Fish Diversity and Fisheries Ecology of Sessa River in Upper Brahmaputra Valley, Assam, India

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ABSTRACT: A study was carried out on fish diversity and habitat ecology of the Sessa river in Dibrugarh district in the state of Assam. Though smaller in size in comparison to the other tributaries of the mighty Brahmaputra, the river holds a significant position in terms of fisheries and livelihood for the riparian communities. A total of 72 fish species belonging to 8 orders, 18 families and 52 genera was recorded from the river. Of these, 56 species are placed in least concern (LC) category while another 9 species are placed in near threatened (NT) category. Likewise, 11 different physico-chemical parameters of the riverine habitat were also studied which reflects marked seasonal variations with respect to certain parameters. Present state of the fisheries resources of the river is also reported with suggestions for sustainable management of them.

Key words: Fish diversity, conservation status, Fisheries ecology, Sessa river.

1.0: INTRODUCTION:

The Dibrugarh district is one of the most resourceful districts of the state of Assam in north-east India. The district covers a geographical area of 3381 sq. km. in eastern part of Assam, lying between 27° 06′ 00″N latitude and 27° 58′ 18″ N and 94° 39′ 00″ E and 95° 30′ 00″E longitude. The mighty Brahmaputra flows along the northern periphery of the district while a handful of its main tributaries, viz., Burhidihing, Disang or Dilli, Dibru, Sessa and Lekhijan are flowing across the district, forming an important component of the Brahmaputra basin.

The Sessa river is an important tributary which flows about 95.6 km (catchment area of 4.48 sq. km) within the district before joining the Burhidihing river at Sessamukh (the latter being joined the Brahmaputra at Dehingmukh, few kilometres downstream from Sessamukh). The Sessa river originates from the eastern foothills of the Arunachal Pradesh hills, and drains water mainly from the Dibrugrah district of Assam. Though much smaller in size and is of highly meandering nature, Sessa river along with a number of lower order streams, is very much significant from the fisheries and agriculture point view of the district. This river sustains a very rich fisheries resource, thereby providing livelihood to a good section of the local communities, besides critically important for promoting regional agriculture and maintaining hydrology and ecological balance of the area.

However, in spite of having significant regional importance in terms of fisheries, livelihood and socio-economy, no information is available on fisheries resources and habitat ecology of this river till date. Against this backdrop, a study has been carried out on fish diversity and fisheries ecology of Sessa river in upper Brahmaputra valley.

2.0: MATERIALS AND METHODS:

2.1: Study area: The present investigation was carried out in the Sessa river in Dibrugarh district of Assam, north east India between January, 2016 and December, 2017. Sessa is a small river that feeds the river Burhidihing, the latter being the largest southern tributary to the Brahmaputra. A map of the district showing Sessa river and sampling sites for collection of water samples for habitat quality analysis is provided in Figure-1.

2.2: Collection and identification of fish specimens and assessment of conservation status: Random field surveys was made in different stretches as well as fish landing centres of the Sessa river in Dibrugarh districtfor the last two years for species inventory. The local fishermen used different types of fishing nets (such as gill nets and cast nets of various mesh sizes) and indigenous fishing traps to capture the fishes. The collected fish species were identified following Talwar and Jhingran (1991) while the conservation status of the recorded fish species has been evaluated following CAMP (1998).

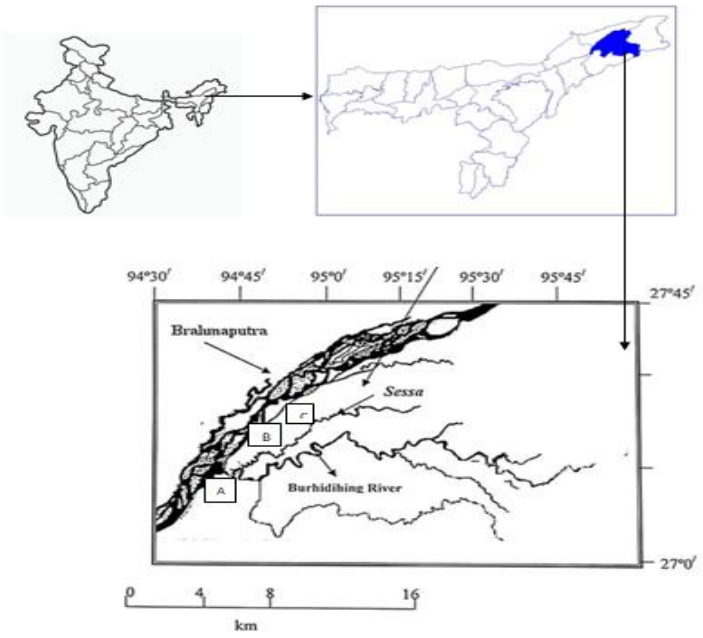

Figure-1: Map of the study area showing the Sessa river in Dibrugarh district and the location of the sampling sites- (A) Sessamukh, (B) Sessa and (C) Jokai

2.3: Analysis of water quality: For the present study, water samples were collected from three sampling sites of the river, viz., Sessamukh (27°27′33.00″ N and 94°73′95.53″E), Sessa (94°51′45.99″E and 27°20′15.32″N) and Jokai (94°55′32.32″E and 27°24′32.56″N) on a seasonal basis (Pre-monsoon: March- May, Monsoon: June-August, Post-monsoon: September-November and Winter: December-February) for habitat characterization. Laboratory analysis of collected water samples was done seasonally for various physico-chemical parameters of the riverine habitat following standard methods. The physico-chemical parameters considered and the methodology followed for the present study are as follows-

(a) Air as well as surface water temperature was measured by a maximum and minimum thermometer graduated up to 110°C.
(b) Transparency was measured using a Sacchi disc of 15 cm diameter.
(c) Specific conductivity was measured by a digital conductivity meter.
(d) The p^H was measured in situ with the help of a digital p^H meter.
(e) Dissolved oxygen, free CO_2 and total alkalinity values were estimated by titration method (APHA, 1995).
(f) Total dissolved solids (TDS) and total suspended solids (TSS) values were determined following Trivedy *et al.* (1987).
(g) Statistical analysis of data has been done following Bailey (1994) and relevant software (SPSS). Pearson correlation was used to study the relationship between different physico- chemical variables of water.

3.0: RESULTS:

3.1: Fish Diversity and their Conservation status:

During the present study, a total of 72 species of fishes belonging to 8 orders, 18 families under 52 genera have been recorded from the Sessa river in Dibrugarh district. A checklist of the fish species recorded from the river and their taxonomic break-up is presented in Table-1 and Table-2 respectively. Among the 8 orders, Cypriniformes is found to be the most dominant order with 28 species followed by Siluriformes (26 *spp.*), Perciformes (9 *spp*.), Mastacembeliformes (3 *spp.*), Osteoglossiformes and Cyprinodontiformes (2 *spp.* each) and Clupeiformes and Tetraodontiformes (1 species each). Again, family-wise Cyprinidae is found to be the most dominant with 24 species. Bagridae (9 *spp.*), Sisoridae (5 *spp*.), Siluridae, Schilbeidae, Erethistidae and Ambassidae (4 *spp.* each), Cobitidae and Mastacembelidae (3 *spp*. each) are among the other important genera of fishes recorded from the Sessa river while rest of the families are represented by 2 *spp*. or 1 species each. Genera-wise *Labeo* and *Mystus* are the most dominant genus (with 4 *spp*. each) among the 52 genera recorded so far from the river followed by *Ompok* and *Puntius* (3 *spp*. each) while *Aspidoparia, Cirrhinus, Devario, Rasbora, Sperata, Bagarius*, *Gagata, Hara, Macrognathus, Parambassis* and *Badis* are represented by 2 *spp*. each whereas rest of genera are represented by single species.

Table-1: A checklist of fish species recorded from Sessa River in Dibrugarh district, Assam and their conservation status

Fish species with Order & Family		Conservation status
Order: Osteoglossiformes		
Family: Notopteridae	01. *Chitala chitala* (Hamilton, 1822)	NT
	02. *Notopterus notopterus* (Pallas, 1769)	LC
Order: Clupeiformes		
Family: Clupeidae	03. *Gudusia chapra* (Hamilton, 1822)	LC
Order: Cypriniformes		
Family: Cyprinidae	04. *Amblypharyngodon mola* (Hamilton, 1822)	LC
	05. *Aspidoparia jaya* (Hamilton, 1822)	LC
	06. *Aspidoparia morar* (Hamilton, 1822)	LC
	07. *Catla catla* (Hamilton, 1822)	LC
	08. *Chela laubuca* (Hamilton, 1822)	LC
	09. *Cirrhinus mrigala* (Hamilton, 1822)	LC
	10. *Cirrhinus reba* (Hamilton, 1822)	LC
	11. *Danio rerio* (Hamilton, 1822)	LC
	12. *Devario devario* (Hamilton, 1822)	LC
	13. *Devario aequipinnatus* (McClelland, 1839)	LC
	14. *Esomus danricus* (Hamilton, 1822)	NE
	15. *Labeo bata* (Hamilton, 1822)	LC
	16. *Labeo calbasu* (Hamilton, 1822)	LC
	17. *Labeo gonius* (Hamilton, 1822)	LC
	18. *Labeo rohita* (Hamilton, 1822)	LC
	19. *Megarasbora elanga* (Hamilton, 1822)	LC
	20. *Ostreobrama cotio* (Hamilton, 1822)	NE
	21. *Puntius conchonius* (Hamilton, 1822)	LC
	22. *Puntius ticto* (Hamilton, 1822)	LC
	23. *Puntius sophore* (Hamilton, 1822)	LC
	24. *Rasbora daniconius* (Hamilton, 1822)	LC
	25. *Rasbora rasbora* (Hamilton, 1822)	LC
	26. *Salmophasia bacaila* (Hamilton, 1822)	LC
	27. *Systoma sarana* (Hamilton, 1822)	NE
Family: Nemacheilidae	28. *Acanthocobitis botia* (Hamilton, 1822)	LC
Family: Cobitidae	29. *Botia Dario* (Hamilton, 1822)	LC
	30. *Canthophrys gongota* (Hamilton, 1822)	LC
	31. *Lepidocephalichthys guntea* (Hamilton, 1822)	LC
Order: Siluriformes		
Family: Bagridae	32. *Batasio batasio* (Hamilton, 1822)	LC
	33. *Hemibagrus menoda* (Hamilton, 1822)	LC
	34. *Mystus bleekeri* (Day, 1877)	LC
	35. *Mystus cavasius* (Hamilton, 1822)	LC
	36. *Mystus tengara* (Hamilton, 1822)	LC
	37. *Mystus vittatus* (Bloch, 1794)	LC

	38. *Rita rita* (Hamilton, 1822)	LC
	39. *Sperata aor* (Hamilton, 1822)	LC
	40. *Sperata seenghala* (Hamilton, 1822)	LC
Family: Siluridae	41. *Ompok bimaculatus* (Bloch, 1794)	NT
	42. *Ompok pabda* (Hamilton, 1822)	NT
	43. *Ompok pabo* (Hamilton, 1822)	NT
	44. *Wallagoattu* (Bloch & Schneider, 1801)	NT
Family: Schilbeidae	45. *Ailia coila* (Hamilton, 1822)	NT
	46. *Clupisoma garua* (Hamilton, 1822)	LC
	47. *Eutropiichthys vacha* (Hamilton, 1822)	LC
	48. *Neotropius atherinoides* (Bloch, 1794)	LC
Family: Sisoridae	49. *Bagarius bagarius* (Hamilton, 1822)	NT
	50. *Bagarius yarrelii* (Sykes, 1839)	NT
	51. *Gagata cenia* (Hamilton, 1822)	LC
	52. *Gagata gagata*(Hamilton, 1822)	LC
	53. *Sisor rabdophorus*(Hamilton, 1822)	LC
Family: Erethistidae	54. *Conta conta* (Hamilton, 1822)	DD
	55. *Erethistes pussilus* Muller &Troschel, 1849	NE
	56. *Hara hara* (Hamilton, 1822)	LC
	57. *Hara jerdoni* Day, 1870	LC
Order: Cyprinodontiformes		
Family: Belonidae	58. *Xenentedon cancila* (Hamilton, 1822)	NE
Family: Aplocheilidae	59. *Aplocheilus panchax* (Hamilton, 1822)	LC
Order: Mastacembeliformes		
Family: Mastacembelidae	60. *Macrognathus aral* (Bloch & Schneider, 1801)	LC
	61. *Macrognathus pancalus* Hamilton, 1822	LC
	62. *Mastacembelus armatus* (Lacepede, 1800)	LC
Order: Perciformes		
Family: Ambassidae	63. *Chanda nama* Hamilton, 1822	LC
	64. *Parambassis lala* (Hamilton, 1822)	NT
	65. *Parambassis ronga* (Hamilton, 1822)	LC
	66. *Pseudambassis baculis* (Hamilton, 1822)	LC
Family: Badidae	67.*Badisas samensis* Ahl, 1937	DD
	68. *Badis badis* (Hamilton, 1822)	LC
Family: Mugilidae	69. *Rhinomugil corsula* (Hamilton, 1822)	LC
	70. *Sicamugil cascasia* (Hamilton, 1822)	LC
Family: Gobiidae	71. *Glossogobius giuris* (Hamilton, 1822)	LC
Order: Tetraodontiformes		
Family: Tetraodontidae	72. *Tetraodon cutcutia*Hamilton, 1822	LC

CAMP Status:

NE: Not evaluated DD: Data deficient LC: Least concern NT: Near threatened
VU: Vulnerable EN: Endangered CR: Critically endangered

Table-2: Taxonomic break-up (Phylogenetic composition) of fishes recorded from Sessa river in Dibrugarh district, Upper Brahmaputra valley

Order	Family	Principal genera (no. of species)	Total number of species in Family	Total number of species in Order
Osteoglossiformes	**Notopteridae**	*Chitala* (1), *Notopterus* (1)	2	3
Clupeiformes	**Clupeidae**	*Gudusia*(1),	1	
Cypriniformes	**Cyprinidae**	*Amblypharyngodon* (1), *Aspidoparia* (2), *Catla* (1), *Chela* (1), *Cirrhinus* (2), *Danio* (1), *Devario* (2), *Esomus* (1), *Labeo* (4), *Megarasbora* (1), *Ostreobrama* (1), *Puntius* (3), *Rasbora* (2), *Salmophasia* (1), *Systomus* (1)	24	28
	Nemacheilidae	*Acanthocobitis* (1)	1	
	Cobitidae	*Botia* (1), *Canthophrys* (1), *Lepidocephalichthys* (1)	3	
Siluriformes	**Bagridae**	*Batasio* (1), *Hemibagrus* (1), *Mystus* (4), *Rita* (1), *Sperata* (2)	9	26
	Siluridae	*Ompok* (3), *Wallago* (1)	4	
	Schilbeidae	*Ailia* (1), *Clupisoma* (1), *Eutropiichthys* (1), *Neotropius* (1)	4	
	Sisoridae	*Bagarius* (2), *Gagata* (2), *Sisor* (1)	5	
	Erethistidae	*Conta* (1), *Erethistes* (1), *Har*a (2)	4	
Cyprinodontiformes	**Belonidae**	*Xenentedon* (1)	1	2
	Aplocheilidae	*Aplocheilus* (1)	1	
Mastacembeliformes	**Mastacembelidae**	*Macrognathus* (2), *Mastacembelus* (1)	3	3
Perciformes	**Ambassidae**	*Chanda* (1), *Parambassis* (2), *Pseudambassis* (1)	4	9
	Badidae	*Badis* (2)	2	
	Mugilidae	*Rhinomugil* (1), *Sicamugil* (1)	2	
	Gobiidae	*Glossogobius* (1)	1	
Tetraodontiformes	**Tetraodontidae**	*Tetraodon* (1)	1	1
Total no of Order: **8**	Total no. of Family: **18**	Total no. of Genus: **52**	Total no. of Species: **72**	

The current conservation status of the recorded fish species from the Sessa river is given in Figure-2. Out of the 72 species of fishes, 56 *spp*. placed in LC (least concern) category, 9 *spp.* in near threatened (NT) category, 5 *spp*. in not evaluated (NE) and 2 spp. are placed in data deficient (DD) category. However, none of the species recorded from the river during the present study is placed either in vulnerable (VU) or endangered (EN) category.

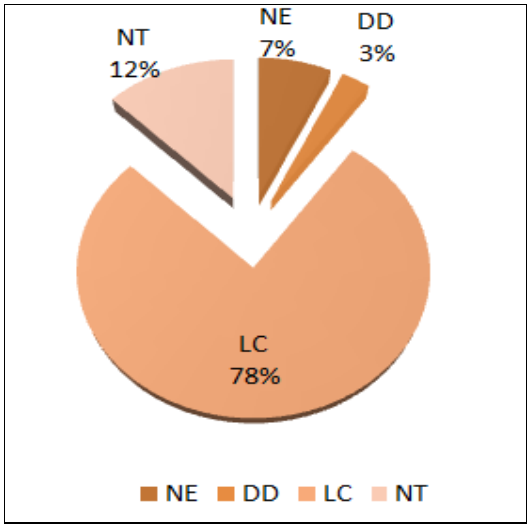

Figure-2: Percentage composition of different conservation categories of the fish species recorded from the Sessa river, Upper Assam

3.2: Ecological characteristics: The physico-chemical qualities or ecological features of the Sessa river has been carried out seasonally and the relevant data are summarized in Table- 3. During the present study, the selected physical parameters (air and surface water temperature, transparency, current flow and conductivity) as well as chemical parameters (p^H, dissolved oxygen, free CO_2, total alkalinity and total dissolved solids) of the Sessa river showed marked seasonal variations. The mean surface water temperature and ambient temperature showed similar seasonal variation implying strong positive correlation between them. The former was ranged from 17.5°C in winter to a maximum of 33.2°C in monsoon while the latter was ranged between 18.6°C (winter) and 33.5°C (monsoon).

The maximum value of mean transparency (45.1±1.74 cm) was recorded in winter while minimum value for the same was 13.1 (±0.07) cm in monsoon. Again, the conductivity of the river water was varied between 57.7±2.9 µS/cm (winter) and 80.1±1.54 µS/cm (monsoon). Similarly, mean current velocity was recorded to be maximum in monsoon (1.06± 0.24 m/sec) whereas the minimum being 0.09±0.003 m/sec recorded in winter.

Table-3: Seasonal variation of selected physico-chemical parameters of Sessa river, Dibrugarh district, upper Assam

Parameters	Season			
	Pre-monsoon	**Monsoon**	**Post-monsoon**	**Winter**
1. Air Temperature (°C)	23.4 - 32.8 (26.3±1.32)	30.9-38.2 (33.5±1.34)	27.6 - 35.9 (32.6±2.02)	16.8 - 21.6 (18.6±0.19)
2. Water Temperature (°C)	21.6 - 28.1 (25.1± 1.27)	29.8 - 35.3 (33.2± 2.52)	26.2 - 30.9 (28.6±1.75)	16.4 - 19.6 (17.5± 0.32)
3. Transparency (cm)	26.2 - 37.4 (33.1±0.22)	11.2 - 15.3 (13.1±0.07)	19.8 - 24.6 (22.1±0.05)	31.6 - 56.2 (45.1±1.74)
4. Conductivity (µS/cm)	59.2 - 76.4 (64.8±2.31)	73.5 - 86.4 (80.1±1.54)	68.8 - 85.1 (73.3±2.76)	47.7 - 60.4 (57.7±2.9)
5. Current flow (m/sec)	0.22 - 0.32 (0.26±. 12)	0.98-1.18 (1.06± 0.24)	0.42-0.71 (0.53±. 81)	0.07-0.16 (0.09±0.003)
6. p^H	6.2-6.8 (6.56 ± 0.3)	6.4-6.6 (6.5 ± 0.08)	6.8-6.9 (6.83 ± 0.46)	6.8-7.1 (6.96 ± 0.12)
7. Dissolved Oxygen (ppm)	6.9 - 8.4] (7.8± 0.64)	9.2 - 9.8 (9.46 ± 0.36)	4.2 - 9.4 (6.3 ± 2.23)	5.7 - 7.1 (6.4 ± 0.57)
8. Free CO_2 (ppm)	3.2 - 7.4 (4.4± 2.10)	2.8- 5.1 (3.76 ± 0.59)	7.4 - 9.8 (8.1 ± 0.9)	6.8 -11.2 (9.3 ± 2.27)
9. Total Alkalinity (ppm)	39.2 - 60.1 (52.8 ± 2.2)	38.8 - 43.7 (39.4 ± 2.8)	29.0 - 45.5 (37.8 ± 7.8)	36.0 - 53.0 (46.6 ± 5.5)
10. Total Dissolved Solids (ppm)	107.2 - 130.4 (119.2±3.03)	178.3 - 203.4 (192.6±5.50)	120.4 -146.3 (130.3±2.08)	69.1- 88.3 (77.8±1.23)
11. Total suspended solids (ppm)	105.6 -145.3 (118.4 ± 9.11)	231.3 - 314.8 (275.1 ± 13.41)	198.2 - 256.8 (218.5 ± 15.19)	87.2 - 112.3 (91.1 ± 8.71)

During the present study, marked seasonal variations were also observed for other chemical parameters of the Sessa river except for pH. The pH remains near neutral throughout the year, ranging between 6.5 and 6.9 in different seasons. The mean values of dissolved oxygen concentration found to be vary from 6.3 ppm in post-monsoon to a maximum of 9.46 ppm in monsoon. Like-wise, the mean value of free CO_2 concentration also showed seasonal fluctuation with an annual

range of 2.8 - 11.2 ppm, the minimum and maximum mean values being 3.76 ppm (monsoon) and 9.3 ppm (winter) respectively. On the other hand, the minimum mean value of total alkalinity was recorded in post-monsoon (37.8 $\pm$ 7.8 ppm) while the maximum value for the same was recorded in pre-monsoon (52.8 $\pm$ 2.2 ppm). The annual mean range of variation in total dissolved solid content was found to be from (77.8$\pm$1.23 ppm (in winter) to 192.6$\pm$5.50 ppm (in monsoon).

Statistical analysis of selected pairs of physico-chemical parameters of the riverine habitat is presented in Table-4. A strong positive correlation ($r= 0.978$; $p < 0.05$ level) is evident between air and surface water temperature during the study period. Again, both air and surface water temperature exhibit strong positive correlation with dissolved oxygen concentration for stream habitat. On the other hand, a strong negative correlation exists between dissolved oxygen and free CO_2 concentration while the correlation between pH and alkalinity was found to be insignificant. Again, a negative correlation was observed between transparency and total suspended solid concentration whereas positive correlation was observed for the values of total dissolved solid and conductivity for the habitat. Further, current flow is positively correlated with dissolved oxygen concentration river water.

Table-4: Pearson's Correlation Coefficient (r) value for certain selected pairs of physico-chemical parameters of the Sessa river, Dibrugarh district, Assam

Sl.No.	Selected pair of habitat parameters	Correlation Coefficient (r)
1	Air temperature vs water temperature	0.978*
2	Air temperature vs DO	0.968*
3	Dissolved oxygen vs free CO_2	-0.867
4	p^Hvs total alkalinity	0.136
5	Transparency vs TSS	-0.983*
6	Conductivity vs TDS	0.819
7	Water temperature vs DO	0.931
8	DO vs Free CO_2	-0.759
9	Free CO_2vs total alkalinity	0.801
10	Free CO_2 vs p^H	0.561
11	Current flow vs DO	0.956*
12	Current flow vs free CO_2	-0.912

[* Denoted significance at 0.05 levels/** Denoted significance at 0.01 level]

4.0: DISCUSSION

The Sessa river is an important fisheries source of the region, fishing being considered as a primary source of livelihood for the riparian communities, particularly in the lower stretches of the river. Out of the 72 fish species recorded so far from the river, carps and catfishes contributes to the bulk of the commercial fisheries of the region as edible fishes. Other groups like smaller barbs, minnows. Loaches, eels as well as perches are important groups of aquarium fishes native to this river. Species of larger catfishes such as *Bagarius*, *Hemibagrus, Spearata, Clupisoma, Eutropiichthys,* etc. are mostly available during high floods in the river confluence. Their availability in the commercial catch is otherwise limited in other seasons of the year. However, other bagrid and siluroid catfishes contribute substantially towards commercial catch of the river throughout the year. Again, though some of the species recorded from the river is placed in least concern (LC) category, their population has been dwindling over the years owing to various reasons and their contribution to the commercial fishery is very much negligible.

Each and every aquatic system has its own hydro-biological features, which are largely influenced by the geology, topography and the climatic regime of the region where it is located. Temperature regulates various physico-chemical as well as biological activities and thus has enormous significance on the life of fishes. Physico-chemical factors such as p^H, temperature, dissolved oxygen etc. influence the survivality of fishes to a greater extent (Devaraju*et al*., 2005). Each fish species has tolerance to varying degree of different physico-chemical characteristics like hardness, alkalinity or temperature occurring in different habitats with preferred substrate type.

During the present investigation, the temporal variation of mean surface water temperature and ambient temperature of the Sessa river showed similar seasonal variation implying strong positive correlation between them (Fig-3a). The former was ranged from 17.5°C in winter to a maximum level of 33.2°C in monsoon while the latter was ranged between 18.6°C (winter) and 33.5°C (monsoon). Thus, the ambient temperature and surface water temperature followed the identical annual trends, maximum and minimum being recorded in monsoon and winter, respectively. Again, mean surface water temperature was observed to be lower than the atmospheric temperature in all the seasons, indicating a strong influence on the former by the later. Other workers also noted the positive influence of ambient temperature on surface water, particularly for standing water bodies (Sunkad and Patil, 2004; Shastri and Pendse, 2001).

The transparency has a great bearing on productivity of a water body through its effect on light penetration. The seasonal variation of transparency in Sessa river showed peaks during winter season and troughs during rainy months (Fig-3b). The maximum value of mean transparency was recorded to be in winter (45.1±1.74 cm) while minimum value for the same was 13.1 (±0.07) cm in monsoon. The low value of transparency in monsoon was due to presence of higher amount of suspended solids in streams supplied by the sediment load from the catchment area. On the other hand, relatively higher value of transparency during winter could be due to less input of solids by the surface run off and cessation of monsoon rain (Gupta *et al.*, 1996). Besides, settlement of suspended particles due to drop in current flow in stream may also be a contributory factor. In all the instances, the transparency exhibited strong and significant negative correlations with values of suspended solids. Boruah (1999), Biswas and Boruah (2000) and Dutta (2002) also made similar observations of transparency.

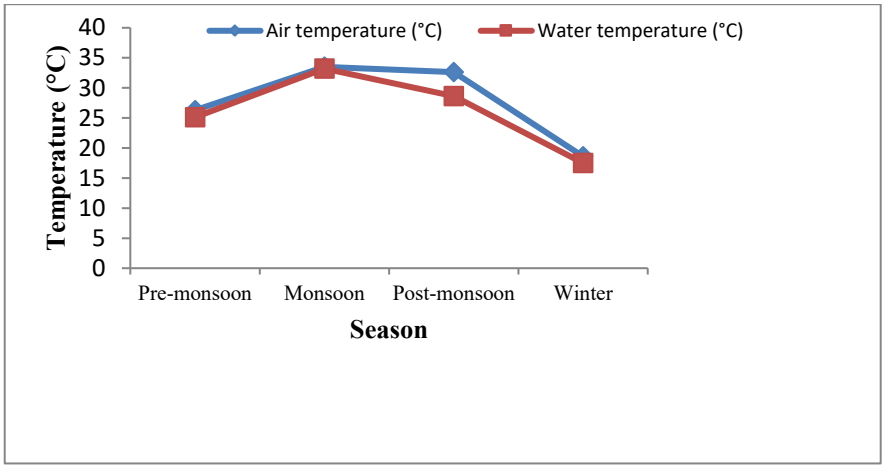

Fig-3(a): Seasonal variation of air and surface water temperature in Sessa river, Dibrugarh district, Assam

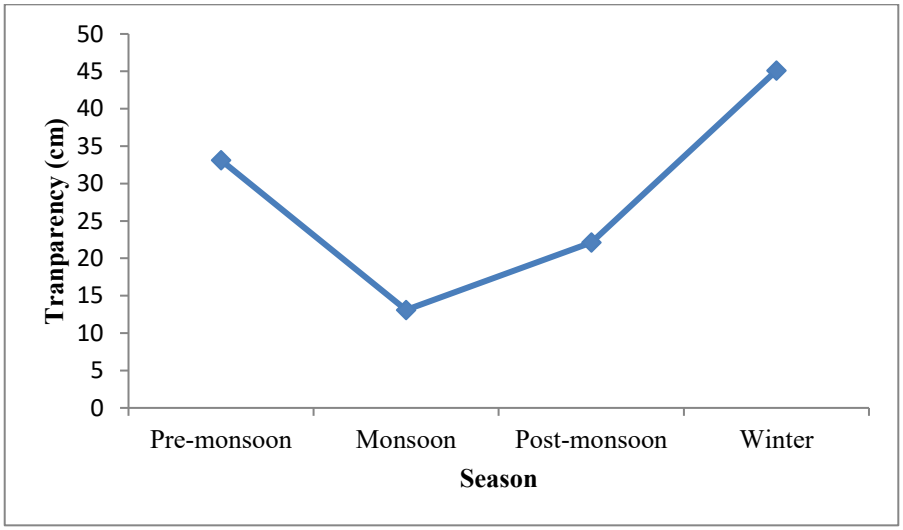

Fig-3(b): Seasonal variation of transparency in Sessa river, Dibrugarh district, Assam

Sharma and Kaur (1994-95) reported that the electrical conductivity of a solution is directly proportional to the amount of electrolytes present therein. The specific conductivity is an index of the amount of water-soluble salts present in water indicating the state of mineralization in an aquatic system (Das, 2000). In the present study, specific conductivity exhibited a moderate seasonal range of fluctuation (Fig-3c) between 57.7±2.9 µS/cm (winter) and 80.1±1.54 µS/cm (monsoon). The conductivity values were positively correlated with that of total dissolved solids. Similarly, a positive correlation was observed between conductivity and dissolved oxygen too, corroborating the findings of Bhaumic *et al.* (2003).

Velocity of water current is another important physical parameter of lotic ecosystems, mostly regulated by the gradient and substrate type (Sultan *et al.*, 2003). Streams in floodplains of this region usually have a moderate velocity of water during monsoon which is gradually decreases towards winter. However, the current flow of the Sessa river was as high as in 1.06± 0.24 m/sec (during monsoon) and as low as0.09±0.003 m/sec in winter.

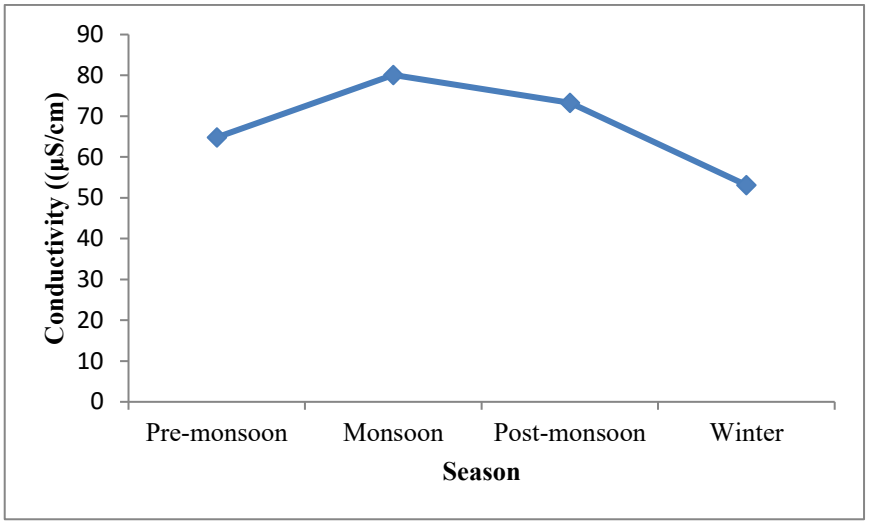

Fig-3(c): Seasonal variation of transparency in Sessa river, Dibrugarh district, Assam

The balance in an ecosystem is maintained when p^H is in between 5.5 and 8.5 (Chandrashekar *et al*., 2003).The pH of the river remains near neutral throughout the year, ranging between 6.5-6.9 in different seasons (Fig-3d) with a maximum record in winter which could be the result of increase in photosynthetic activity of the phytoplankton and marginal aquatic macrophytes present in the habitat. In general, the water had a good buffering action and is also manifested by the findings of the present study.

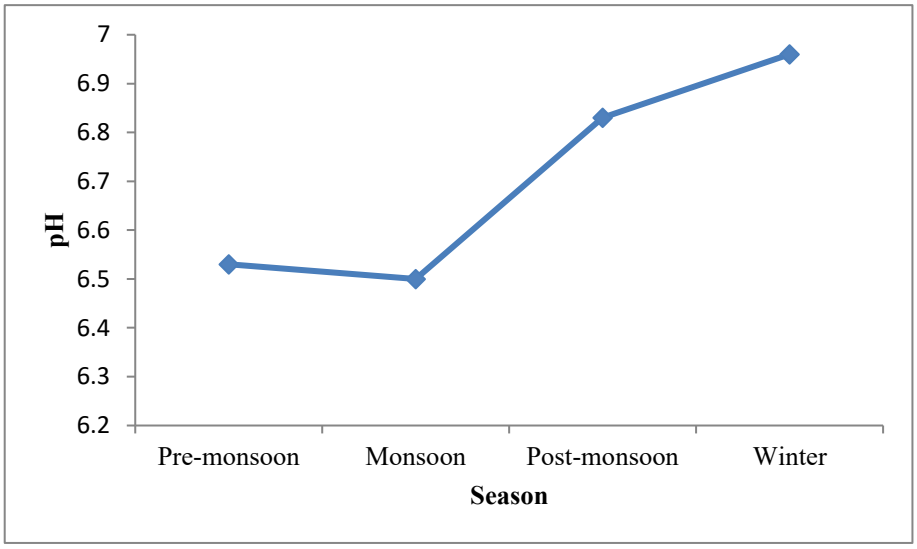

Fig-3(d): Seasonal variation of transparency in Sessa river, Dibrugarh district, Assam

DO is a critical factor in natural waters and is significant both as regulator of metabolic process and indicator of water quality (Sultan *et al.*, 2003) and the photosynthetic activity and microbial decomposition are the major contributors to O_2 budget of a water body (Devaraju *et al.*, 2005). A temporal difference in mean values of DO for different seasons is distinctly evident in this river (Fig-3e). Higher concentration of DO in river waters during monsoon may be due to turbulence and oxygenation resulting from high rainfall and mixing up of well aerated run off from catchment. These observations are in conformity with the findings of Gupta and Mehrotra (1991) and Jha and Barat (2003). Moreover, Hannan (1979) also reported that circulation and mixing of water during rainy seasons re-oxygenate the water. A strong positive correlation was observed between DO with that of air and surface water temperature. Similarly, DO have showed a positive correlation with current flow ($r= 0.922$; $p<0.05$).

Seasonal data of free CO_2, an indicator of biological respiration of aquatic systems, showed a narrow range of fluctuation (Fig-3e). Free CO_2 concentration of this river also showed seasonal fluctuation, the minimum and maximum mean values being 3.76 ppm (monsoon) and 9.3 ppm (winter) respectively. The concentration of free CO_2 was greater in winter than other seasons possibly due to greater biological activities and abundant growth of algal bloom in shallow marginal areas of streams. Correlation studies showed highly significant negative relation between free CO_2 and that of DO and current flow while it shows a positive correlation with that of total alkalinity and pH.

In the present study, the total alkalinity (TA) refers to bicarbonate alkalinity, as the carbonate alkalinity was recorded to be absent. The temporal variation in TA values (from 37.8 $\pm$ 7.8 ppm to 52.8 $\pm$ 2.2 ppm) for the river is depicted in Fig-3(e). The values of TA found to be positively correlated to free CO_2 values. However, no significant relation was established between TA and p^H during the present study.

Total suspended solids (TSS) level appeared to be low in the rievr. Maximum amount of TSS was recorded during the rainy months (115.3 ppm). The presence of higher amount of TSS during monsoon happens to be a natural phenomenon in this region as the water bodies receive huge input of suspended solids as surface run off from the catchment area following heavy monsoonal downpour. However, it was observed to decline gradually thereafter, minimum being TSS being recorded in winter.

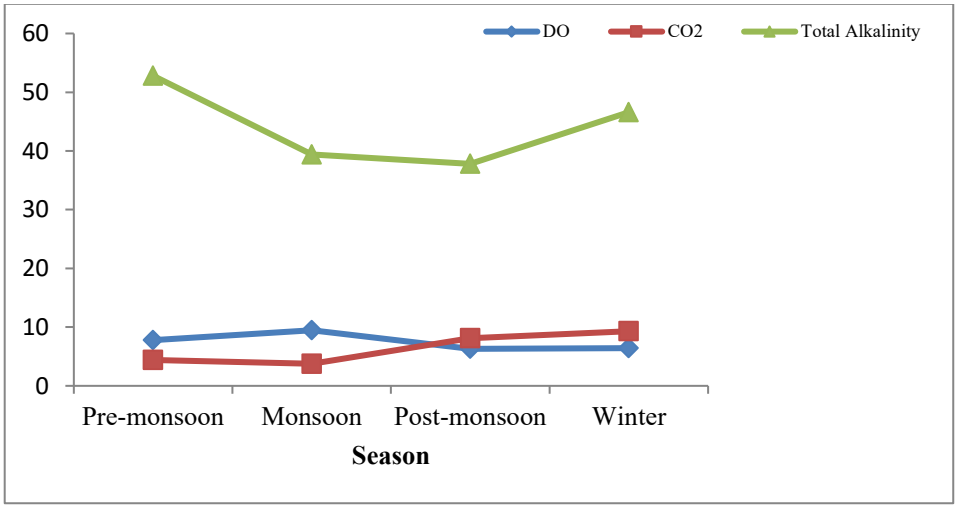

Fig-3(e): Seasonal variation of DO, CO_2 and total alkalinity in Sessa river, Dibrugarh district, Assam

Total concentration of dissolved ions has a wide bearing on the productivity of water bodies (Das, 2000). Like the TSS, TDS concentration also recorded to be in the higher side throughout the year, fluctuated widely in different seasons (Fig-3f). The maximum TDS concentration was recorded in rainy months thereby exhibits a similar trend of variation with that of the TSS. It shows a significant positive correlation with TSS ($r= 0.982$, $p<0.05$ while exhibits negative correlation with transparency and conductivity. A similar range of both TSS and TDS was also recorded by Das (2007).

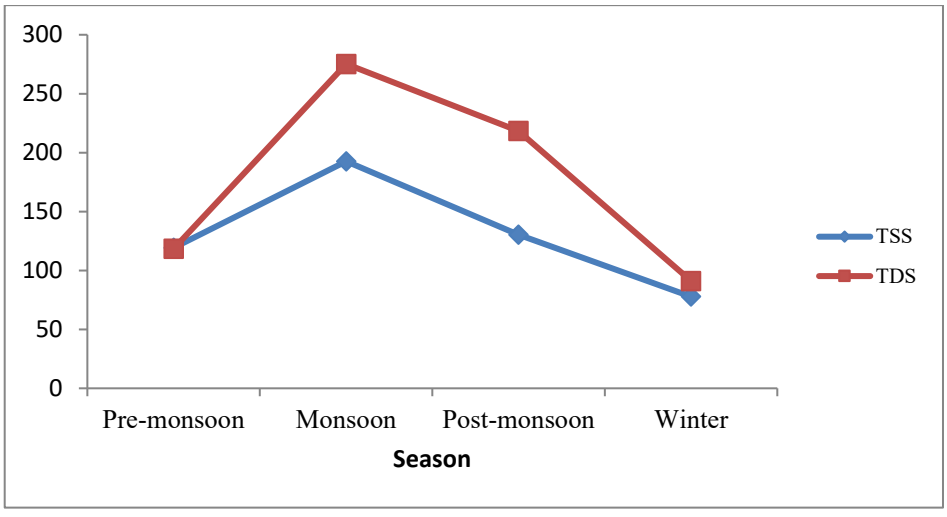

Fig-3(f): Seasonal variation of TSS and TDS in Sessa river, Dibrugarh district, Assam

During the present study, it has also been observe that some of the commercially important fish species once common in the river is declining due to various reasons and human activities. The river has been under constant threat mainly due to steady increase in human interventions, removal of riparian cover, sand and silt mining in riverbed, undergoing developmental projects as well as aquatic pollution, particularly in its lower reaches. Adoption of illegal fishing practices, particularly the use of banned fishing gears like mosquito net in remote areas and stretches of the river possesses a serious concern in this area. Since, a good section of the riparian communities are earning their livelihood based on the fishing

and allied activities based on the fisheries of the Sessa river, decline of natural fish population would also affect the lives of those communities and hinder the socio-economic development of the region.

The river water and its biological resources including fisheries has been under constant threat of aquatic pollution, particularly in Lezai-Kalahowa area of the district after the commissioning of the Brahmaputra Cracker and Polymer Limited (BCPL) at Lepetkata for production of petrochemical products. Being located in close proximity to the river, most of the wastes generated in the production process of BCPL find their way to the river water, causing serious pollution of the river not only affecting every facet of the riverine ecosystem and their resources including fishes but also the local fishing communities and others dependent on the river for their sustenance. In fact, there are days when fishes caught from the Sessa river even remain unsold in the local markets for the pungent smell and deteriorating taste of the fish flesh owing to the chemical pollution, endangering the fish population as well as the health and livelihood of the people that dependent on the fisheries resources of the river.

5.0: CONCLUSION:

Considering the importance of Sessa river in Dibrugarh district of Assam from the fish biodiversity, commercial fisheries and livelihood of riparian communities' point of view, priority need to be given to manage the fisheries resources and the riverine habitat in a sustainable manner through community participation approach. Being a small river, except during the monsoon, the river offers sufficient scope for the expansion of culture-based fisheries through cage culture and pen culture of selected commercially fish species for rest of the year. This would be helpful in maximize the earning of local fishers and lessening the pressure on natural fish stock of the river. Moreover, strict enforcement of relevant existing fisheries laws, rules and regulations and proper vigilance is necessary for curbing illegal fishing practices, particularly use of banned fishing gears like mosquito net in remote areas and stretches of the river. Adding to this, pollution and contamination of river water by the waste water and untreated or partially treated waste discharge from nearby industrial set-ups is another area of concern for fisheries and habitat quality of the river. As such, a monitoring and surveillance system needs to be implemented at the earliest, especially in relation to chemical pollution. Further studies are also required with respect to commercial fisheries, seasonal catch composition, socio-economic conditions of the local fishers and their approach towards conservation of fish diversity and management of fisheries of this river for formulating region specific fishery management plan.

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