Biodiversity Assessment Of River Singla In Karimganj District Of Assam: A Survy Of Fish Species Composition And Water Quality.

Dr Satyajit Das[1]*, Kakoli Chanda[2]

[1*]Assistant Professor, Department of Zoology, Lumding College.
[2] Research Scholar, Department of Life Science and Bioinformatics, Assam University, Silchar

***Corresponding author:** Dr Satyajit Das
*E-mail: satyajitdasaufm@gmail.com

Abstract
The present investigation has been carried out to examine the water chemistry and ichthyofaunal diversity of River Singla in Karimganj district of Assam during the study period from 2018-2020. The water chemistry parameters include Air Temperature (AT), Water Temperature (WT), Turbidity, pH, Dissolved Oxygen (DO), free Carbon-di-Oxide (FCO_2), Total Alkalinity (TA), Total Hardness (TH), Conductivity (Cndvty), Nitrate (NO_3), Phosphate (PO_4) etc. and were estimated by following standard procedure of American Public Health Associatio (APHA). During the investigation period, the ichthyo species were collected by using different experimental fishing gears such as gill nets, cast nets, drag nets, triangular scoop nets and a variety of traps etc. The fishes were preserved in formaldehyde solution and were then identified by following standard literature and keys. During the study period the averages of the parameters in three different seasons such as AT and WT were found to be within a range from 22±1.180C to 33.6±0.50^{0}C and 18±0.70^{0}C to 25.4±0.50 ^{0}C resp; pH and TA fluctuated between 6.68±0.10 to 7.98±0.11 and 34±1.58 mg/L to 58.4±0.92 mg/L resp.; the value of DO and FCO_2 portrayed a range of 7.12±0.13 mg/L to 8.24±0.19 mg/L and 1.68±0.12 mg/L to 3.16±0.13 mg/L; the TH and conductivity ranges from 40.4±0.6 mg/L to 65.4±0.81 mg/L and 99.4±0.92 µmohs/cm to 187.4±1.98 µmohs/cm respectively. In addition, the value of nitrate and phosphate has been recorded as 0.096±0.00 mg/L to 0.354±0.01 mg/L and 0.29±0.01 mg/L to 0.516±0.02 mg/L respectively. The ichthyofaunal diversity revealed a total of 58 species of fishes belonging to 42 genera, 20 families and 8 orders have been recorded from River Singla during the study period. Orderwise cypriniformes (43%) reflected highest abundance, while Clupeiformes and beloniformes reflected least abundance (2% each).

Keywords: Abumdance, diversity, ichthyo species, investigation, Parameters, River Singla, Water Chemistry.

Introduction

The dependence of man on the biological wealth of lakes, wetlands, rivers, oceans etc., could not be over emphasized. But the fast expansion of individual inhabitants and increased demand for water and its bio-resources had been resulting in further loss of stream habitat which had lead to aquatic organisms becoming less abundant. In order to discontinue further dreadful conditions of the fragile ecosystem, there was a need of integrated and accelerated effort towards ecological renovation and conservation (Kar *et al.*, 2003 a; Kar, 2007; Kar, 2013).

Freshwater biodiversity constitutes a vitally important component of our planet, with a species richness that was relatively higher compared to both terrestrial and marine ecosystems (Kar, 2007). The freshwater ecosystem supports various orders of animals, plants and fungi contributing to a big portion of the biota consisting of animals, plants and microbes.

India is one of the Mega biodiversity countries in the World and occupies 9th position in terms of freshwater Mega biodiversity (Goswami and Goswami, 2006). In India, there are *c* 2500 species of fishes; of which, *c* 930 live in freshwater (FW) and *c* 1570 are marine (Kar, 2003, 2007). The bewildering biodiversity of North-Eastern region has been attracting many ichthyologists both from India and abroad.

oncomitantly, North-Eastern region of India has been identified as a `Hotspot' of Biodiversity' by the World Conservation Monitoring Centre (WCMC, 1998). This rich diversity of the region can be assigned to certain reasons, notably, the geomorphology and the tectonics of this zone. The hills and the undulating valleys of this area give rise to large number of torrential hill streams, which lead to big rivers; and, finally, become part of the Ganga-Brahmaputra-Barak-Chindwin-Kolodyne-Gomati-Meghna system (Kar, 2000, 2007, 2013).

Fishes are primarily adapted, cold blooded, aquatic vertebrates which breathe by means of pharyngeal gills, propelling and balancing themselves by means of fins. They make up most of the abundant class of vertebrates, both in terms of number of species and of individuals.

Fishes have great significance in the life of mankind, and, are the staple food item in the diet of many consumers throughout the world. They form an important economy of many nations and give incalculable recreational value to the naturalist, sports enthusiast and home aquarist. Fishes play important role directly or indirectly in the heritage of human beings. At the same time, the explosion of human population and increased demand for water and its bio-resources have

been resulting in further loss of stream habitat that leading to aquatic organism becoming less abundant particularly the fisheries resources. Integrated and accelerated efforts are essential towards environmental restoration and preservation in order to stop further degradation of these fragile ecosystems (Kar *et al.,* 2003 b; Kar, 2007; Kar, 2013).

Fishes are the most diverse of the vertebrate taxa and are distributed in a wide range of aquatic environments (Bone and Marshall, 1982; De Silva *et al.,* 2007). Of the bewildering diversity of 39,900 vertebrate species known to exist so far, almost half *i.e.* 21,723 species are living species of fishes. Out of them, *c* 8,411 species are of freshwater fishes and the rest 11,650 are marine species. In the Indian region alone, of the 2,500 fish species, 930 are freshwater inhabitants and 1,570 are marine (Jayaram, 2010; Kar, 2007; Kar 2013).

North Eastern region of India, covering *c* 2, 62,379 sq. km. area have been classified into two bio-geographic zones-Eastern Himalaya and North East India, based on floristic and faunistic composition, and the local climate (Rodgers and Panwar, 1988). The North Eastern (NE) region of India lies between 22°00´N to 29°5´N latitude and 88°00´E to 97°30´E longitudes, and shares international border with Bhutan, China, Myanmar and Bangladesh. The NE region of India represents important part of Indo-Myanmar bio-diversity hotspot and the fish fauna of North East India are one of the richest in India and especially noted for the torrential species.

This rich diversity of the region could be assigned to certain reasons, notably, the geo-morphology and the tectonics of this zone. The hills and undulating valleys of this area give rise to large number of torrential hill streams, which leads to big rivers and that finally, become part of the Ganga-Brahmaputra-Barak-Chindwin-Kolodyne-Gomati-Meghna system (Kar *et al.*, 2002 a, 2007, 2013).

Water is one of the nature's most important gifts to mankind, and, is essential and most precious commodity for life. Rivers are vital freshwater systems and are essential for the sustenance of life. The entire territory of Mizoram state forms a complex hill system with varying elevation, traversed throughout by a number of rivers and rivulets. The drainage system of the state provides main water resources for domestic, industrial and agricultural purposes, in addition to serving as potential habitats for fish and other aquatic biota.

Water quality deals with the study of physical, chemical and biological characteristics in relation to all other hydrological properties. Any characteristic of water that affects the survival, growth and production of aquaculture species, influences management decisions, causes environmental impacts or reduces product quality and safety (Dutta, 2011).

Materials And Methods

3.1. Study Sites

River Singla originates from hills of Mizoram, at a height of 365.21m MSL and joins with river Kushiara in Karimganj District of Assam. It is located within a geographical location of 240 36' 49" N and 920 24' 50" E. The river Singla enters Sone Beel after traversing a meander course of 62.75 km. The outlet of Sone Beel, River Kachua joins the bigger river Kushiara after covering a length of about 19.30 km. Although the river Kachua was blocked by a blind dam constructed by the government of Assam during 1950-51, the dam was replaced by a lock gate in in 1964 after experiencing navigational and fishery problems; and, the major outflow was partially diverted through a channel called Khagra, which joins river Longai in the sub-urban region of Karimganj.

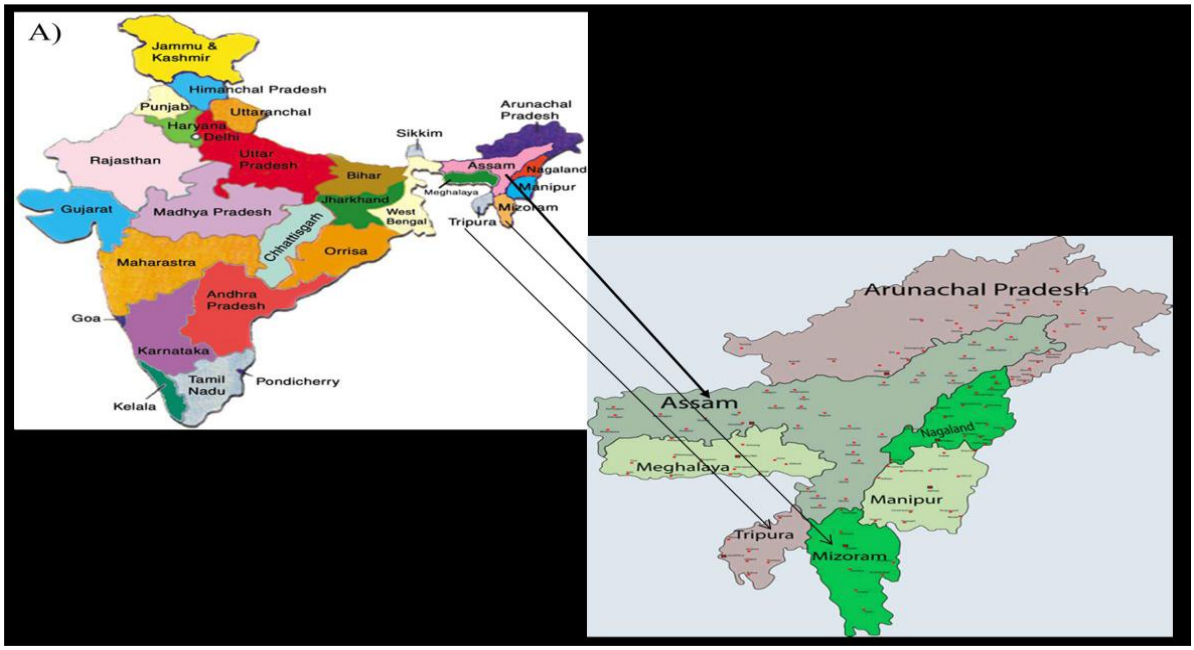

Figure .1: Map of India showing North-Eastern Part and in Map of North-East showing Assam, Tripura and Mizoram.

3.2. Physico-Chemical Parameters of Water

The physico-chemical parameters, such as, Air Temperature (AT), Water Temperature (WT), Turbidity, pH, Dissolved Oxygen (DO), Free Carbon-di-Oxide (FCO_2), Total Alkalinity (TA), Total Hardness (TH), Conductivity (Cndvty), Nitrate (NO_3) and Phosphate (PO4) were estimated after APHA (1995, 1998, 2010).

In the field, temperature was measured with the help of a Mercury-in-glass celsius thermometer; pH was measured with the Qualigens-make Indikrom wide range pH-papers (pH 2.0-10.5), turbidity was measured with help of standard turbidity rod. In the laboratory, pH was measured with Systronics made digital pH meter Type-335, turbidity was measured with Systronics made digital Nephelo-Turbidity meter Type-131, conductivity was measured with Systronics made D.D.R. Conductivity pH meter Type-335, D.O. was measured with both Systronics made digital Dissolved Oxygen meter Type-312 and Winkler's Iodometric titration method (Welch (2003), FCO_2 and T.A. were also measured with the Titration method of Welch (2003) using Phenolphthalein and Methyl Orange as indicators. Phosphate was measured with Stannous Chloride method (APHA, 1998, 2010) and nitrate was measured with the Brucine method (APHA, 1998, 2010) using Systronics made Spectrophotometer Type-105.

3.3. Fish Sampling

General survey of the fish biodiversity was done using standard procedures (Armontrout, 1990). Fish samples were collected from the studied rivers during 2018 to 2020 through experimental fishing; using cast nets (dia.3.7 m and 1.0 m), gill nets (vertical height 1.0 m- 1.5 m; length 100 m -150 m), drag nets (vertical height 2.0 m), triangular scoop nets (vertical height 1.0 m) and a variety of traps and with hook and lines in certain places (where netting is not possible). Camouflaging technique was also used to catch the fishes. Fishes were also collected from certain fish landing centers situated around the collection sites. Local people were involved in the netting and also in the fish collection. Sampling sites of the fishes were based mainly on the micro-habitats and substrate types of the rivers. The geographical coordinates of each site were recorded with the help of a Garmin GPS.

3.4. Fish Preservation and Identification

Fish species had been preserved, at first, in concentrated Formaldehyde in the field. After that, the fishes were transferred to laboratory and preserved in 10 % formalin. The small size fishes were preserved in 5% aqueous formalin solution and big size fishes in 10% aqueous formalin solution and kept in the air-tight plastic bottles.

In the laboratory, the fishes were identified by following standard literature, notably, Day (1873, 1878, 1885, 1889), Misra (1976), Roberts (1978, 1989), Rainboth (1996), Sen (1982, 1985, 2000), Talwar and Jhingran (1991), Jayaram (1981, 1999, 2010), Nath and Dey (1997, 2000), Vishwanath (2000, 2002), Vishwanath and Singh (1986, 1987), Vishwanath and Sarojnalini (1988), Vishwanath and Kosygen (1999, 2000a, 2000b. 2001), Vishwanath and Linthoigambi (2007), Vishwanath *et al.* (1987, 1998 2007) and Kar (2007, 2013) and www.fishbase.org. The conservation status of the collected fish species were assessed as per IUCN (2012, 2014). All the fishes were kept in the Assam University Fish Museum (AUFM) for preservation and record. After labelling the fishes were drawn and photographed with the help of digital camera (Nikon Coolpix L-810).

3.5. Traditional Fish Catching Devices

The fishing techniques were classified based on Dey (1981), Brandt (1980), Kar (1990, 2007, 2013), Kar and Dey, (1991, 1993). Kar *et al.*, (1999, 2005, 2007, 2008, 2009). Suggestion(s) of the local stakeholders had been obtained regarding Management and conservation of the Rivers and their bio-resources.

3.6. Measures of Biodiversity

Shannon-Weiner Index (H/) (Shannon-Weiner, 1949); Simpson index of diversity (1-D); Simpson dominance index (D); Species richness; species evenness (Pielou, 1966) etc. have been described for analyzing the species diversity.

3.7. Statistical Analysis packages

All the statistical analysis were carried out using Microsoft Office Excel 2007, XL Stat-Pro, R and SPSS 19.

3.8. Software's used

1. Microsoft Office word 2007 and 2010: Used basically for the Text typing, Graph preparation and Statistical Analysis.
2. GPS Garmin Software for input of latitude and longitude in the map.
3. SPSS 19: Statistical Analysis.
4. Microsoft Office Excel 2007, Microsoft Office PowerPoint 2007.

4. Results And Discussion

4.1. (i) Physico-chemical parameters of water of the studied river

Water is the universal basic liquid on which the dynamics of a water body and thereby the life of the biota in it depends. The present study of physico-chemical parameters of the Rivers revealed the details of the following parameters.

4.1.1 Air Temperature (AT) (^{0}C): The air temperature (AT) often had an impact on chemical concentration. The temperature of air plays a significant role in the regulation and distribution pattern of biotic communities.

4.1.2 Water Temperature (^{0}C): Water temperature (WT) had been identified as the primary abiotic factor controlling key physiological, biochemical and life history processes of fishes (Beitinger *et al.*, 2000). WT alters the physico-chemical condition of water. The rise in temperature of the water leads to the speeding up the chemical reactions in water and reduces solubility of gases.

4.1.3 pH: The term pH is the negative logarithm of hydrogen ion concentration. The pH of a water body is very important in determination of the water quality since it affects other chemical reactions such as solubility and toxicity of metals.

4.1.4 Dissolved oxygen (mg/L): Dissolved Oxygen (DO) is an important limnological parameter indicating level of water quality and organic pollution in the water body. The value of DO is significant in determining the water quality criteria of an aquatic system.

4.1.5 Free Carbon-dioxide (mg/L): Free carbon dioxide (FCO2) dissolves in water in varying amounts and the dissolution depends on partial pressure and temperature. FCO2 plays an important role in water bodies by producing calcium bicarbonate from calcium carbonate and this gas alters the pH of water by reacting with it to form carbonic acid. It was the basic raw material of photosynthesis in aquatic ecosystems.

4.1.6 Total alkalinity (mg/L): The value of total alkalinity (TA) provides idea of natural salts present in water (Gawas *et al.*, 2006). Alkalinity of water is its capacity to neutralize a strong acid to a designated pH; or stated in another way, it was the quantity and kind of compounds present, which collectively shift the pH to the alkaline side of neutrality (Kar, 2007, 2013).

4.1.7 Turbidity (NTU): Turbidity is the water parameter, which affects the transparency or light scattering of the water. Turbidity is the measure of the relative clarity of water. Sources of turbidity include solids such as clay, silt, plankton, industrial waste, sewage, and microorganisms.

4.1.8 Transparency (cm): Transparency is the cleanliness of an aquatic ecosystem. Transparency helps to measure the presence of particles present in water due to which the productivity of the water body differs from each other. More is the transparency, more is the penetration of sunlight into the water, resulting high productivity.

4.1.9 Total hardness (mg/L): Total hardness (TH) is an important parameter to fish culture and is a commonly reported aspect of water quality. Water hardness had a direct impact on fish health. Water hardness refers to the concentration of metal ions in the water. It measured the quantity of divalent ions such as calcium and magnesium in water.

4.1.10 Conductivity (µmhos/cm): Conductivity measures the capacity of water to convey electric current. Conductivity of water varies directly with the temperature and it was proportional to its dissolved mineral matter content.

4.1.11 Nitrate (mg/L): Nitrates (NO3-) occur in small amounts in all aquatic environments and were required to maintain the growth and metabolism of plants and animals. The levels of phosphates and nitrates heavily impact the overall health of the freshwater fishes and its inhabitants (Yanamadala, 2005).

4.1.12 Phosphate (mg/L): Phosphate has an important role in the maintenance of overall health of the fishes of a water body and their habitat. Excess of phosphate level become detrimental resulting in over fertilization of aquatic plants and may cause eutrophication.

Physico-chemical parameters of water of river Singla

The samples were collected from different study sites during pre-monsoon, monsoon and post monsoon seasons of the study period from 2018 to 2020. The analysis of some of the parameters was carried out in the field and others in the laboratory. The average values (mean ± standard error, n = 5) of the parameters of three seasons from 2018 to 2020 are tabulated below (Table 1; Figure. 2). From the observation, it has been found that, AT and WT ranged from 22±1.180C to 33.6±0.500C and 18±0.700C to 25.4±0.50 0C respectively. pH and TA fluctuated between 6.68±0.10 to 7.98±0.11 and 34±1.58 mg/L to 58.4±0.92 mg/L respectively. The value of DO and FCO2 portrayed a range of 7.12±0.13 mg/L to 8.24±0.19 mg/L and 1.68±0.12 mg/L to 3.16±0.13 mg/L respectively. The TU and Transparency value has been recorded within the limit of 33±0.70 NTU to 68.4±1.16 NTU and 22.8±0.66 cm to 32.4±1.2 cm respectively. TH and conductivity of water depicted a range of 40.4±0.6 mg/L to 65.4±0.81 mg/L and 99.4±0.92 µmohs/cm to 187.4±1.98 µmohs/cm respectively. In addition, the value of nitrate and phosphate has been recorded as 0.096±0.00 mg/L to 0.354±0.01 mg/L and 0.29±0.01 mg/L to 0.516±0.02 mg/L respectively.

Table 1. Mean year wise values of Physico-chemical parameters of water of river Singla in different seasons during study period

River Singla, (mean ± SE, n=5)			
Parameters	**Pre-monsoon**	**Monsoon**	**Post-monsoon**
AT (^{0}C)	32.2±0.86	33.6±0.50	22±1.18
WT(^{0}C)	25.4±0.50	25±0.83	18±0.70
pH	7.02±0.06	7.98±0.11	6.68±0.10
DO (mg/L)	7.86±0.10	8.24±0.19	7.12±0.13
FCO2(mg/L)	2.64±0.07	1.68±0.12	3.16±0.13
TA(mg/L)	39.6±1.5	58.4±0.92	34±1.58

TU(NTU)	51±0.70	68.4±1.16	33±0.70
Transparency (cm)	26.4±0.67	22.8±0.66	32.4±1.2
TH(mg/L)	46.14±1.5	65.4±0.81	40.4±0.6
Conductivity(µmohs/cm)	129.6±0.81	187.4±1.98	99.4±0.92
Nitrate(mg/L)	0.096±0.00	0.354±0.01	0.156±0.01
Phosphate(mg/L)	0.402±0.01	0.516±0.02	0.29±0.01

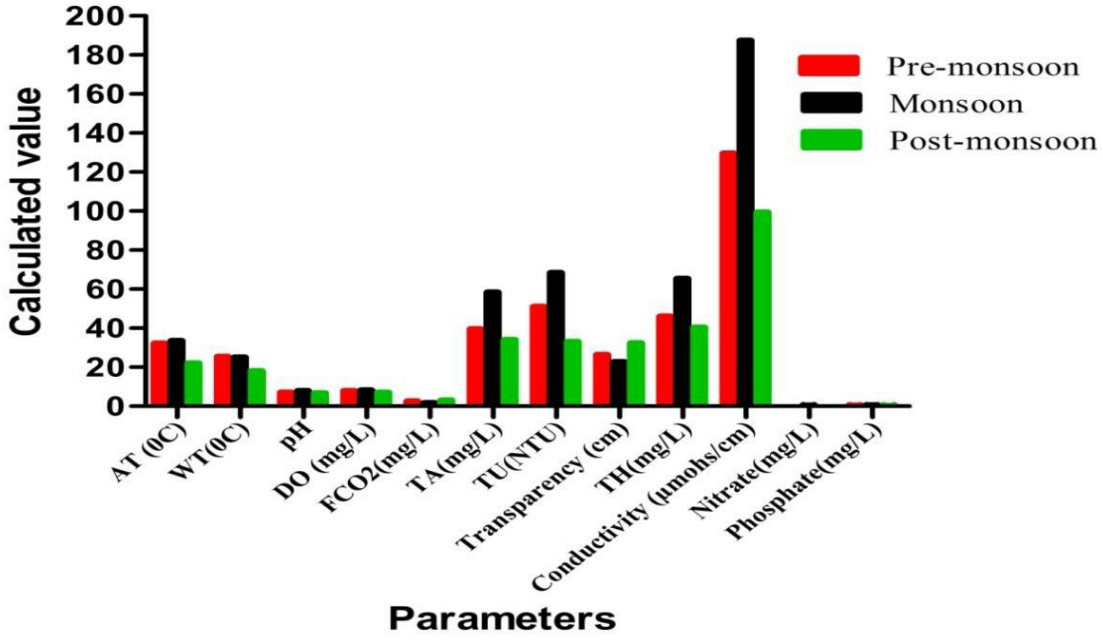

Figure. 2. Seasonal variations of physico-chemical parameters of water of river Singla during the study period.

4.1. (ii). a. Fish diversity of River Singla

Altogether 58 species of fishes belonging to 42 genera, 20 families and 8 orders have been recorded from River Singla during the study period (Table 2). Orderwise cypriniformes (43%) reflected highest abundance, while Clupeiformes and beloniformes reflected least abundance (2% each) (Figure 3). Familywise abundance of fishes portrayed highest value for Cyprinidae followed by mastacembelidae and chandidae. Incidentally, fishes belonging to clupeidae, claridae, belonidae, synbranchidae, gobiidae, anabantidae, belonidae and tetradontidae reflected very less abundant (Figure 4).

b. Fish Species Richness and diversity indices:

These indices reflect the richness and diversity status of the fishes in the studied rivers. Results indicated variations in the various values in different rivers indicating their diverse nature. Calculations based on different formulae in standard literature have been done and presented in the following tables.

Results (Table.3.) indicated that, Species Richness (SR) and Evenness (e^) portrayed range of 24.43 to 47.32 and 0.59324 to 0.68653 respectively. On an overall basis, monsoon season reflected higher SR. Among the diversity indices, Shannon- Weiner index (H/) and Simpson Index of Diversity (1-D) portrayed range values of 1.72 to 1.83 and 0.797917 to 0.829794 successively.

Table.2. Ichthyospecies diversity and their incidence [presence(+) and absence (-)] of River Singla during the study period.

Sl no.	Order	Family	Scientificname	Pre monsoon	Monsoon	Post monsoon	Conservation Status (IUCN)
1	Osteoglossiformes	Notopteridae	*Notopterusnotopterus(Pallas,1769)*	-	+	-	LC
2			*Chitalachitala*(HamiltonBuchanon,1822*)*	-	+	-	NT
3	Clupeiformes	Clupeidae	*Gudusiachapra*(Hamilton-Buchanan, 1822)	+	+	+	LC

4	Cypriniformes	Cyprinidae	*Salmophasiabacaila*(Hamilton-Buchanan, 1822)	+	+	+	LC
5			*Cabdiomorar*(Hamilton-Buchanan,1822)	+	-	+	LC
6			*Bariliusbendelisis*(Hamilton-Buchanan, 1807)	+	+	+	LC
7			*Bariliusbarna*(Hamilton-Buchanan,1822)	+	+	+	LC
8			*Bariliusbarila*(Hamilton-Buchanan,1822)	+	+	+	LC
9			*Esomusdanricus*(Hamilton-Buchanan,1822)	+	+	+	LC
10			Devarioaequipinnatus(McClelland,1839)	-	+	-	LC
11			Amblypharyngodonmola(Hamilton-Buchanan, 1822)	+	+	+	LC
12			Neolissochilushexagonolepis(McClelland, 1839)	-	-	+	NT
13			Puntiussophore(Hamilton-Buchanan,1822)	+	+	+	LC
14			Puntiusticto(Hamilton-Buchanan,1822)	+	+	+	LC
15			Pethiaconchonius(Hamilton-Buchanan, 1822)	+	+	+	LC
16			Cirrhinusmrigala(Hamilton-Buchanan, 1822)	-	+	+	LC
17			Cirrhinusreba(Hamilton-Buchanan, 1822)	+	-	+	LC
18			Catlacatla(Hamilton-Buchanan, 1822)	-	+	-	LC
19			Labeorohita(Hamilton-Buchanan,1822)	+	+	-	LC
20			Labeogonius(Hamilton-Buchanan, 1822)	-	+	-	LC
21			Labeocalbasu(Hamilton-Buchanan,1822)	-	+	-	LC
22			Crossocheiluslatius(Hamilton-Buchanan, 1822)	+	-	+	LC
23			Garragotylagotyla(Gray, 1830)	+	-	+	LC
24			Garra kempiHora,1921	-	-	+	LC
25			Garralissorhynchus(McClelland, 1842)	+	-	+	LC
26		Cobitidae	Botiadario(Hamilton-Buchanan, 1822)	+	+	+	LC
27			Botiarostrata(Hamilton-Buchanan,1822)	+	+	+	VU
28			Lepidocephalichthysguntea(Hamilton-Buchanan,1822)	+	+	+	LC
29	Siluriformes	Bagridae	Mystusvittatus(Bloch, 1794)	+	+	+	LC
30			Mystuscavasius(Hamilton-Buchanan,1822)	+	+	+	LC
31			Mystusbleekeri(Day,1877)	+	-	+	LC
32			Mystustengara(Hamilton-Buchanan, 1822)	+	-	+	LC
33		Siluridae	Ompokbimaculatus(Bloch,1794)	-	+	-	NT
34			Wallagoattu(BlochandSchneider,1801)	-	+	-	NT
35		Schilbeidae	Ailiacoila(Hamilton-Buchanan,1822)	+	-	+	NT
36			Eutropiichthysvacha(Hamilton-Buchanan,	+	-	+	LC

			1822)				
37		Sisoridae	Gagatagagata(Hamilton-Buchanan, 1822)	-	+	+	LC
38			Gagatacenia(Hamilton-Buchanan, 1822)	-	+	+	LC
39			ErethistespusillusMullerandTroschel,1849	-	-	+	LC
40			Glyptothoraxtelchitta(Hamilton-Buchanon, 1822)	-	-	+	LC
41		Claridae	Clariasbatrachus(Hamilton-Buchanan,1822)	+	+	+	EN
42		Heteropneustidae	Heteropneustesfossilis(Bloch,1794)	+	+	+	LC
43	Beloniformes	Belonidae	Xenentodoncancila(Hamilton-Buchanan, 1822)	+	+	+	LC
44	Synbranchiformes	Synbranchidae	Monopteruscuchia(Hamilton-Buchanan, 1822)	+	-	+	LC
45		Mastacembelidae	Macrognathusaral(BlochandSchneider, 1801)	+	-	+	LC
46			Macrognathuspancalus(Hamilton-Buchanan, 1822)	+	-	-	LC
47			Mastacembelusarmatus(Lacepede, 1800)	+	-	-	LC
48	Perciformes	Chandidae	Chandanama(Hamilton-Buchanon, 1822)	-	+	-	LC
49			Parambassisranga(Hamilton-Buchanan, 1822)	-	+	-	LC
50		Nandidae	Badisbadis(Hamilton-Buchanan,1822)	+	+	+	LC
51			Nandusnandus(Hamilton-Buchanan,1822)	+	-	+	LC
52		Gobiidae	Glossogobiusgiuris(Hamilton-Buchanan, 1822)	+	+	+	LC
53		Anabantidae	Anabastestudineus(Bloch, 1792)	+	-	-	DD
54		Belontidae	Trichogasterfasciata (BlochandSchneider, 1801)	+	+	-	LC
55		Channidae	Channapunctata (Bloch,1793)	+	+	+	LC
56			Channastriata(Bloch,1793)	+	+	+	LC

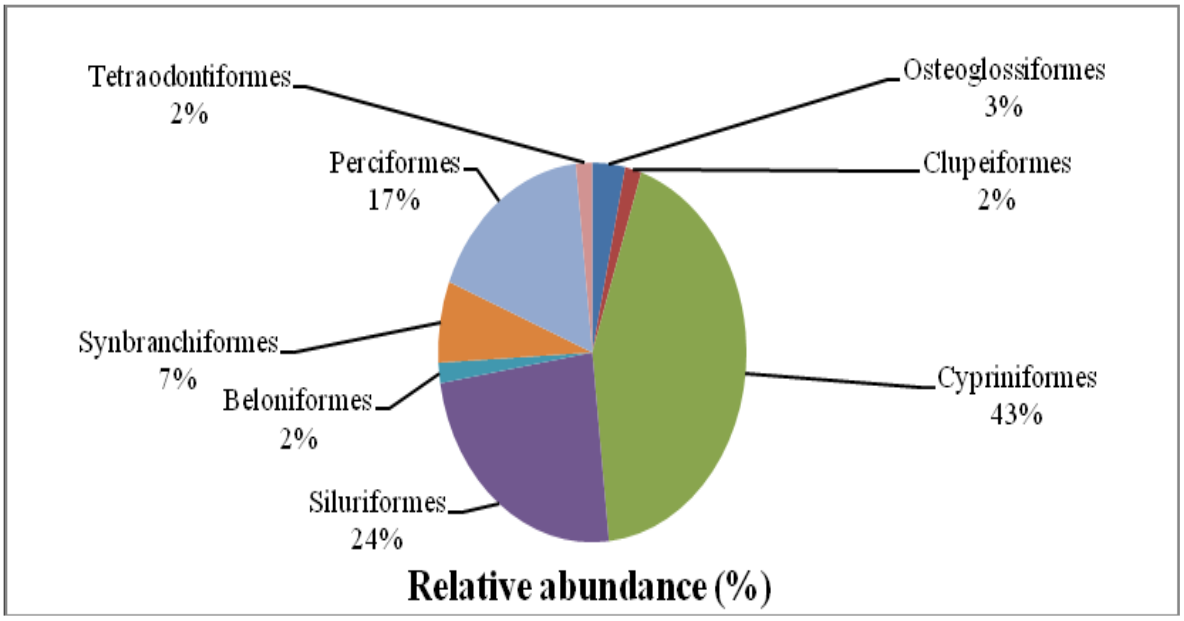

Figure. 3 . Orderwise relative abundance of fishes in river Singla.

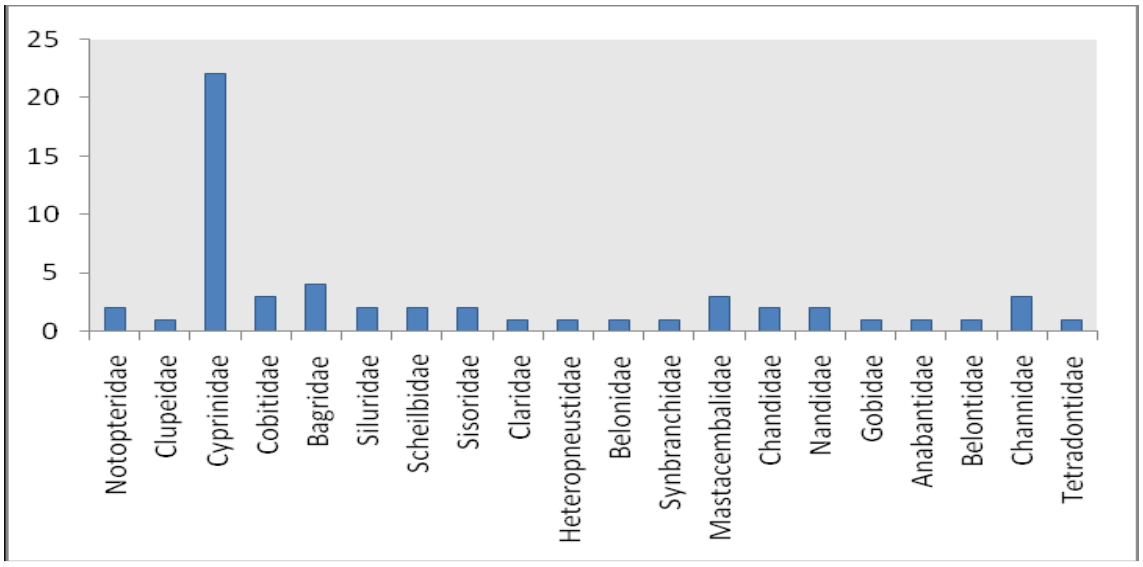

Figure.4. Familywise abundance of fishes in river Singla.

Table. 3. Species richness and diversity indices of river Singla in different seasons

Sl. No	Seasons	Indices					
		Total Number of fishes (N)	Species Richness (SR)	Species Diversity ($H^{/}$)	Simpson Diversity Indices		Evenness (e^) ($e^{H^{/}}$/logN)
					Simpson Index of Dominance (D)	Simpson Index of Diversity (1-D)	
1	Pre-Monsoon	537	27.73	1.72	0.202083	0.797917	0.63004
2	Monsoon	1001	47.32	1.78	0.197776	0.802224	0.59324
3	Post Monsoon	463	24.43	1.83	0.170206	0.829794	c0.68653

c. **Correlation matrix analysis of physico-chemical parameters of water and fishes**

The statistical analysis had been carried out by Pearson's correlation coefficient between physico-chemical parameters of water and the fish species of the studied rivers. A linear association implies that as one variable increases, the other

increases or decreases linearly. Values of the correlation coefficient close to 1 (positive correlation) imply that as one variable increases, the other increases nearly linearly. However, a correlation coefficient close to -1 implies that as one variable increases, the other decreases nearly linearly. Values close to 0 imply little linear correlation between the variables or no correlation.The level of significance is shown in table 4.

******. Correlation is significant at the 0.01 level (2-tailed).

*****. Correlation is significant at the 0.05 level (2-tailed)

In river Singla, FCO2 is found to be negatively correlated with pH, TA, TU, TH, Conductivity, nitrate and Phosphate and TU positively correlated with pH and DO; TA positively correlated with AT, WT, pH, and DO. DO and TH are positively correlated with fish yield.

d. Community Based Fishery management approach adopted by the fisherfolk of River Singla in Karimganj district of Assam, India.

Community Based Fishery management (CBFM) provides with the primary responsibility of the aquatic communities and the fishermen, in maintaining the fishery resources. This Community based fishery management system is more localised; and, hence, the techniques of management, are of different types, depending on the regional differences. For this reason, CBFM is not defined by one approach or set of guidelines, that dictate its implementation; rather, CBFM , centres around the premise that, community collaboration and participation can be an extremely productive and accurate means of managing, monitoring and maintaining fishery resources.

Fisheries are one of the most important and basic resources in many parts of the globe. However, general management methods are to be applied in order to provide with the strength of fishery resources and potentials to the resource users / stakeholders for long term use. Further, the general people are also to be provided with the new strategies of management and sustainable development of the fishery potentials. In fact, CBFM is one of the new developing strategies, which takes a more regional and integrated management approach, which can be very much affordable practice for the aquatic resources management and socio-economic upliftment. Moreover, CBFM achieves such productivity by combining the scientific research with community involvement and local ecological knowledge to make monitoring programmes specific to local areas. Notwithstanding the above, CBFM proposes that, resource users (The Fishermen) and resource communities, should have been provided with the primary role, in deciding, how the local own resources of the community should be managed. Further, CBFM focuses on the unique applied and flexible management strategy, specific for most situations and it utilises the large knowledge base of fishermen, who already have most of the tools for good local monitoring and research.

Concomitantly, an approach has been made with an aim to promote the sustainable use of the fishery resources of River Singla by empowering local communities, in order to, manage their own local resources. The River Singla has originated from the Mizoram hill at a height of 365.21m MSL as 'Thing Tlwang Lui'. River Singla enters Sone Beel after traversing a meander course of 62.75km. The oulet of Sone Beel, *viz.*, river Kachua joins the river Kushiara at Karimganj after covering a length about 19.30 km. The catchment of the wetland includes the reserve forest(RF) of the province, *viz.*, the Singla reserve forest. During monsoon, wetland receives some humic, as well as, inorganic and organic nutrients from the hillocks and cultivable areas. In this approach of CBFM, the monitoring sites that had been covered are mostly the villages, *viz.*, Rongpur, Borobhubi, Chutobubi, Kalamagura, Lalkanai, Kalagang, Luchaichora and Ripho.

The assessment employed catching of fish species from the river and the use of gears in performing catching of the fishes by different fishermen communities. Some of the CBFM sites have management committees and established the principle of fishery management. In some monitoring sites, it has been found that, the local fishermen communities are maintaining the ethics or moral of CBFM, such as fish shelter, ban period of fish capture, ban in harvesting the juveniles, restriction in use of harmful fishing gears and techniques etc. However, some of the CBFM monitoring sites do not have such management committees and, thus, the principle of CBFM not established and hence, there occur the destruction of fish habitat by the common, poor, needy people. The fishermen are harvesting the fishes of their own way, using the harmful fishing gears and techniques.

Table .4. Pearson's Correlation for different Physico-Chemical parameters and fish diversity of river Singla

	AT (^{0}C)	WT (^{0}C)	pH	DO (mg/L)	FCO_2 (mg/L)	TA (mg/L)	TU (NTU)	Transparency (cm)	TH(mg/L)	Conductivity (µmohs/cm)	Nitrate (mg/L)	Phosphate (mg/L)	Fish species
AT(^{0}C)	1												
WT (^{0}C)	0.99**	1											
pH	0.78	0.67	1										
DO(mg/L)	0.97*	0.93	0.90	1									
FCO_2(mg/L)	-0.83	-0.74	-1.00**	-0.94	1								
TA (mg/L)	0.75	0.64	1.00**	0.88	-0.99**	1							
TU(NTU)	0.92	0.85	0.96*	0.98*	-0.98*		1						

Transparency(cm)	-0.96*	-0.91	-0.92	-1.00**	0.95*	-0.90	0.98*	1					
TH(mg/L)	0.75	0.64	1.00**	0.88	-0.99**	1.00**	0.73	-0.99**	1				
Conductivity (µmohs/cm)	0.83	0.73	1.00**	0.93	-1.00**	0.99**	1.00**	-0.95*	0.99**	1			
Nitrate(mg/L)	0.40	0.25	0.89	0.60	-0.84	0.90	0.73	-0.99**	0.90	0.84	1		
Phosphate(mg/L)	0.91	0.84	0.97*	0.98*	-0.99**	0.96*	1.00**	-0.99**	0.96*	0.98*	0.74	1	
Fishspecies	-0.98*	-0.93	-0.90	-1.00**	0.94	-0.88	-0.98*	-0.91	1.00**	-0.93	-0.59	-0.98*	1

e. **Fisherman communities**

The fishermen or the fisher folk are the engine or bibcock in harvesting the fishes from any water body. The fishermen use various methods of fishing and are very much experts in implementing different types of fishing devices according to the type of fish, fish size, season of the fishing period and fish habitat. The type and technique of fish device fabrication may also differ from one community to another. Sometimes, a fishing implement is fabricated specifically for a particular fishing community and often they feel proud of such identification of a community specialized in operating a particular type of fishing implement or device (Kar 2000, 2007, 2013).

Most of the fishermen in the CBFM monitored villages belong to Scheduled Caste (SC) in the midstream and downstream region, whereas, in the upstream region of the river, the fishermen are mainly of scheduled Tribe (ST). The fishermen, in general, are poor and not very literate. There have not been much aspiring welfare measures for their upliftment. In most of the monitoring sites, no well organised co-operative movement has been observed among the fishermen community, except in some villages.

In the midstream and downstream region the river, which covers the areas of Karimganj district, the fishermen belongs to 4 principle communities *viz.*, Kaibarta, Patni, Maimal and Namasudra. Moreover, based on the intensity of fishing, the fiherfolk of the river Singla have been further classified to three different categories *viz.*, Professional, Part-time and Occasional. However, in the upstream region of the river, the fishermen belongs to Mizoh, Hmar, Reang and Kuki community.

f. Awareness programme for management

The Community Based Fishery Management need to be speeded out further across the different monitoring villages and district of the river in order to build up true fisheries co-management. This system of fishery management can reflect the importance of local problems and work on the managing system suited for the local fishers. The initiative should be taken care of, for greater emphasis, on identifying effective habitat specific management, harvesting of fishes, proper utilisation of the resources by the fisher folk. The community based fishery management programme should be performed in regular basis , in order to aware the general people, about the use of their local fishery resources, to control fishing efforts at different season of the fishing period, to use the best strategy suitable for the better fish production and to reserves fish habitat. Moreover, the general people should be awared about the potentiality of their own local resources and should be provided with sufficient knowledge of scientific research about the potentiality of the water body in order to conserve the aquatic system for sustainable development and upliftment.

5. Conclusion

Fishes are important to man as a good source of protein, for healthy living of fishes they need a proper and suitable habitat and environment. The study was done with an aim to know water chemistry, fish diversity of the river Singla.

During the present study period, the micohabitats were found to be represented mostly by bedrocks, gravels, cobbles in the upstream rheophilic region; and, principally of fine sand in the downstream plain water regions. Fish covers portrayed mainly overhanging vegetation and bottom free boulders. The riparian vegetation included mainly shrubs and trees; while, the riparian land use pattern depicted mainly human habitation, agriculture. However, Various anthropogenic factors resulted in soil erosion and siltation.

Physico-chemical characteristics of water varied according to seasons. Most of the water parameters varied seasonally. Concentrations of nutrients like nitrite, phosphates *etc*. were within permissible limits. The air temperature in river water was largely regulated by solar radiation and topography. Temperature, in turn, regulates the dissolved oxygen concentration of water and primary productivity, causes a great variability in plant and animal distribution. The values of DO, pH, FCO2 , TA, TH, TU, Conductivity, Nitrate, Phosphate etc were found to be within the range of WHO standards and it reflects the better condition of the habitat for the growth and development of the aquatic plants and animals.

The fish fauna of the rivers exhibit a combination of both hill stream and plain water forms occupying diverse ecological conditions in their distributional ranges. During the present study, 58 species of fishes belonging to 42 genera, 20 families, 8 orders have been recorded. the fishes belonging to the order Cypriniformes depicted the highest value of abundance and were found to be dominant over others in most of the study seasons.

6. References

1. APHA. (1995). *Standard Methods for the Examination of Water and Wastewater*. American Public Health Association (USA). pp. xxxix + 1193.
2. APHA. (1998). *Standard Methods for the Examination of Water and Wastewater.* American Public Health Association (USA). Washington, USA. Twenty Edition. pp. 2605.
3. APHA. (2010). *Standard Methods for the Examination of Water and Wastewater*. American Public Health Association (USA). Washington, USA. Sixteen Edition. pp. 1-10.
4. Armontrout, N. B. (1990). *Aquatic Inventory*. Bureau of Land Management, Eugene district (USA). pp. 32.
5. Arunachalam, M. Methods for fish habitat inventory in streams/rivers. Proc. Workshop. Germplasm Invent. Gene Banking Freshwater Fish. Nat. Bur. Fish. Gene. Resour., Lucknow, India. 1999.
6. Day, F. Relationship of the Indian and African freshwater fish fauna. J. Linn. Soc. (Zool.). 1885; (18): 308-317.
7. Day, F. The fauna of British India, including Ceylon and Burma: Fishes. 1989: 509-548.
8. Dutta, R. Hydrobiology and Fishery Potential of Namsang (Chatju) stream in Arunachal Pradesh. Gauhati University, Guwahati, Assam, India. Ph.D. Thesis. 2011.
9. Goswami, T. K. and Goswami, M. M. Icthyofaunal diversity and catch statistics of Jamlai wetland in Kamrup district of Assam, India. J. Inland Fish. Soc. India. 2006; 38 (2): 38-44.
10. International Union for Conservation of Nature (IUCN). The Red List of Threatened Species. Version 2012. Available at: www.iucnredlist.org. 2012
11. International Union for Conservation of Nature (IUCN). The Red List of Threatened Species. Version 2014. Available at: www.iucnredlist.org. 2014.
12. Jayaram, K. C. The freshwater fishes of the Indian Region. Narendra Publishing House (Delhi), India. 1999: xvii +551.
13. Jayaram, K. C. The freshwater fishes of the Indian region. Narendra Publishing House (Delhi), India. Second Revised Edition. 2010: xxxi + 616.
14. Kar, D. Peoples' Perspective on Fish Conservation in the Water bodies of South Assam, Mizoram and Tripura, in Mahanta, P. C. and Tyagi, L. K. (eds.) Participatory Approach for Fish Biodiversity Conservation in North-East India. National Bureau of Fish Genetic Resources (ICAR) (Lucknow), India. 2003: 325-328.
15. Kar, D. Fundamentals of Limnology and Aquaculture Biotechnology. Daya Publishing House. New Delhi. India. 2007: xvi + 609.
16. Kar, D. Wetlands and Lakes of the World. Springer Publications (London). 2013: xxx + 687.
17. National Bureau of Fish Genetic Resources (NBFGR). Manual on Habitat Inventory. National Bureau of Fish Genetic Resources (ICAR) (Lucknow), India. 2000 : 27.
18. Sen, N. Occurrence, distribution and status of diversified fish fauna of North-East India, in Ponniah, A. G. and Sarkar, U. K. (eds.) Fish diversity of North-East India. National Bureau of Fish Genetic Resources, ICAR (Lucknow), India. 2000: 31-48.
19. Talwar, P. K. and Jhingran, A. G. Inland Fishes of India and Adjacent Countries. Oxford and IBH Co., Pvt. Ltd. (New Delhi), India. Vol. I and II. 1991: xix + 1158.
20. Vishwanath, W. Fishes of North East India: A field guide to species Identification. Manipur: National Agricultural Technology Project. Manipur University, India. 2002 : 198.
21. World Conservation Monitoring Centre (WCMC). Freshwater biodiversity: a preliminary global assessment. A document prepared for the 4th meeting of the conference of the practices to the convention of biological diversity. World Conservation Monitoring Centre. 1998.