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Nutrient Dynamics in the Floodplain Wetlands of West Bengal

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The results of the study on the nutrient dynamics of eleven floodplain wetlands (*beels*) in West Bengal are reported. In the *beels* of Dinajpur phosphorus has become a limiting factor for production due to acidic soil (pH 5.6-5.9). Total nitrogen was significantly high in most of the *beels* especially during monsoon and post-monsoon months. Majority of the *beels* were infested with macrophytes in the littoral zones. A significantly high concentration of essential nutrients was recorded in the weed infested littoral areas while they were less in the weed-free limnetic zones. The C/N ratio was recorded in the production range (5-13) in many of the *beels* except in weed-chocked Nehali *beel* where the ratio was extremely high (39-55) owing to the accumulation of undecomposed organic matters at the bottom.

Key words: *Beels*, limno-chemistry, nutrients, macrophyte, productivity

One of the most important aquatic resources in West Bengal is floodplain wetlands (*beels*) having rich floristic and faunistic diversity with immense fish yield potential. Emergent steps are necessary to augment fish production in a sustainable manner from these vast, biologically delicate biotopes. Though, during the last two decades there was an increase in fish production from such neglected water bodies withthe active participation of co-operatives, these efforts should be blended with scientific ecological principles for maintaining higher productivity.

Nutrients, both from autochthonous as well as allochthonous inputs play a versatile role in defining trophic status of the *beel* ecosystem. Most of the *beels* are densely populated with macrophytes restricting supply of nutrients to primary producer. So proper understanding of nutrient dynamics is a must while studying the ecology and production functions of these water bodies in a sustainable manner.

Barring the works of Vass (1992), Pathak (1989 & 1990), Singh (2000 & 2001) and Saha *et al.* (2001) very little is known about the nutrient regime of the *beel* ecosystem. The present study conducted during 1995-98 is an attempt to generate a sound database on nutrient dynamics for accentuating fish production of these ecotopes.

Materials and Methods

The floodplain wetlands of West Bengal under study were selected from different districts of West Bengal located between North Dinajpur and Midnapore district. The locations of the *beels*, their name, water spread and type are enlisted in Table 1. Most of the *beels* are shallow in nature having maximum depth of 3.0 m excepting Bansdaha with a maximum depth of 8.0 m in monsoon.

Sarasanka, a tectonic depression was 70% weed-choked with the dominance of *Salvinia*. Percentage of weed chocking area and the predominant macrophyte species were as follows: Haripur-closed (70%, *Vallisneria*), Haripur-open (30%, *Hydrilla*), Kole (20%, *Creatophyllum* & *Vallisneria*), Bhomra (75-85%, *Hydrilla*), Bhaluka (40%, *Eichhornia*) and Nehali (90%, *Nymphaea*). Patari (recently re-excavated) and Kola were totally weed free ox-bow lakes amongst the *beels* studied.

Samples of water and sediment were collected from different segments covering littoral as well as profundal zone of these *beels* during 1995-97 in pre-monsoon (April-May), monsoon (mid July-mid Sept), post-monsoon (Oct-Nov) and winter (Jan-Feb) periods. Bhomra (surface macrophyte free) and *beels* of Dinajpure districts were studied during 1996-98. Water samples were brought to the laboratory preserving with respective preservatives and analysed, following 'Standard Methods' (APHA, 1992). Soil analyses were performed using standard methods (Tandon, 1993).

Results and Discussion

The effective functioning of any aquatic ecosystem depends on the circulation of nutrients which takes place in most of the occasions at a faster rate specially in shallow tropical floodplain wetlands. Unlike small reservoirs, the *beel* ecosystem has its chief nutrient source from autochthonous input followed by allochthonous sources when flood water/run-off water enters into the *beel* inundating nearby crop fields if the *beel* is not well protected with embankments. The open *beels* are getting nutrients more during monsoon through their connections with the main river systems. In this study, the *beels* like Haripur -open, Kole and Churamon moranadi are replenished by allochthonous inputs due to their openness feature.

The role and importance of nitrogen (N) and phosphorus (P) in aquatic productivity have been recognised and widely studied.

The seasonal average of nutrients in water of some select *beels* of West Bengal are presented in Table 2. Pooled average of both post-monsoon and winter data are shown in the column marked by 'post'. In most occasions, the maximum values correspond to the samples collected during peak monsoon period. Amongst the *beels* studied, nitrate-N was noticed maximum in Bhomra (SMF), followed by Kola and Bhomra. SRP was found more during monsoon and immediate post-monsoon months to the tune of 350 (Bhomra, SMF), 210 (Bansdaha), 200 (Kola) and 170 (Bhomra). There was a drastic fall of nutrient contents both in surface as well as column waters during peak pre-monsoon months due to their quicker utilization by macrophytes. Concentration of nitrate-N and SRP in most part of the year was very meagre in many of the *beels* studied as also reported by Pathak (1989), Mukhopadhyay (1997) and Singh (2000). Though, decomposition of bottom organic matters including detritus (basically formed due to decayed and partially decayed macrophytes) are at peak in summer months, releasing nutrients into available forms, they are utilised at a faster rate both from soil as well as water phase by submerged and floating macrophytes.

Table 1. Distribution of some select *beels* of West Bengal

Beels	Location	Latitude (N)	Average Area (ha)	Type
Sarasanka	Dantan, Midnapore	21°58'15"	17.00	Closed
Haripur-closed	Haripur, Maldah	25°12'20"	21.00	Closed
Haripur-open	Haripur, Maldah	25°12'20"	30.00	Open
Bansdaha	Purbasthali, Burdwan	23°30'	26.00	Seasonally open
Kole	Somra Bazar, Hooghly	23°7'28"	70.00	Open
Bhomra	Kastadanga, Nadia	22°55'15"	45.00	Partially open
Kola	Bagdah, 24-parganas(N)	22°10"	12.00	Partially open
Bhaluka	Chakmanikya, S. Dinajpur	26°10'20"	35.00	Seasonally open
Patari	Sukhdevpur, S. Dinajpur	26°20'10"	43.00	Seasonally open
Nehali	Raiganj, North Dinajpur	26°55'10"	42.00	Closed
Churamon moranadi	Itahar, North Dinajpur	26°45'15"	24.00	Seasonally open

Substantial amount of available nutrients were found in the *beels* in this study free of surface as well as submerged macrophytes like Kola and Bhomra (SMF). As available nutrients are limiting factors in these ecosystem in most part of the year due to their quicker turnover primarily by macrophytes, productivity profiles of these water bodies could be assessed only by stoichiometric determination of total-N as well as total-P in water. The data in Table 2 showed phenomenal presence of total-N (inorganic - NO_2^{-1}, NO_3^{-1}& NH_4^+ and organic) and total-P (SRP+organic-P) in these *beels*. Maximum total-P was encountered in Kola *beel* followed by Bhomra, Bhomra, Bansdaha, Haripur-open and Sarasanka. *Beels* of Dinajpur marked comparatively lower values of total-P in water as the release of phosphorus either from catchment or from the bottom sediment was hindered due to P-fixation by soil which is somewhat acidic in nature. As, organic nitrogen occupies prime share in total-N, presence of total-N in water was overwhelming in these ecosystem especially during monsoon and post monsoon to the maximum tune of 2325 in Kola, 1970 in Bhomra (SMF), 1650 in Bhomra, 1180 in Bansdaha, 870 in Haripur-open and 690 in Sarasanka. Dinajpur *beels* showed low values of total -N as compared to their southern counterparts.

Silicate-silicon remains as silicate in natural freshwater, which is in available form. Silica is the structural constituent of diatoms and many sponges regulates their growth in these ecosystem. Silicate-Si content was very poor during summer months and moderately present in monsoon and post-monsoon months supporting a moderate crop of Bacillariophyceae in these water bodies. Exceptionally high concentration of silicate-Si was found in Kulia *beel* even during March-May (Kuldip Kumar, 1990), otherwise it was low to moderate in most of the *beels* of West Bengal (Sugunan *et al.*, 2000).

Floodplain wetlands are of higher trophic levels having enriched bottom sediment. This helps in maintaining sustained high primary productivity both in terms of phytoplankton and macrophytes. Unlike reservoirs, the basin soil of the *beels* studied was basically rich with higher contents of organic carbon and available nitrogen. Available-P content was somewhat low due to its fixation by clay colloids and its quicker utilization by macrophytes and planktons.

Table 2. Nutrient status of water of some select *beels* of West Bengal (seasonal average)

Name	Nitrate-N (μgl^{-1})			Total-N (μgl^{-1})			SRP (μgl^{-1})			Total-P (μgl^{-1})			Silicate-Si (μgl^{-1})		
	Pre	Mon	Post	Pre	Mon	Post	Pre	Mon	Post	Pre	Mon	Post	Pre	Mon	Post
Sarasanka	3	260	280	25	540	690	3	130	100	28	598	360	2.2	4.6	5.5
Haripur-Close	2	08	10	20	500	560	2	50	42	25	490	320	2.4	5.4	6.2
Haripur-Open	3	25	30	20	590	870	2	40	50	32	690	610	5.2	12.0	6.8
Bansdaha	2	10	10	30	1180	790	2	210	180	30	778	500	1.0	3.0	3.9
Kole	10	20	30	55	600	840	3	30	40	30	400	510	0.8	6.2	9.4
Bhomra	10	340	290	110	960	1650	5	170	150	80	890	600	0.4	6.8	5.4
Bhomra-smf	10	420	480	100	1400	1970	15	350	270	92	1325	900	2.0	8.5	6.6
Kola	20	380	350	90	2325	1600	20	200	160	110	1940	1100	1.4	3.5	2.8
Bhaluka	2	46	50	35	480	550	3	40	45	30	360	480	0.8	1.8	1.2
Patari	2	40	40	24	310	360	2	50	40	20	260	200	0.5	1.0	1.2
Nehali	2	40	35	30	590	500	2	30	40	28	310	488	0.5	1.2	1.5
Ch-moranadi	2	50	60	20	580	630	2	42	50	25	460	570	0.9	1.8	2.2

(Pre = Pre-monsoon; Mon = Monsoon; Post = Post-monsoon)

Again, unlike reservoirs, the rich nutrient regime of sediment of *beels* was not reflected in the water phase owing to luxury utilization of nutrients by macrophytes as well as their storage by microbes thereby removing them effectively from circulation (Pathak, 1997).

Sediment characteristics (seasonal average) of some select *beels* of West Bengal are presented in Table 3. Pooled average of both post-monsoon and winter data are shown in the column marked by 'post'. Soil reaction was acidic in Sarasanka (pH 5.52 - 6.13) and the *beels* in Dinajpur district. In extreme summer, when water level falls drastically exposing many parts of the littoral areas of Bhomra, Haripur-closed, Bhaluka, Patari and Chramon moranadi, higher pH of sediment was encountered in these *beels*. Amongst the *beels* studied, Bhomra showed higher pH only because of its calcareous nature of catchment as well as bottom sediment. Sediment pH has a distinctive role in releasing nutrients particularly SRP from soil to water phase. Accordingly, more nutrients were found in available forms in the *beels* having neutral to slightly alkaline soil reaction.

Organic carbon (C, %) was noticed more in Bhomra, Bansdaha, and Sarasanka with exceptionally higher content in weed-chocked Nehali (6.20-10.90) *beel*. In general, *beels* infested with macrophytes are richer with organic matter (Sugunan *et al.*, 2000 and Singh, 2001). Total-N content was phenomenally more during post-monsoon months in Bhomra, Bansdaha, Sarasanka and Kola having wide seasonal variations. C/N ratio, an estimator of degree of organic matter decomposition was in most occasions in the productive range (5-15) with some exceptions noticed in Sarasanka (23), Bhaluka (30) and Nehali (39-55), enabling release of nutrients through mineralization from sediment to water phase.

Phenomenal presence of available-N (mg100 g^{-1} soil) was marked in most of the *beels* ranging to a low of 14.02 (Kole) and to a high of 109.20 (Nehali). It is interesting to note that a substantial increase in available-N content was noticed in Bhomra *beel* when its surface macrophyte was removed; same was also true in the case of available-P. In general, many of the *beels* were poor in available-P content. Littoral soil is nutritionally richer than the profundal one. Thus, rich nutritional load, high detrital pool at the bottom and shallow nature of the *beels* with high trophic status are favourable for raising good fish crop, provided proper management strategies are followed.

Table 3. Sediment characteristics of some select *beels* of West Bengal (seasonal average)

Name	pH			Organic-C (%)			Total-N ($mg100g^{-1}$)			Available-N ($mg100g^{-1}$)			Available-P ($mg100g^{-1}$)		
	Pre	Mon	Post	Pre	Mon	Post	Pre	Mon	Post	Pre	Mon	Post	Pre	Mon	Post
Sarasanka	6.13	5.52	5.80	3.20	3.88	4.44	0.18	0.30	0.35	58.05	63.20	60.10	Trace	0.30	0.25
Haripur-Close	7.92	7.68	7.77	1.44	1.58	1.69	0.12	0.15	0.13	37.92	34.56	33.04	Trace	0.44	0.50
Haripur-Open	7.96	7.50	7.57	0.98	1.65	1.77	0.10	0.12	0.12	24.08	31.02	36.66	Trace	0.64	0.52
Bansdaha	7.76	6.80	6.90	3.20	5.64	4.80	0.38	0.59	0.63	72.80	80.24	86.80	0.20	1.28	1.40
Kole	8.30	7.80	7.88	0.26	0.42	0.40	0.04	0.11	0.13	14.02	20.22	26.88	0.20	1.00	0.86
Bhomra	8.65	7.48	7.46	0.90	5.20	5.76	0.36	0.60	0.65	43.12	76.58	88.48	1.08	14.66	20.30
Bhomra-smf	8.10	7.50	7.35	0.76	3.65	3.82	0.35	0.64	0.78	56.85	94.57	80.25	1.25	26.54	20.10
Kola	6.98	6.50	6.09	2.50	3.00	3.09	0.25	0.31	0.34	58.85	72.14	82.90	2.05	7.44	10.40
Bhaluka	5.80	5.46	5.30	1.50	3.90	3.76	0.12	0.13	0.13	58.02	60.32	62.44	Trace	0.20	0.30
Patari	7.70	6.80	5.90	1.30	1.90	1.64	0.11	0.12	0.16	42.0	44.10	44.50	Trace	0.20	0.28
Nehali	7.00	6.45	5.20	6.20	10.90	9.46	0.16	0.18	0.20	72.50	88.60	109.20	Trace	0.98	1.60
Ch-moranadi	5.80	5.52	5.70	1.20	1.42	1.50	0.17	0.20	0.20	54.00	60.33	62.50	Trace	10.30	7.65

Nurient cycle in *beel* ecosystem is a complex phenomenon involving sediment, water and plant in association with climatic factors thus resulting in storing, releasing and utilisation of the nutrients either in organic or in inorganic forms. Piling up of undesirable decayed or partially decomposed plant matters complicate the nutrient cycle further, creating unhealthy environment for many of the beneficial and mineralising microbes leading to eutrophication. In shallow *beels*, higher nitrogen content interferes with the release and availability of phosphorus for the primary producers, whereas, in deeper *beels* with less infested macrophytes, an optimum balance in dissolved inorganic nitrogen and SRP is maintained due to lesser accumulation of organic matter at the bottom getting reflected into higher primary productivity.

At present, some of the *beels* are under regular stocking programme viz., Kola, Bansdaha, Bhomra and Sarasanka. In Kola, out of 12 ha water body, one ha is utilised for raising fingerlings and the same are being stocked in the remaining ox-bow lake phase wise in every three months following a regular harvesting policy to supply table size fresh fish in the market. In others, stocking is being done once in a year with quarterly harvesting programme. In Sarasanka, nursery as well as rearing ponds were excavated along the length of the water body as to avail stocking materials easily. Deweeding of surface vegetations, partial excavation of the littoral areas for desilting, raking of the bottom especially in shallow *beels* with application of lime @ 300 to 400 kg per hectare, planting of short duration leguminous crops in the exposed areas during premonsoon months followed by proper stocking with more than 100 mm sized fingerlings are some of the plausible management options for increasing productivity status and fishery of the *beels* of West Bengal.

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