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Diversity, Density & Nutrient lock up efficiency of Macrophytes in a Wetland of N.Bihar

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Abstract

Macrphytes are crucial for the functioning of aquatic ecosystem. They are involved in several feedback mechanisms. Their presence or absence reflects the nutrient status of the system. Greater amounts of nutrients, N, P, and K, in particular, provoke a high primary production, namely, eutrophication of aquatic ecosystems. The frequency, density and abundance of dominant macrophytes was done following Misra(1968). For calculating the nutrient accumulation per unit area the respective mean values for macrophytes were multiplied with the plant density. 28 plant species distributed in 26 genera in 18 families has been identified and documented. In terms of the number of species, emergent species constituted the largest(12) group, followed by rooted floating-leaved(5), free-floating(5), and submerged(6) species . The lock up efficiency of macrophytic components were also found high (metric tons) during study period - viz. (0.63) nitrogen, (0.019) phosphorus and (0.678) of potassium. However it showed a distinct variation throughout the year and it was found to be in direct correlation with the density.

Key words: Eutrophication, Nutrients, Potassium, Emergent, Density

I. Introduction

Wetlands are present throughout the globe stretching from mountain to sea. Their habitats are varied and so are their resident forms. As an ecosystem they are highly productive and at the same time highly volatile being particularly vulnerable to environmental fluctuations. Among their resident forms Macrophytes are considered the key stone species in their functioning as an ecosystem. These contribute significantly towards the primary as well as biological production of the wetland and serve as the natural habitats for many aquatic major biodiversity.

Macrophytes are involved in several feedback mechanisms that tend to keep the water clear. Early investigations have shown that aquatic macrophytes reflect the nutrient status of their immediate habitats by their presence or absence (James and Barko 1990, Sand-Jensen & Borum 1991, Horpilla and Nurminen 2001). Macrophytes and associated Periphytic communities serve as important sinks for nutrients that enter the wetland and as major regulators of nutrient dynamics in aquatic ecosystems through habitat coupling. They influence nutrient, heavy metal, and pollutant cycling, sediment stability, and characteristically determine the eutrophication degree [Chamber 1994, Lewis 1997]. Unlike terrestrial species, aquatic plants absorb macro (N, P, K, Ca, Mg, S) and micronutrients (Fe, Mn, Cu, Zn, Mo, Co, B) from water through their leaves while from sediments through roots and rhizomes and incorporate them into tissue to produce plant biomass. Nutrient and metal accumulation in their tissues may reflect the concentrations in aquatic environment. Although indispensable for plant life cycle, greater amounts of nutrients, N, P, and K, in particular, provoke a high primary production, namely, eutrophication of aquatic ecosystems.

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Monitoring the structure (species abundance, diversity) of macrophytic communities can provide indications of environmental impacts upon aquatic ecosystems. However considerable interspecific and geographical differences of plant nutrient removal efficiency along different environmental gradients do exist (Schimdt et al.2010).Thus the evaluation of nutrient sequestration efficiency of macrophytes in wetlands becomes of crucial importance.

Study site:--An unexplored wetland at Muktapur in samastipur district of N.Bihar was been selected for study. It is located 6 km North of Samastipur town and is one of the largest ox-bow lakes of the district with a water spread area of 60 ha. It a 'U' shaped impoundment. The depth of the lake varies between 3 and 6 m.. The wetland is fed by a tributary of river Gandak and occasionally receives jute mill effluents. There are a number of orchards crop fields and willow plantations in its catchment . The adjoining local population utilizes the water body for multipurpose including large scale harvesting , fishing, washing and irrigation.

II. Materials and Method

Monthly Samplings were performed at 5 different locations selected to represent all parts of the wetland and all habitat types including mid water areas. Quadrant of $1m^2$ was used for sampling of emergents and rooted floating leaf type macrophytes and $0.5m^2$ was used to free floating types. Sampling for the submerged macrophytes was achieved using Eckman dredge. Frame constructed of 1.25 in. diameter PVC pipe was used for quadrants. At every sampling location the frame was oriented in a north/south direction.

The frequency, density and abundance of dominant macrophytes was done following Misra(1968). Identification is based on the published literature of Subramanyan (1962), Zutshi (1975), Kak (1985), Fassett (1992) and Cook(1996). The plant nutrients (Nitrogen, Phosphorus and Potassium) were determined following Jackson (1973). Acquisition of N, K & P per kg of biomass in the macrophytes was worked out from the analysis of samples. For calculating the nutrient accumulation per unit area the respective mean values for macrophytes were multiplied with the plant density i.e. the number of plants per unit area.

III. Results and Discussion

In the present investigation the wetland exhibited a heterogenous assemblage of Macrophytes. In the present study, as many as 28 plant species (26 angiosperms,one ferns and one algae) distributed in 26 genera in 18 families has been identified and documented. In terms of the number of species, emergent species constituted the largest (12) group, followed by rooted floating-leaved(5), free-floating(5), and submerged(6) species (table-2).

Among the plant diversity parameters, plant frequency (%), density and abundance varied greatly in the study areas. *Eichornia crassipes, Azolla pinnata, Trapa bispinosa, Ipomoea aquatica Phragmatics karka Lersia hexandra Cantala asiatica, Hydrilla verticellata and Cynodon dactylon* were present throughout the year. Plant frequency ranged between 1% and 100% with maximum occurrence was recorded for *Cynodon dactylon* and minimum for *Limnophila indicum*, both members of monocot belonging to family Poaceae and Scrophulariaceae (Table 3,4). The lowest density but high abundance of *Limnophila indicum* suggested highly localized distribution of this economically important plant, and needs urgent conservation.

Altogether the frequency (%) of 28 plants was classified into five frequency classes (A-E), and highest number of plant species was found in class E (Frequency 81-100%) (Figure). The density was the highest (5.0) in case of *Cynodon dactylon* and it was closely followed by Cyperus iria (3.12),*Eichhornia crassipes* (2.22) and Sachharatum spontaneum(2). Lowest value (0.38) was obtained for Nechamandra alternifolia (Table 2). As total number of plants increased, density of particular species increased, and the reduction of plant number resulted in lowering of density value. Results

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revealed that out of 28 plants, 42.85% plants exhibited density in range of 0-1, 17.85% in 1-1.5, 28.57% in 1.5-2.0 and 10.71% plants in values >2.0. Obviously, plant density value within study area hovered low to moderate magnitude. Low density but high abundance of plants as found in many plant species indicates their distribution only in certain quadrants.

Table 1. Nutrient accumulation per annum (November, 2013 -October, 2015) in macrophytes.

Nutrient	Amount accumulated (Metric ton)
Nitrogen	0.63
Phosphorus	0.019
Potassium	0.678

Table: 2.Number, frequency(F), Density(D) and Abundance(AB) of plants in over two year period (20quadrate/month)

Name	Total no. of individual (a)	Number of quadrates (b)	F(%) = b/400x100	D = a/400	Frequency class (A-E)	AB=a/b
Free Floating						
1.Azolla pinnata	500	360	90	1.25	E	1.39
2.Eichhornia crassipes	890	300	75	2.22	D	2.96
3.Pistia stratiotes	678	340	85	1.69	E	1.99
4.Lemna sp.	658	322	80	1.64	D	2.04
5.Spirodella sp	160	340	85	1.69	E	1.99
Rooted floating						
6.Euryale ferox	180	90	45	0.45	C	2
7.Nelumbo nucifera	260	90	23	0.65	B	2.88
8.Nymphaea nouchali	695	360	90	1.73	E	1.93
9.Nymphoides indicum	280	100	25	0.7	C	2.8
10.Trapa bispinosa	425	360	90	1.06	E	1.18
11.Chara branchypus	310	140	35	0.78	B	2.21
12.Potamogeton crispus	210	120				
Submerged						
13.Hydrilla verticellata	355	300	75	0.88	D	1.18
14.Nechamandra alternifolia	150	160	40	0.38	B	0.94
15.Vallisneria spiralis	280	160	40	0.7	B	1.75
16.Ceratophyllum demersum	510	380	90	1.27	E	1.34
Emergent						
17.Centela asiatica	710	385	96	1.77	E	1.84
18.Commelina benghalensis	470	270	67	1.17	D	1.74
19.Lersia hexandra	175	140	35	0.44	B	1.25
20.Ipomoea aquatic	280	190	47	0.70	C	1.47
21.Echinochlon colonum	190	95	23	0.47	B	2.00
22.Echinochloa crus-galli	190	95	23	0’47	B	2.00
23.Cynodon dactylon	2000	400	100	5.00	E	5.00
24.C.rotundus	718	370	92	1.79	E	1.94
25.Phragmatis karka	580	340	85	1.45	E	1.70
26.Limnophila indicum	170	100	25	0.43	B	1.7
27.Saccharatum spontaneum	800	360	90	2	E	2.22
28, Cyperus iria	1250	390	98	3.12	E	3.2

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Table-3 Seasonal variation in IVI values of Macrophytes

Species	Importance Value Index(IVI)			
	Summer	winter	Spring	Average
Free Floating				
1.Azolla pinnata	0	21.15	0	7.05
2.Eichhornia crassipes	27.25	43.5	34.71	35.15
3.Pistia stratiotes	6.04	6.29	0	4.11
4.Spirodela sp	19.41	0	0	6.47
5.Lemna sp.	12.22	6.86	0	6.36
Total	64.92	77.8	34.71	59.14
Rooted Free Floating				
6.Euryale ferox	3.16	0	0.91	1.35
7.Nelumbo nucifera	1.5	0	1.35	0.95
8.Nymphaea nouchali	2.1	3.09	0	1.73
9.Nymphoides indicum	3.23	0	1.91	1.71
10.Trapa bispinosa	19.31	0	12.19	10.50
Total	29.3	3.09	16.36	16.24
Submerged				
11.Hydrilla verticellata	16.37	24.9	54.54	31.94
12.Nechamandra alternifolia	2.67	0	1.87	1.51
13.Vallisneria spiralis	0	3.51	0	1.17
14.Ceratophyllum demersum	23.61	11,56	0	11.72
15.Chara branchypus	0	6.03	0	2.01
16.Potamogeton sp.	0	0	5.43	1.81
Total	42.65	34.44	61.84	50.16
Emergent				
17.Cantella asiatica	2.05	1.76	2.11	1.97
18.Camelina benghalensis	2.8	0	1.87	1.55
19.Lersia hexandra	38.97	18.56	36.83	31.45
20.Cyperus iria	13.8	0	0	4.60
21.Phragmatics karka	2.82	5.29	11.28	6.46
22.Saccharatum spontaneum	5.43	6.29	0	3.91
23.Limnophila indicum	0	0	2.75	0.92
24.Cyperus rotundus	8.5	0	4.05	4.18
25.Ipomoea aquatica	7.69	13.11	3.05	7.95
26.Echinochlon colonum	4.49	6.26	0	3.58
27.Echinochloa crus-galli	0	0	5.71	1.90
28.cynodon dactylon	30.4	16.5	28.8	25.23
Total	116.95	67.77	96.45	93.7
Grand Total	**253.82**	**183.1**	**209.36**	**219.24**

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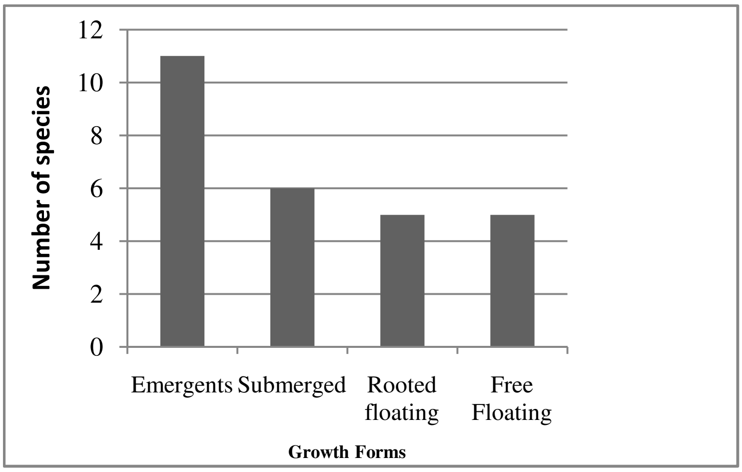

Furthermore in the present investigation the number of aquatic macrophyte species was higher during the summer (24) and spring(19) and lower during the winter (18).The dominance of species by growth forms on the basis of IVI value is presented in Table 3. Emergents were the most dominant form throughout the year. This can be attributed to the emergents' high tolerance for fluctuation of water level (Van der Valk and Davis 1976). Seasonally, emergents' IVI was highest in the summer, followed by winter and spring. Among emergents, *Leersia hexandra* was the most dominant in the summer and the spring,followed by Ipomoea aquatic in winter and Phragmatics karka in spring and *Cyperus iria* in the summer.

Similarly the nutrient lock up efficiency of the Macrophytes also showed a distinct variation throughout the year and it was found to be in direct correlation with the density. The range of variations were N-0.452 to 1.482%. K-0.3918- 1.985%, & for P-0.01 to 0.07%, The trend of increase and decrease were also observed to be identical for these components. There occurred a progressive increase with the onset of spring and decrease with the progress of winter. Maximum values (N-14.78 g m^{-2} **,** K-17.61 gm^{-2} & P-0.486g m^{-2}) were found in the month of April whereas minimum concentration of these components (N-1.318 g m^{-2}, K-1.68 g m^{-2} , & P-0.042 g m^{-2}) were obtained in the month of January.The pools of nutrient in the aquatic plants of the wetland showed maximum annual accumulation of potassium and minimum phosphorus level; the order of sequence being K>N>P. Duarte 1992 and some others have reported a close correlation between N & P levels. The increase in the nutrient content of the macrophytes from spring onwards corresponds to the luxuriant growth of vegetation during this season throughout the wetland, which dies and decays with the onset of late autumn to winter when least values of nutrient accumulation values were observed. The lock up efficiency of macrophytic components were also found high (metric tons) during study period - viz. (0.63) nitrogen, (0.019) phosphorus and (0.678) of potassium. It is positively related with the production of biomass.(Table-1)

Although tissue N concentration is much higher than P concentration, diagnostic studies of water ecosystems indicate phosphorus as a limiting nutrient for plant growth. Generally, rooted aquatics satisfy their demands for P from sediments, thus interfering biomonitoring due to nutrient concentration, water depth, light regime, and pH limiting their distribution. Despite that, P is often chosen as a critical element to control nutrient loading rate. Aquatic plants play an important role in taking out excessive P from wastewaters, which cause pollution when present in greater amounts. P amounts taken out rely upon plant species and P from water and substratum while, frequently, a main P source for macrophytes is the surface mud layer.

However, only a part of the vegetation in wetland is transformed into animal biomass whilst the rest decays and decomposes thereby adding a large quantity of organic matter and debris brought to the wetland by various feeding channels. If harvested periodically it will greatly help in the reduction of

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nutrient load and check eutrophication. According to Gopal and Kulshreshtha (1980), emergent macrophytes because of larger biomass and production rates, have better nutrient removal potential / efficiency than other macrophytes.

Moreover an evident nutrient and heavy metal bioconcentration ability significantly enlarges the possibilities of utilization of aquatic plants not only for bioindication, but, also, for the purification of water, substratum, and littoral zone. Due to rapid industrial development and urbanization, with respect to the ecological problems caused by chemical contaminants, pollution reinforces studies of the possibility of utilization of macrophytic vegetation to remediate pollutants from environment, namely water detoxification . Utilization of aquatic plants for a biological clean-up technique in various polluted ecosystems is highly acceptable due to their high biomass production resulting in a high uptake of macronutrients (N, P, K, S) and heavy metals.

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