Eco. Env. & Cons. 28 (August Suppl. Issue) : 2022; pp. (S178-S184)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i04s.026

Ecological Productivity Studies of the Dominant Aquatic Macrophytes in Kapla Beel, Assam North East India

Upen Deka[1], Upasana Borthakur[2] and Shreemoyee Phukan[2]

[1]Department of Botany, Silapathar College, Silapathar, Dhemaji 787 059, Assam, India
[2]Department of Chemistry, Silapathar College, Silapathar, Dhemaji 787 059, Assam, India

(Received 17 November, 2021; Accepted 12 January, 2022)

ABSTRACT

The present research work was carried out to study the primary productivity of dominant aquatic macrophytes with reference to water quality parameters during the year 2017 and 2018. Dominant aquatic plant species were found out based on IVI values. Among the dominant macrophytes, *Eichhornia crassipes* showed the maximum productivity values (1134gm/m^2) during the summer as well as the winter seasons (659gm/m^2).While *Hygroryza aristata* showed lowest productivity values (438gm/m^2 and 376gm/m^2) both in summer and winter seasons respectively. The macrophytes showed positive correlation with temperature, pH and turbidity while they showed highly negative correlation with DO. Luxuriant growth of these macrophytes and their subsequent death and decay results the lower dissolved oxygen value of the water body. It is due to the fact that during decomposition of aquatic macrophytes, microorganisms uses most of the oxygen dissolved in water body. Therefore aquatic macrophytes can be used for indicators of water quality and their presence may enhance the water quality due to their ability to absorb excess nutrients from the water body.

Key words: *Dominant aquatic macrophytes, Productivity, Eichhornia crassipes, IVI value, Water quality.*

Introduction

Wetlands act as bio-filter, as they receive large amount of organic as well as inorganic nutrients from the eutrophic water bodies or nutrient enriched pollutants through various dynamic processes, e.g. water cycle, nutrient cycle and food chain, for which they are known as 'Kidney of the Landscape'. Wetlands are also known as 'Biological Super Market' as the areas are rich in high species diversity (Allen-Diaz *et al*., 2004). Macrophytes are important component and play a major role in primary productivity of the aquatic ecosystem. It also controls water quality by exuding various organic and mineral components. They are important components of the aquatic ecosystem because they enhance the physical structure of habitats and biological complexity which increases biodiversity of the ecosystem (Esteves, 1998; Wetzel, 2001; Pelicice *et al.* 2008). The study of aquatic macrophyte is an essential component of understanding a water body due to its important ecological role and its ability to characterize the water quality (Gharzan *et al.*, 2006). The occurrence and distribution of aquatic macro-phytes depends on water depth, transparency, chemical composition, pH and salinity (Madsen *et al*., 2006;

([1]Assistant Prof., 2Assistant Prof.)

Vis *et al*., 2007). The presence of certain macrophytic species in aquatic ecosystems also depends on composition and properties of sediments also (Heegard *et al.,* 2001; Barendregt Bio, 2003; Makela *et al*., 2004).

Several works relating to primary productivity of aquatic macrophytes have been carried out throughout the world including different parts of India. Ambasht (1971) investigated the ecosystem study of a tropical pond in relation to primary production of different vegetational zones. Unni (1976) studied the production of submerged aquatic plant communities of Doodhadhari lake of Raipur of Madhya Pradesh. Devi (2000) recorded the phytosociology and primary production of the macrophytes in the freshwater ecosystem of Canchipur of Manipur. Devi (2002) studied vegetational structure and primary production of the macrophytes of Ikop lake of Manipur. Nikolic *et*. *al*. (2009) studied the primary production dynamics of dominant hydrophytes in Lake Provala. Bharali *et*. *al*. (2010) reported on a study on primary productivity of the wetlands of Kaziranga National Park of Assam. Acharjee (1997) investigated the ecological studied and productivity of some beel in lower Brahmaputra basin, Assam. Most of the wetlands of Barpeta district are in a verge of degradation due to various anthropogenic activities like encroachment, siltation due to flood, construction of roads, agricultural activities, development of commercial fisheries, lack of efficient inlet and outlet and excessive growth of *Eichhornia crassipes* in the wetland areas. The water quality in wetland may vary depending on the geological morphology, vegetation and land use such as agriculture, industrialization and urbanization in the catchment. The study therefore focuses to evaluate the physicochemical characteristics of water, aquatic macrophytes and the assessment of relationships between macrophytes assemblage and physicochemical conditions in Kapla beel Barpeta district, Assam, India.

Materials and Methods

Description of the study sites

The present investigation was carried out at Kapla beel of Barpeta district of Assam, India situated at the geographical position between $26^0 18'12''$ N to $26^0 25'7''$N latitude and $91^0 08'42''$ E to $91^0 14'50''$ E longitude. The wetland covers an area of 91 hectare which remains covered by water along with its aquatic vegetation almost around the year. The beel has an inlet on the eastern side connected with Chilla beel and Hablakhowa beel and has an outlet on western side which ultimately meets the mighty river Brahmaputra.

Sampling

Wetland was visited at least twice in a month and continued for two years i.e. from January, 2017 to December, 2018. Importance Value Index (IVI) was calculated by summing the relative values of density, frequency and dominance. For the statistical analysis, data were arbitrarily pooled in two groups viz. Summer (May- October) and Winter (November – April). For productivity of the macrophytes, plant samples were collected monthly regular intervals by using quadrat of 1m × 1m size. After collection, samples were kept in polythene bags marked with pencil and brought to the laboratory. Plant materials were washed to remove the adhering silt, soil, mud, other plants and animal debris. Then, the plant species were oven dried at (80°C) to determine the biomass. The primary productivity of the macrophytes was determined by the Harvest method as described by Trivedy and Goel (1986).

The Net Primary Productivity on monthly basis has been expressed in terms of gram per square meter per month (gm^{-2} $month^{-1}$) and the values of the Annual Net Primary Productivity were expressed in terms of grams per square meter per annum (gm^{-2} yr^{-1}).

$$\text{Biomass} = \frac{b_2 - b_1}{d}$$

$$\text{Whereas,} \quad \text{NPP} = \frac{(b_2 \times a_2) - (b_1 \times a_1)}{a_1 \times d}$$

b_1= biomass at time t_1 (g/m^2) a_1= area covered by macrophyte at time t_1 b_2= biomass at time t_2 (g/m^2) a_2= area covered by macrophyte at t_2 (m^2) d = No of days between t_1 and t_2

Physico-chemical analysis of water was done in the field by using water Analyzer kit.

Results and Discussion

Importance value index of macrophytes

Dominant aquatic macrophytes viz. *Eichhornia crassipes, Hygroryza aristata, Leersia hexendra,* and *Hymenachne assamica* showed higher Importance Value Index (IVI=30.34, IVI=25.9, IVI=19.74 and

IVI=14.08 respectively) (Table 1). Dominance of these aquatic macrophytes in the wetland may be due to less turbidity as well as maximum amount of light penetration results in increase in photosynthesis rate of phytoplankton. Increased level of turbidity decreases photosynthesis rate and consequently lowered the dissolved oxygen value.

Physico-chemical characteristics of water

Maximum pH value was recorded during the winter season and showed comparatively lower value during the summer season. Dissolved oxygen value was found maximum in winter season as compared to summer season. Turbidity was found maximum during the summer season. It is due to heavy rains during the season that carried silt from nearby agricultural fields into the wetland areas. Average values of N, P, K were found maximum during the summer season due to leaching from the nearby crop fields or from the surrounding villages of the wetland through surface runoff into the wetland while they showed lowest values during the winter season of the study periods.

Distribution of water quality characteristics maps of Kapla beel showed that the southwestern side of the beel has the highest water temperature recorded during summer season. It is due to the fact that the areas exhibit without any free floating aquatic macrophytes for which the sunlight can directly enhanced the water temperature. During the summer season pH value was recorded maximum in southern side of the beel while the eastern side showed maximum pH value during the winter season. Significantly, during summer as well as winter seasons maximum dissolved oxygen values were recorded in the eastern part and minimum in the western side of the beel. It is because western part of Kapla beel was heavily eutrophicated. It is due to death and decay of exotic invasive aquatic macrophyte i.e. *Eichhornia crassipes* during the study period.

Reationship between productivity and physico-chemical characteristics of water

During the study period, the macrophytes viz. *Eichhornia crassipes, Leersia hexandra Hymenachne assamica* and *Hygroryza aristata* were found dominated in Kapla beel along with other macrophytes. During the summer season, average annual productivity of *Eichhornia crasspes* was found to be maximum (1134 g/m^2). This is followed by *Leersia hexandra* and *Hymenachne assamica* (810 g/m^2 and 639 g/m^2 respectively) and *Hygroryza aristata* (438 gm/m^2). Similarly, during the winter season also, average annual productivity of *Eichhornia crassipes* was found to be maximum (659 g/m^2). This is followed by *Hymenachne assamica* and *Leersia hexandra* (558g/m^2, and 527 g/m^2, respectively) and *Hygroryza aristata* (376 g/m^2). During the summer season relatively higher values of N, P, K of water was observed in the wetland. It is due to leaching of some amount of the chemical fertilizers containing mostly N, P, K used in the agricultural fields near the wetland areas used by the local farmers which ultimately enhances the N, P, K level of the water body of the wetland. Maximum amount of nitrogen found in water of the wetland could have been derived from peat soils also through nitrification of ammonia produced from organic matter decomposition. Deka in 2016 working on the wetlands of Nalbari district of Assam have reported similar kind of results. The high phosphorus content in the water samples of the wetland was due to agricultural runoff and also due to discharge of water containing detergents used by the people of the surrounding areas of the wetland. There is a direct relationship between the primary productivity of aquatic macrophytes and the physico-chemical properties of water like water temperature, intensity of light, water depth, sediment composition and the amount of available nutrients in the water body (Shilla and Dativa, 2008). The inflow and outflow of water, nutrient loading and entry of harmful materials i.e. pollutants have both immediate and long term effects on the metabolic rates. However primary production showed direct correlation with p^H, BOD and Turbidity in the wetland.

In the present investigation, the total annual production of *Eichhornia crassipes* varied from 659 gm/m^2/yr to 1134 g/m^2/yr during the study period. The present findings are found to be higher than those values reported by Gopal *et al*. (1978) in Ramgarh reservoir. They had reported 92.90 g/m^2/yr – 564.50 g/m^2/yr productivity value of *Eichhornia crassipes* from Ramgarh reservoir. Similarly Westlake in 1975 reported 500 g/m^2/yr productivity value of *Eichhornia crassipes* from temperate freshwater lake. Total annual production of *Leersia hexandra* varied from 527 g/m^2/yr to 810 g/m^2/yr during the present study period. The present values are also found conformity to that reported by Misra (1989) in the shallow ponds of Veranasi (778.00 g/m^2/yr).

Among the dominant aquatic macrophytes,

Table 1. Importance Value Index (IVI) of the aquatic macrophytes of the wetland [RD = Relative Density, RF= Relative Frequency, RDo= Relative Domnance]

Name of the species	RD	RF	RDo	IVI
Achyranthes aspera L.	0.57	0.88	0.69	2.14
Alternanthera philoxeroides (Mart) Griseb.	0.607	0.793	1.713	3.11
Alpinia allughas	0.086	1.58	0.122	1.78
Amaranthus viridis L.	0.77	1.88	0.92	3.56
Aponogeton natans (L.) Engl. & Krause.	0.173	0.798	0.489	1.46
Centella asiatica (L.) Urban	1.34	0.886	1.61	3.83
Ceratophyllum demersum L.	1.29	0.943	0.69	2.91
Carex baccans L.	0.67	1.886	0.8	3.36
Cyperus brevifolius (Rottb) Endl. Ex. Hassk	0.693	1.58	0.978	3.25
Cyperus compressus L.	0.693	1.58	0.978	3.25
Cyperus difformis L.	0.693	1.58	0.978	3.25
Cyperus diffusus Vahl.	0.67	1.886	0.8	3.36
Cyperus iria L.	2.59	1.886	3.1	7.58
Cyperus rotundus L.	1.19	0.943	0.55	2.68
Cyperus digitatus Roxb. Var. bountii.	1.66	1.654	0.76	4.07
Cyperus marina L.	1.19	0.943	0.46	2.59
Diplazium esculentum (Retz) Sw.	1.19	0.943	0.46	2.59
Eclipta prostrata L.	0.48	1.886	0.57	2.93
Eichhornia crassipes (Mart) Solms.	19.2	3.773	7.41	30.34
Enhydra fluctuans Lour.	1.66	1.654	0.76	4.07
Euphorbia hirta L.	1.19	0.943	0.46	2.59
Euryale ferox Salisb.	0.38	0.943	0.92	2.24
Fimbristylis bisumbellata (Forssk.) Bubani	1.19	0.943	0.46	2.59
Grangea maderaspatana (L.) Poir.	0.86	0.943	2.07	3.87
Hygroryza aristata L.	4.163	15.87	5.873	25.9
Hymenachne assamica L.	7.12	2.83	4.13	14.08
Leersia hexandra SW.	9.4	2.83	7.51	19.74
Hydrilla verticillata (L. f) Royle	0.346	1.58	0.489	2.41
Ipomoea aquatica Forsk.	1.22	1.232	1.69	4.14
Ipomoea carnea Jace.	1.92	1.83	1.53	5.27
Kyllingia brevifolia Stokes.	0.38	0.943	0.92	2.24
Lippia javanica (Burm.f) Spreng.	1.19	0.943	0.46	2.59
Hymenachne acutigluma	5.12	1.83	1.13	10.08
Lemna perpusilla Torr.	0.346	0.798	0.978	2.12
Limnophila heterophylla	0.346	1.58	0.002	1.92
Limnophila indica	1.82	1.886	2.18	5.89
Limnophilla sessiliflora (Vuhl) Bl.	0.67	1.88	0.8	3.35
Ludwigia adscendens (L.) Hara	0.38	1.886	0.46	2.72
Ludwigia octavavis (Jacquin) Raven	1.25	0.943	2.99	5.17
Ludwigia perennis L.	1.29	0.943	0.69	2.91
Ludwigia prostrata Roxb.	3.86	2.88	2.03	8.77
Mikania micrantha Kunth. Ex. H.B.K.	0.77	0.943	1.84	3.54
Monochoria hastata (L.) Solms	0.693	0.793	1.957	3.44
Monochoria vaginalis (Burm f.) Presl.	0.693	1.58	0.978	3.25
Myriophyllum tuberculatum Roxb.	0.19	0.943	0.46	1.59
Nelumbo nucifera Gaertn.	2.92	1.83	1.53	6.27
Nymphaea nouchali Burm. f.	0.607	1.58	0.856	3.04
Nymphaea pubescens Willd.	0.433	1.58	0.611	2.62
Oryza rufipogon Griff.	0.77	1.886	0.92	3.57
Ottelia alismoides (L.) Pers.	0.67	1.88	0.8	3.35
Oxalis corniculata L.	0.82	0.886	0.18	1.89
Pistia stratiotes L.	4.58	3.88	2.01	10.47

Table 1. *Continued ...*

Name of the species	RD	RF	RDo	IVI
Polygonum barbatum L.	0.38	0.886	0.46	1.72
Polygonum glabrum Willd.	0.48	1.18	0.57	2.23
Polygonum orientale L.	0.48	0.943	1.15	2.57
Potamogeton crispus L.	0.173	0.793	0.489	1.45
Ranunculus aquatalis	0.086	0.798	0.244	1.12
Rumex nepalansis Spreng.	0.53	1.72	0.76	3.01
Sagittaria sagitifolia L.	0.26	0.793	0.734	1.78
Salvinia molesta (L.) All	1.26	0.793	0.734	1.78
Schoenoplectus articulatus L.	1.44	0.83	0.15	2.42
Schoenoplectus grossus (L. f.) Palla	0.77	1.83	0.61	3.2
Spirodella polyrrhiza (L.) Schleid	0.48	0.943	0.15	1.57
Trapa natans L.	1.63	1.886	0.95	4.47
Utricularia aurea Lour.	0.77	1.83	0.61	2.2
Vallisneria natans (Lour.) Hara	0.21	0.886	0.64	1.73
Vetiveria zizanioides (L.) Nash	0.44	0.83	0.15	1.41
Xanthium strumarium L.	0.48	0.943	0.15	1.57

Table 2. Average physico-chemical characteristics of water of the wetland

Sl no.	Parameters	Summer	Winter
1	Temperature (^{0}C)	33.83+ 0.75	22.83+5.87
2	pH	6.61+0.29	7.01+0.28
3	Dissolved Oxygen (DO) (mg/l)	3.62+1.26	7.02+1.75
4	Turbidity (cm)	65.16+15.77	32.46+9.17
5	Available Nitrogen of Soil (ppm)	870.06±345.27	732.81±21.40
6	Available Phosphorus of Soil (ppm)	42.78±2.80	31.79±7.65
7	Available Potassium of Soil (ppm)	142.99±14.07	132.65±5.02

Table 3. Annual Productivity of the dominant aquatic macrophytes of Kapla beel (g/m^2/yr)

Name of the plant species	Summer season	Winter season
Hymenachne assamica	639	558
Eichhornia crassipes	1134	659
Hygroryza aristata	438	376
Leersia hexendra	810	527

Hymenachne assamica showed negatively correlated with DO whereas it shows positive correlation with Temperature, pH, BOD and turbidity. Most dominant macrophytes viz. *Eichhornia crassipes Hygroryza aristata* and *Leersia hexendra* showed positive correlation with Temperature, pH and turbidity and BOD. On the other hand they are highly negatively correlated with DO. It may be due to the luxurient growth of such dominant aquatic macrophytes and their subsequent death has resulted deposition of heavy detritus. Besides the population of microorganism increases tremendously during the decomposition process which starts consuming most of the dissolved oxygen of water resulting into lowering of dissolved oxygen content of water. However the decomposition process of organic matter releases humic acid that enhanced the pH value of the water bodies.

The present study reveals that availability of nu-

Table 4. Correlation matrix aquatic macrophytes and water parameter

Sl No	Name of the species	Temp.	p^H	D.O.	B.O.D	Turbidity
1	*Hymenachne assamica*	0.764	0.795	-0.705	0.498	0.634
2	*Eichhornia crassipes*	0.879	0.876	-0.933	0.994	0.450
3	*Hygroryza aristata*	0.856	0.906	-0.955	-0.999	0.390
4	*Leersia hexendra*	0.787	0.696	-0.787	-0.920	0.691

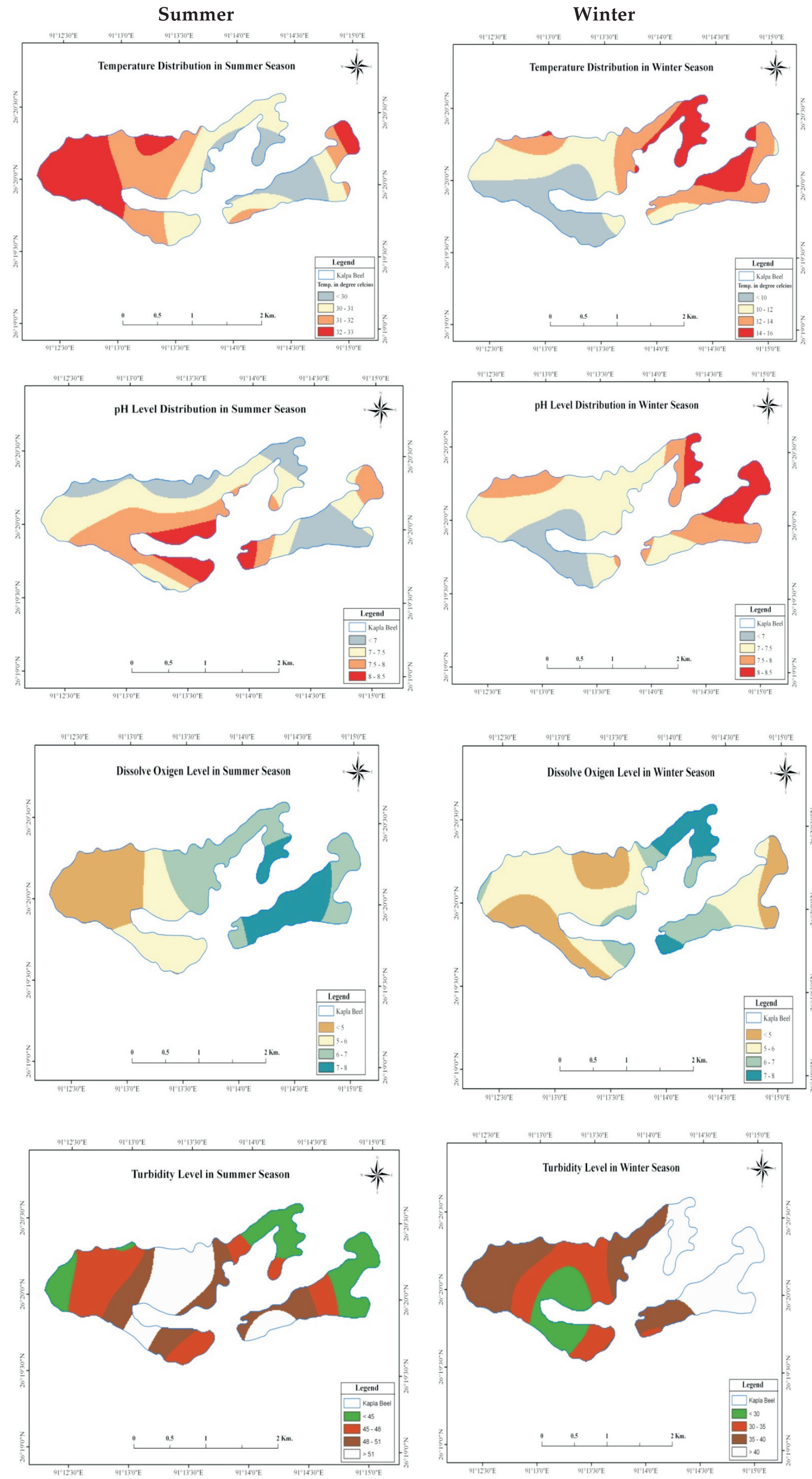

Fig. 1. Water quality distribution maps of the study sites

trients due to addition of N, P, K used in the nearby agricultural fields and organic matter decomposition helps in higher biomass production of the dominant aquatic macrophytes in the wetland. Sediments carried out through runoff from the surrounding areas also enhanced the nutrient quality of soil as well as water of the wetland. Highest IVI value of *Eichhornia crassipes, Hygroryza aristata, Leersia hexendra*, and *Hymenachne assamica* indicates the dominant growth in the wetland and the pysicochemical parameters of the wetland were also found to be related to aquatic macrophytes either positively or negatively.

Acknowledgement

Authors also gratefully acknowledged National Remote Sensing Centre, Hyderabad for providing the satellite imageries of the wetland of the study site.

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