolved form. Oxygen is measured in its dissolved form as dissolved oxygen (DO). If more oxygen is consumed than is produced, dissolved oxygen levels decline and some sensitive animals may move away, weaken, or die. The dissolved oxygen level of the studied stretch is within primary water quality criteria (5≤) in terms of designated best use for drinking water and outdoor bathing except for monsoon of 2013 when DO values are quite low i.e. 0.81081mg/l. A DO level >2 mg/L is required in order to prevent anaerobic conditions that can cause bad odors, which is not met during monsoon 2013. In this context it may be stated that within the Nagaon town many urban drains and household outlets have been directly connected with the river Kolong. Thus, the river receives wastewater and sewage through them although it has been used for the two aforementioned purposes.

e. **BOD**: Biochemical oxygen demand, or BOD, measures the amount of oxygen consumed by microorganisms in decomposing organic matter in stream water.BOD values have increased markedly during the year 2013 when compared to those of 1993. The BOD concentrations were higher than the permissible limit of 3 mg/L at the studied site in both the season during 2013. BOD directly affects the amount of dissolved oxygen in rivers and streams. The greater the BOD, the more rapidly dissolved oxygen is depleted in the stream. This means less oxygen is available to higher forms of aquatic life. Further, organic matter of river water when oxidized at the expense of oxygen, the BOD concentration increases with decrease in DO. This is the case in river Kolong.

f. **Chloride**: Concentration of chloride in the river water has increased noticeably in 2013 as compared to 1993 but the values are within the standard values (250mg/l). Chloride concentration in water indicates the presence of organic waste in water which may be attributed by the sewage disposal from the households present near the river bank.

g. **Total Hardness**: Capacity of water for reducing and destroying the lather of soap is known as its hardness. It is total concentration of calcium and magnesium ions. Total hardness values showed an increasing trend but are below the standard value (300mg/l) during both the years. River water is found to be hard i.e. hardness is between 150 to 300 mg/l during the year 2013 while it was soft to moderately hard during 1992 i.e. values are within 0 to 150mg/l.

h. **Magnesium**: Magnesium concentration exceeds the permissible limit of 100mg/l set by WHO (WHO, 2004) during both the seasons in 2013 while values were much below standard value of 30mg /l during both the seasons in 1992.

i. **Calcium**: Concentrations of calcium have also amplified in the course of time, but the values were well below permissible limit of 200mg/l.

j. **Total Alkalinity**: Capacity of water to neutralize acid is known as its alkalinity. Presence of carbonates, bi-carbonates and hydroxide compounds of Ca, Mg, Na and K are responsible for the alkalinity of river water. Total alkalinity also showed an increasing trend with the values exceeding the standard value of 120mg/l during 2013 while values are less than standard values during 1993. In our case, total alkalinity values are more than total hardness in all the seasons indicating the presence of basic salts of Na, K along with Ca and Mg except during 2013 monsoon when total alkalinity is less than total hardness indicating the presence of neutral salts of calcium and magnesium.

k. **Phosphate** and **sulphate** concentration are within the permissible limits during both the study years.

The overall water quality of the river is not in acceptable order. Few parameters viz. Conductivity, BOD, Total alkalinity, Total hardness, Calcium, Magnesium and chloride shows an elevated level during 2013 as compared to 1993 during both the seasons, whereas values of parameters like pH, DO, Phosphate and Sulphate were found to be lower during 2013 than in 1993during both the seasons. Increasing trend of BOD and decreasing trend of DO in the study area reveals that there is a rise in organic pollution in the study area. The present studies indicate increase in water pollution levels in the River Kolong due to discharge of various types of waste water, sewage and effluents.

In this context it should be noted that the Kolong system is the only natural water course flowing through densely populated urban centre of Nagaon and thus it receives tons of garbage, wastewater, sewage and human excreta directly and indirectly through household and urban drains.

CONCLUSION

The most critical aspect of the river is the curtailed discharge and velocity, which has caused severe damage to the water quality of the river in terms of self-assimilation and self-purification capacity. Consequently, for restoring the identified highly polluted stretch ‘discharge augmentation scheme’ is must for regulating proper flow. The thickly populated Nagaon Town area has its greatest adverse impact on the water quality of Kolong River. Therefore, stretch of the river in and around the township of Nagaon should be selected for protecting the water course from any ill effect due to human activities so that the desired water quality may be maintained.

Thus, resolution of this multifaceted problem requires integrated knowledge base covering various interdisciplinary fields. It is undoubtedly a great challenge for the people of the region and the government to rejuvenate the Kolong river and bring back its lost vigour and resourcefulness.

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