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A study of certain physico-chemical characteristics of Satajan wetland with special reference to fish diversity indices, Assam, India

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ABSTRACT

The present work was, mainly, intended to create information on physico-chemical parameters along with fish diversity indices in the Satajan to have a vivid picture of the ecological status of the Satajan wetland, a weed infested water body situated at Lakhimpur district of Assam comprising 34 acres of area. The studies revealed that the certain physico-chemical parameters were satisfactory with few exceptions like chloride content and low dissolved oxygen value. Water temperature of the studied water body was slightly higher than the air temperature during winter season.

Key words: Fish Diversity indices, Physico-chemical parameter, Dissolved oxygen

INTRODUCTION

Wetlands are one of the Earth's richest ecosystems, offering "sanctuary" to a wide diversity of plants and animals. In addition, they play other key roles, for example provisioning and maintaining water quality for countless living organisms. Since the wetland is considered a transitional area between land and water. It is a half-way world between terrestrial and aquatic ecosystems [1]. wetlands are saturated by water and harbouring special type of flora and fauna, those usually undergo time scheduled characteristic changes from hydric to mesic types. Such habitats are well known for high diversity in class, composition and four broad categories of functions viz. physical/hydrological, chemical, biological and socioeconomic [2]. Although the value of wetlands for fish and wildlife protection has been known from several decades, some of the other benefits like conservation of biodiversity, maintenance of water quality, recharge and discharge of water regime etc. have been identified only in recent years [3].

Freshwater fish are one of the most threatened taxonomic groups [4] because of their high sensitivity to the quantitative and qualitative alteration of aquatic habits [5, 6, 7]. The endemic fish families form 2.21% of the total bony fish families of the Indian region. 223 endemic fish species are found in India, representing 8.75 % of the total fish species known from the Indian region [8]. The present investigation is proposed to carry out to explore the seasonal change of physico-chemical properties of water which is the key driver of aquatic ecosystem along with ichthyofauna diversity and species richness and composition, evenness of the existing species, habitat status etc. by using different commonly used diversity indices.

MATERIALS AND METHODS

Study area

Satajan wetland (27°12'36"N and 94°2'56"E) is located in the floodplain of River Ranga, regulated by 405MW Ranganadi Hydroelectric Project which was created by great devastating earthquake of 1950. The wetland is weed

infested with some floating pits and open water areas having water depth of minimum 1.2 meter to 6.5 meters (winter). The total area covering by the Satajan wetland is only 34 acres but from the biodiversity point of view it is highly significant as it has been observed that last few decades, the said wetland has been preferred by more than twenty five species of migratory and residential birds as a safe haven of.

Study of water quality

For the study of water quality parameters, ten random samplings were made in the Satajan wetland. Sampling was made thrice in a month and data were presented seasonally viz., *pre-monsoon* (Mar-May), *monsoon* (Jun-Aug), *post-monsoon* (Sept-Nov) and *winter* (Dec-Feb). The study was carried out between March, 2011 and February 2012. Water samples were collected from four different sampling sites of the wetland every ten days interval. The methodology adopted for the analysis of water samples are:

- a. Water & air temperature: - Mercury thermometer graduated up to 110°C.
- b. Transparency: - Secchi disc of 18 cm diameter [9].
- c. pH :- Digital pH meter (model LT -11, Labtronics)
- d. Total dissolved solid (TDS), total suspended solid (TSS) and total solid (TS): Trivedy and Goel [9]
- e. Dissolved oxygen (DO₂):- Winkler's modified method [10]
- f. Free carbon dioxide (FCO₂):- Titration method is using phenolphthalein as indicator [11].
- g. Total alkalinity: - Titration method is using methyl orange as an indicator [11]
- h. Chloride: - By using potassium chromate as an indicator [10].

Study of fish diversity

Fishes were collected from the wetland particularly during post monsoon and winter season with the help of local fishermen by using different types of nets including gill net, cast net (khwali Jaal), drag net (ghokota jaal) etc with different mesh size (0.5cm to 2.5cm). For diversity studies, five hauls of each fishing gear have been considered as sample while altogether twenty samples were considered for the present calculation. One specimen of each of the available fish species was preserved in 5% formalin solution and detailed taxonomic examination either in fresh or preserved specimens were made following the key of [12, 13, 14].

Statistical analysis and diversity indices

All the water quality parameters were collected and descriptive statistics were done by following standard literature [15] and analytical statistics were done by software SPSS, version 11.5. Fish species diversity was subjected to diversity analysis using different indices like Shannon – Weiner index (H) [16], Simpson Dominance index (D), Simpson index of diversity (1-D) [17], Margalef's index [18], Pielou Evenness Index [19], McIntosh Diversity Index and McIntosh Evenness Index [20].

Shannon Diversity Index “H”

$$H = -\sum [(n_i / N) \times (\ln n_i / N)]$$

H: Shannon Diversity Index

n_i: Number of individuals belonging to i species

N: Total number of individuals

Pielou Evenness Index “J”

$$J = H / H_{max}$$

J: Pielou evenness index

H: The observed value of Shannon index

H_{max} : lnS

S: Total number of species

Simpson Diversity Index “D”

Simpson's index of dominance:

$$D = \sum n_i (n_i - 1) / (N (N - 1))$$

Where, n_i = the total number of individuals of a particular species. N = the total number of individuals of all species.

Simpson's index of diversity: $1 - D$

Margalef Diversity Index "Ma"

$$Ma = (S-1) / \ln N$$

Ma: Margalef Diversity Index

S: Total number of species

N: Total number of individuals

McIntosh Diversity Index "Mc"

$$Mc = [N - \sqrt{(\sum ni^2)}] / [N - \sqrt{N}]$$

Mc: McIntosh Diversity Index

ni : Number of individuals belonging to i species

N: Total number of individuals

McIntosh Evenness Index "McE"

$$Mc E = [N - \sqrt{(\sum ni^2)}] / [N - (N / \sqrt{S})]$$

Mc E: McIntosh evenness index

ni : Number of individuals belonging to i species

S: Total number of species

N: Total number of individuals

RESULTS AND DISCUSSION

Seasonal variation of physico-chemical parameters of Satajan wetland is depicted in the table 1. The mean air temperature was highest in monsoon (34.26 ± 1.15) and lowest (13.84 ± 1.69) in winter. The mean water temperature was also following the same trend (Fig 1). Temperature is one of the most important physical factors influencing the aquatic life. Air temperature is determined by the air masses over the particular land mass, climatic condition [21,22], time of sample collection, climate and solar radiation [23] and topography [24] have an impact on air temperature.

Water temperature, a regulatory factor for various physico-chemical as well as biological activities in ecosystems, was found to fluctuate markedly with the variation in air temperature [25]. There are several factors which influence the water temperature in river basin. Some of these factors are basin morphology, altitude, topography and vegetation [26]. Air and water temperature play important role in the physicochemical and physiological behaviour of biotic components of aquatic ecosystems [27]. In the present study area, the water temperature was higher than the air temperature during winter months which may be due to the accumulation organic matter from the pit as well as droppings of the migratory birds.

The mean value of DO_2 was maximum (6.37 ± 0.51) in winter season and minimum (3.20 ± 0.41) in monsoon. The water temperature and transparency may be the reason of present finding. The abundance of floating vegetation and pit formation (organic matter) may be the cause of low dissolved oxygen of the wetland. Dissolved oxygen is the most important parameter which can be used as an index of water quality, primary production and pollution [8]. Dissolved oxygen content is the most significant factor regulating metabolic processes of the organism and also the community as a whole. Dissolved oxygen in general affects the solubility and activity of various nutrients and therefore, the productivity of an aquatic ecosystem [28]. A marked variation of dissolved oxygen content in water bodies of India was observed by various investigators [29], and it varies greatly from one water body to the other in the same area. Rodgi & Nimbergi (1978) [30] viewed that disposal of domestic sewage and other oxygen demanding wastes reduce the dissolved oxygen of the receiving water body.

The free CO_2 concentration in water indicates the presence of decomposable organic matter, bacterial action on organic matter and physiological activities of biotic components [27]. In the present study, the maximum (17.30 ± 4.77) and minimum (9.88 ± 1.24) value of free CO_2 was recorded in the monsoon and winter season respectively. Lower level of free CO_2 during winter is mainly due to high photosynthetic activity utilizing free CO_2 , which is in agreement with the earlier work [31].

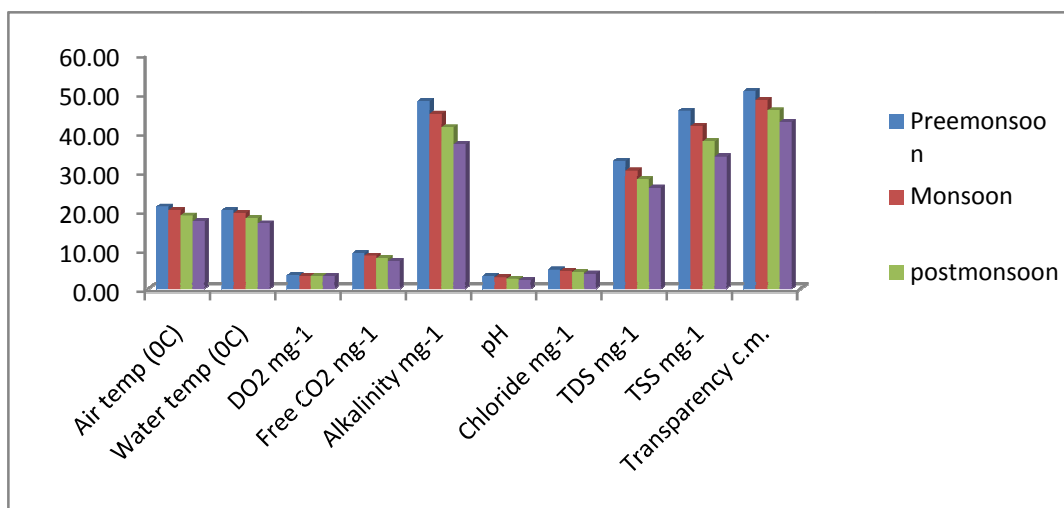


Fig 1. Seasonal variation of Physico-chemical parameters in Satajan wetland (2011-2012)

Table 2: Fish species of the Satajan wetland

Sl.No	Fish species	Family	Family wise % composition
1	<i>Notopterus notopterus</i> (Pallas)	Notopteridae	2.38
2	<i>Amblypharyngodon mola</i> (Ham-Buch)	Cyprinidae	30.95
3	<i>Chela cachiuis</i> (Ham-Buch)	Cyprinidae	
4	<i>C. laubuca</i> (Ham-Buch)	Cyprinidae	
5	<i>Devario rerio</i> (Ham-Buch)	Cyprinidae	
6	<i>D. regina</i> (Fowler)	Cyprinidae	
7	<i>Esomus danricus</i> (Ham-Buch)	Cyprinidae	
8	<i>Cirrhinus mrigala</i> (Ham-Buch)	Cyprinidae	
9	<i>Labeo gonius</i> (Ham-Buch)	Cyprinidae	
10	<i>L. rohita</i> (Ham-Buch)	Cyprinidae	
11	<i>Puntius conchoniuis</i> (Ham-Buch)	Cyprinidae	
12	<i>P. sophore</i> (Ham-Buch)	Cyprinidae	
13	<i>P. terio</i> (Ham-Buch)	Cyprinidae	
14	<i>Paruciosoma daniconius</i> (Ham-Buch)	Cyprinidae	
15	<i>Lepidocephalus berdmorei</i> (Blyth)	Cobitidae	4.76
16	<i>L. guntea</i> (Ham-Buch)	Cobitidae	
17	<i>Mystus tengara</i> (Ham-Buch)	Bagridae	7.14
18	<i>M. vittatus</i> (Bloch)	Bagridae	
19	<i>Rama chandramara</i> (Ham-Buch)	Bagridae	
20	<i>Ompok pabo</i> (Ham-Buch)	Siluridae	4.76
21	<i>Wallago attu</i> (Bloch & Schneider)	Siluridae	
22	<i>Pseudotropius atherinoides</i> (Bloch)	Schilbeidae	2.38
23	<i>Laguvia sp.</i>	Sisoridae	2.38
24	<i>Heteropneustes fossilis</i> (Bloch)	Heteropneustidae	2.38
25	<i>Clarius batrachus</i> (Linnaeus)	Clariidae	2.38
26	<i>Xenentodon cancila</i> (Ham-Buch)	Belonidae	2.38
27	<i>Monopterusuchia</i> (Ham-Buch)	Synbranchidae	2.38
28	<i>Channa gachua</i> (Ham-Buch)	Channidae	9.52
29	<i>C. punctatus</i> (Bloch)	Channidae	
30	<i>C. aurantimaculata</i> (Musikasinthorn)	Channidae	
31	<i>C. striatus</i> (Bloch)	Channidae	
32	<i>Chanda nama</i> (Ham-Buch)	Ambassidae	4.76
33	<i>Parambassis ranga</i> (Ham-Buch)	Ambassidae	
34	<i>Badis badis</i> (Ham-Buch)	Badidae	2.38
35	<i>Nandus nandus</i> (Ham-Buch)	Nandidae	2.38
36	<i>Anabas testudineus</i> (Bloch)	Anabantidae	2.38
37	<i>Glossogobius giuris</i> (Ham-Buch)	Gobiidae	2.38
38	<i>Trichogaster fasciata</i> (Schneider)	Osphronemidae	7.14
39	<i>T. lalia</i> (Ham-Buch)	Osphronemidae	
40	<i>T. sota</i> (Ham-Buch)	Osphronemidae	
41	<i>Macrogonathus aral</i> (Bloch & Schneider)	Mastacembelidae	4.76
42	<i>M. pancalus</i> (Ham-Buch)	Mastacembelidae	

Table 3: Fish diversity indices of Satajan wetland

Diversity Indices	Index Value
Shannon Diversity Index "H"	3.066
Pielou Evenness Index "J"	0.820
Margalef Diversity Index "Ma"	5.551
Simpson Diversity Index "D"	0.067
Simpson's index of diversity "1 - D"	0.933
McIntosh evenness index "McE"	0.876
McIntosh diversity index "Mc"	0.760

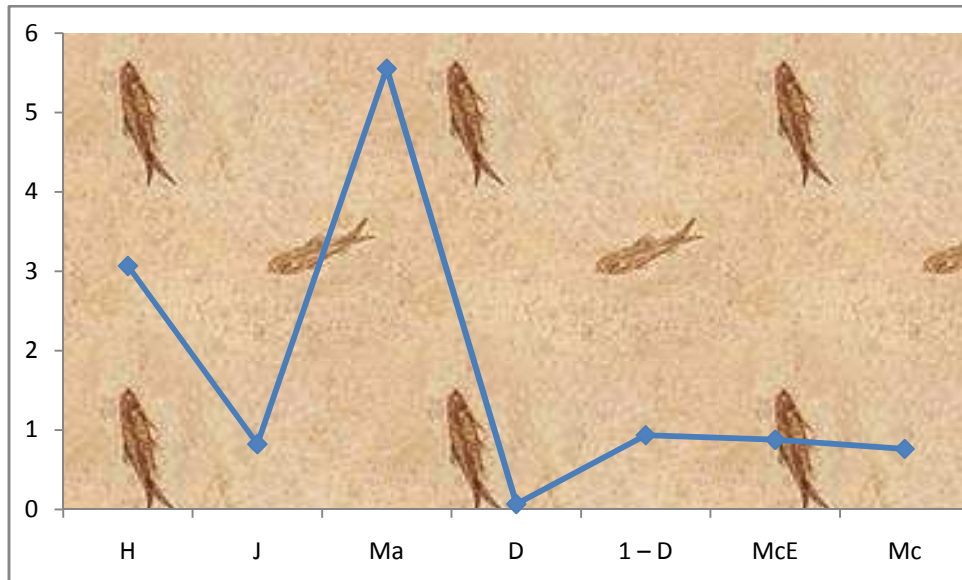


Fig. 2: Fish diversity Indices of Satajan wetland

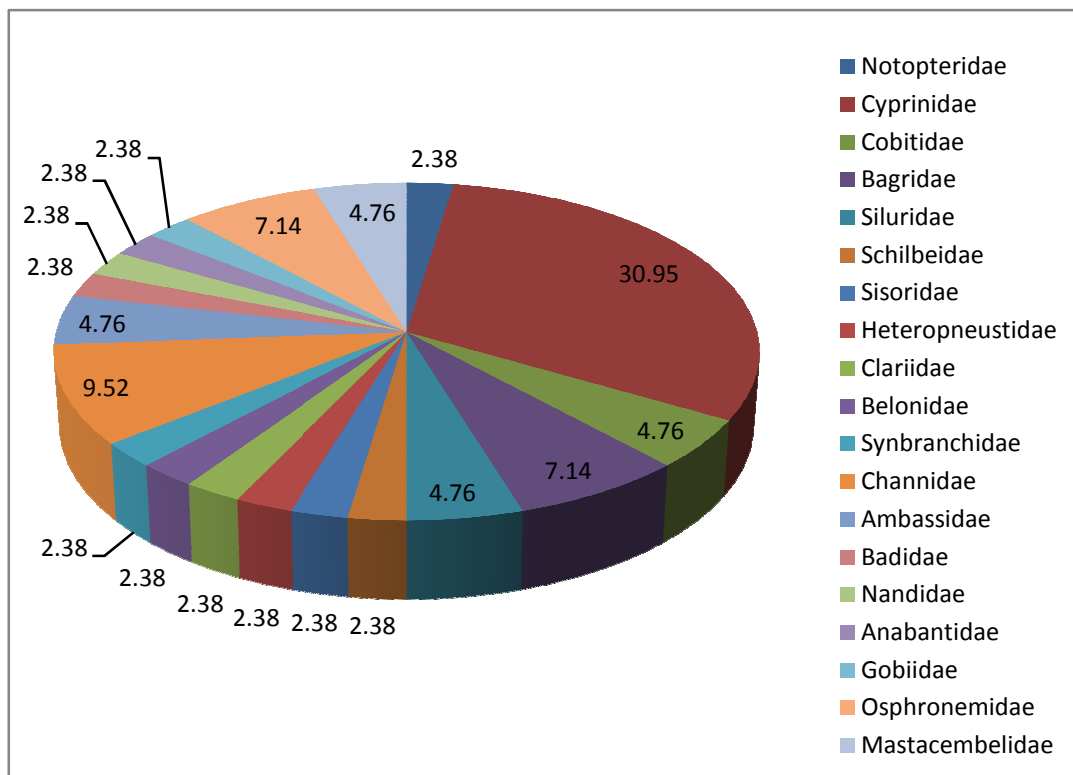


Fig. 3: Family wise percent composition of fish species



Plate 1a & 1b: Satajan in winter with countless visitors



Plate 2a & 2b: Satajan during summer

Alkalinity is important for aquatic life in fresh water systems because it equilibrates a pH change that occurs naturally as a result of photosynthetic activity of aquatic vegetation. The present finding is similar with the earlier findings [8].

pH of natural waters is due to available hydrogen ion concentration, the pH of the raw water sources mostly lies within the range of 6.5 to 8.5 [32]. The P^H of the Satajan wetland was slightly acidic (6.41 ± 0.20) during monsoon which was turned to neutral range (7.15 ± 0.16) during winter. Higher pH value is normally associated with the high photosynthetic activity in water [33]. The lowering of pH in monsoon may be due to higher runoff from the adjacent catchment area which is having slightly acidic soil [34]. Although the tolerance of individual species varies, pH values between 6.5 and 8.5 usually indicate good water quality and this range is typical of most major drainage basins of the world [35].

Chloride occurs naturally in all types of water bodies. The most important source of chlorides in the water is the discharge of domestic sewage [9]. The higher concentration of chloride in water is an index of pollution of animal origin and there is direct correlation between chloride concentration and pollution levels [27]. The slightly moderate range of chloride concentration in Satajan was also probably due to accumulation of domestic sewages from neighbouring human habitation and cattle shed.

Water has the capacity to dissolved salts those are in contact. So variety of salts will be there in water those were actually the component of rocks and soil of flood plain. In fresh water ecosystem, dissolved solids originate from natural sources and depend upon location, geological basins of water body, drainage, rainfall bottom deposits and inflowing water. Dissolved salts and minerals are necessary components of good quality water as they help maintain the health and vitality of the organisms that rely on this ecosystem service [36]. The concentration of total dissolved solids in Indian waters varies greatly and a maximum of 2416mg^{-1} was reported [29]. Sharma and Kumar (2002)[25] reported the presence of total dissolved solids ranged between 35.00 and 77.5mg^{-1} in the lakes of Garwal Himalayas. The dissolved solids are in fact more diverse in nature and apart from its natural sources of its input; sewage becomes the most important source [37]. The quantity, quality, intensity and duration of light influence the

life of organisms in different ways [38]. Transparency or light penetration was found to fluctuate according to season. An inverse relationship between transparency and suspended sediment load was observed. The rain water brought large amounts of dissolved and suspended inorganic and organic materials from upper catchment areas as well as from lower floodplain zone during rainy season that made water turbid and cause lower transparency. Similar observation was also made by Timms & Midgley, (1970) [39]. The slightly moderate range of TSS and low range of TDS in Satajan may be due to the presence of abundant amphiphytes in and around the wetland.

Being an obligate aquatic fauna, fish community of the Satajan wetland is particularly important to evaluate the ecological health of the wetland. The present study revealed that there are as many as 42 species of fish belonging to 19 families. Among the families Cyprinidae having 13 species followed by Channidae (04 Species), Bagridae and Osphronemidae (3 species each). The available fish species and family wise species composition is depicted in the table 2. The diversity indices so far calculated is also shown in the table 3.

Shannon index is an index applied to biological systems by derived from a mathematical formula used in communication area by Shannon in 1948[40]. It's the most preferred index among the other diversity indices. The index values are between 0.0 – 5.0. Results are generally between 1.5 –3.5, and it exceeds 4.5 very rarely. The values above 3.0 indicate that the structure of habitat is stable and balanced; the values under 1.0 indicate that there are pollution and degradation of habitat structure. The calculated H value (3.066) of the Satajan indicates its healthy status. Pielou index was derived from Shannon index by Pielou in 1966. The ratio of the observed value of Shannon index to the maximum value gives the Pielou Evenness Index (J) result. The values are between 0 – 1. When the value is getting closer to 1, it means that the individuals are distributed equally [19]. The “J” value of the present study area (0.820) is also closer to 1. Fish species of the Satajan is almost evenly distributed at present. Simpson diversity index was derived by Simpson in 1949[40]. Simpson index values (D) are between 0 – 1. But while calculating, final result is subtracted from 1 to correct the inverse proportion. Simpson's diversity index is a measure of diversity. In ecology, it is often used to quantify the biodiversity of a habitat. It takes into account the number of species present, as well as the abundance of each species. The “D” and “1-D” value of the Satajan (Table 3) is satisfactory still now. Margalef diversity index “Ma” has no limit value and it shows a variation depending upon the number of species. Thus, it's used for comparison the sites [41]. McIntosh index “Mc” was suggested by McIntosh in 1967. The values are between 0 – 1. When the value is getting closer to 1, it means that the organisms in a community are homogeneously distributed [20]. The “Mc” value of the Satajan is 0.760, which signifies it nearly homogeneous fish community. McIntosh evenness index “McE” was derived from McIntosh index. The values are between 0 – 1. When the value is getting closer to 1, it means that the individuals are distributed equally[42]. The present observed data of McE is also satisfactory. The changing patterns of different indices were depicted in the figure 2.

Diversity index is a statistical method which is planned to evaluate the variety of a data group consisting of different types of components. Features of a population such as number of existing species (Richness), distribution of individuals equally (Evenness) and total number of existing individuals underlie the basis of diversity indices[43,44]. Thus, any changes in any of these three features will affect the whole population, so that the diversity indices depending upon these features are used effectively to determine the changes in a population [40, 45].

CONCLUSION

The year-round monthly as well as seasonal variation of physico-chemical parameters of Satajan wetland is providing an almost vivid picture of ecological status at present. Overall water quality studied was found within the permissible limit for biological components except DO₂ level and chloride content of the wetland signifies the sewage contamination. Disposal of domestic sewage along with cow dung from nearby area could be a reason of contamination

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