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On Some Aspects of the Structure and Functions of the Wetlands of North Bihar, India

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Abstract: Bihar has a rich wetland area and has high diversity among inhabiting species. Therefore conservation of these wetlands is necessary for protecting such diverse and unique species. Different physico-chemical parameters such as dissolved oxygen, alkalinity, presence of phytoplanktons and zooplanktons were analyzed in the present study in different types of swamps and wetland of Katihar, Purnea, Saharsa, Khagaria, Begusarai, Samastipur, Darbhanga, Madhubani, West and East Champaran, Sitamarhi, Vaishali, Siwan and Muzaffarpur. Each and every type of wetland was found to have variation within the parameters undertaken. Each and every wetland has their own unique condition and supports variable life forms.

Keywords: Bihar, Wetlands, Species, Physico-chemical, Life forms

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Introduction

Gokce (2018) stated that “Wetlands are an ecosystem from mangrove to subarctic peatlands that have affected human”. Wetlands (flood plains, marshes, swamps and chauras) are one of those lentic waters which form links between terrestrial and aquatic ecosystems and play an important role in eutrophication. Such ecosystems will have a

community structure intermediate between the open water and forest types and in such environment the autotrophic-heterotrophic stratification is very less. According to Odum (1962) the most productive ecosystems of the ecosphere are those in which autotrophic-heterotrophic strata lie close together, thus, ensuring efficient nutrient regeneration and

recycling. Wetlands have been named as “Kidneys of the Earth” as according to Yu *et al.* (2019) “they provide important functions towards stabilizing the environment, long-term protection of water sources, effectively minimizing sediment loss, purifying surface water from industrial and agricultural pollutants, and enhancing aquifer recharge”.

In the region of North-Bihar districts (Katihar, Purnea, Saharsa, Khagaria, Begusarai, Samastipur, Darbhanga, Madhubani, West and East Champaran, Sitamarhi, Vaishali, Siwan and Muzaffarpur) many such types of wetlands exist (Fig. 1). The eco-restoration of such wetlands for sustainable use of resources is of utmost significance. Therefore, the objective of present study is to investigate the structure and function of these wetlands and to explore the possibilities for their ecological restoration of denuded environment for their sustainable development for aquaculture and pisciculture.

Materials and Methods

Study area: The wetlands under study include three typical swampy wetlands of North-Bihar, that have been described in the text by the names of permanent (Doped), Makhana and Chaur swamps.

These three different types of swamps were selected for seasonal observations of certain physico-chemical factors of water. The first two swamps were perennial in nature while the third one was seasonal, as it completely dried up during summer months (March to July). The pH, DO₂, FCO₂, CO²⁻, HCO₃⁻ were studied every months for two years from January 2017 to December, 2018. Certain parameters like free H₂S, Si⁻ and Cl⁻ content were analysed monthly. The physico-

chemical factors were analyzed according to Welch (1948) and APHA (1981). The standing crops of periphyton, phytoplankton, zooplankton, macro-invertebrates and fishes were studied using different sampling devices and taxa were identified in the laboratory by the literature available in their respective fields.

Results and Discussion

The results of physico-chemical factors of the swamps under study are shown in Tables 1-3, respectively.

1. Physico-chemical conditions of Swamps and Wetlands:

Generally, there is higher dissolved oxygen and less FCO₂ concentration in chaur swamps than in Makhana and doped swamps. Low pH of water together with high atmospheric and water temperatures, heavy accumulation of organic matter and hypoxic conditions of soils and water are responsible for the production of major decomposition products viz., hydrogen sulphide, methane, free ammonia, etc. in these wetlands. Gas envelopes have been constructed for different types of swamps. Such envelopes were represented graphically by plotting all the monthly measurements of DO₂ and FCO₂ within a particular swamp and enclosing these data with a polygon. More steep envelope in Makhana (*Eurale ferox*) swamps was evident of hypercarbic environment but it was flatter than the gas envelopes of chaur swamp which was infested with emergent *Cyperus* reeds with a combination of sufficient submerged macrophytes. There was comparatively more DO₂ and less FCO₂ concentration in chaur swamp than Makhana and doped swamps. The concentrations of FCO₂ in swamps control the pH, bicarbonate-carbonate alkalinities (Fig. 2).

Fig. 1: Wetlands in districts of North-Bihar

Fig. 2: Gas envelop of swamps and wetlands

Table 1: Monthly variations of dissolved oxygen and free carbon dioxide in the waters of three wetlands of North-Bihar

<i>Months</i>	<i>Hyacinth Swamp</i>		<i>Makhana Swamp</i>		<i>Chaur Swamp</i>	
	Dissolved O₂ <i>(mg/L)</i>	Free CO₂ <i>(mg/L)</i>	Dissolved O₂ <i>(mg/L)</i>	Free CO₂ <i>(mg/L)</i>	Dissolved O₂ <i>(mg/L)</i>	Free CO₂ <i>(mg/L)</i>
2017						
Jan	0.65	25.00	6.25	0.00	5.80	19.00
Feb.	0.00	38.00	6.80	0.00	5.00	22.00
Mar.	0.00	36.00	6.00	8.50		
Apr.	0.00	40.00	6.00	8.50		
May	0.00	39.00	0.30	24.00		
Jun	0.00	41.00	0.20	20.00		
Jul.	0.00	24.50	2.50	12.00		
Aug.	0.00	32.00	4.30	10.00	5.25	28.00
Sep.	0.00	30.00	3.25	12.00	6.50	25.25
Oct.	0.00	28.00	3.85	8.50	5.20	20.00
Nov.	0.00	24.00	5.50	2.50	7.00	10.30
Dec.	0.53	30.00	6.00	0.00	6.45	12.00
2018						
Jan	0.82	32.50	6.45	0.00	6.00	10.50
Feb.	0.00	35.00	6.90	0.56	5.50	24.00
Mar.	0.00	34.00	5.80	4.50		
Apr.	0.00	35.00	5.50	6.50		
May.	0.00	35.00	2.00	13.50		
Jun.	0.00	40.50	0.85	18.00		
Jul.	0.00	25.00	0.50	25.00	5.00	28.50
Aug.	0.00	22.00	3.55	20.00	5.50	25.50
Sep.	0.00	20.00	3.00	19.50	6.50	15.00
Oct.	0.00	28.50	3.85	15.60	6.00	15.65
Nov.	0.00	21.00	3.90	16.00	5.75	21.00
Dec.	0.25	25.00	4.50	6.50	8.85	18.50

Table 2: Monthly variations of HCO_3^- , CO_3^{2-} and pH of water in three tropical wetlands of North-Bihar

Months	Hyacinth Swamp			Makhana Swamp			Chaur Swamp		
	HCO_3^- (mg/L)	CO_3^{2-} (mg/L)	pH	HCO_3^- (mg/L)	CO_3^{2-} (mg/L)	pH	HCO_3^- (mg/L)	CO_3^{2-} (mg/L)	pH
2017									
Jan.	100.00	7.8	120.00	2.50	8.1	95.00	0.0	8.0	
Feb.	104.00	7.8	101	3.80	9.0	85.00	0.0	7.9	
Mar.	106.00	7.5	150.00		7.5				
Apr.	115.00	7.5	150.00		7.5				
May.	294.00	7.7	230.00		7.0				
Jun.	360.00	7.2	245.00	7.1					
Jul.	324.00	7.8	192.00		7.0				
Aug.	80.00	7.9	140.00		7.5	79.50		7.5	
Sep.	78.00	7.3	159.00		7.7	78.50		7.7	
Oct.	115.00	7.2	135.00		7.8	64.00		7.5	
Nov.	81.00	7.5	100.00		7.9	50.00		7.5	
Dec.	97.00	7.8	115.00	3.80	8.1	52.00		7.6	
2018									
Jan.	98.00	7.6	115.00	3.50	8.5	82.00		7.9	
Feb.	110.00	7.6	120.00		8.0	80.50		7.9	
Mar.	112.00	7.5	192.00		8.0				
Apr.	118.00	7.6	155.00		7.9				
May.	115.00	7.5	160.00		7.8				
Jun.	116.00	7.3	197.00		7.3				
Jul.	109.00	7.2	204.00		7.3	70.00		7.6	
Aug.	90.00	7.2	195.00		7.2	71.00		7.6	
Sep.	94.00	7.2	175.00		7.2	78.50		7.7	
Oct.	96.00	7.5	132.00		7.5	75.00		7.6	
Nov.	98.00	7.5	120.00		7.5	75.00		7.6	
Dec.	98.00	7.5	107.00		7.6	76.50		7.7	

Table 3: Monthly variations in the free Hydrogen Sulphide, Chloride and Silicate in the three tropical wetlands of North Bihar

Months	<i>Hyacinth Swamp</i>			<i>Makhana Swamp</i>			<i>Chaur Swamp</i>		
	<i>H₂S</i> (mg/L)	<i>Chloride</i> (mg/L)	<i>Silicate</i> (mg/L)	<i>H₂S</i> (mg/L)	<i>Chloride</i> (mg/L)	<i>Silicate</i> (mg/L)	<i>H₂S</i> (mg/L)	<i>Chloride</i> (mg/L)	<i>Silicate</i> (mg/L)
	2017								
July	3.90	1.90		1.45	1.50				
Aug.	4.60	1.75		2.52	1.50		1.50	0.40	
Sep.	4.00	1.65		2.50	1.50		2.20	0.40	
Oct.	3.50	1.65		2.25	1.50		0.00	0.30	
Nov.	2.15	1.60		1.20	1.55		1.50	0.35	
Dec.	2.00	1.65		1.09	0.55		1.62	0.35	
2018									
Jan.	2.45	1.50	45.5	0.85	0.55	36.0	1.00	0.40	35.5
Feb.	3.68	1.55	45.0	0.95	0.50	34.0	1.35	0.45	30.0
Mar.	4.05	2.05	48.0	0.55	0.75	34.5			
Apr.	3.00	2.05	51.0	1.65	0.92	32.0			
May.	4.56	2.00	56.0	3.05	1.05	38.0			
Jun.	4.92	1.80	54.00	3.31	1.00	38.5			
Jul.	4.62	1.85	52.0	3.00	0.85	40.5	1.60	0.50	32.0
Aug.	5.25	1.70	52.0	1.54	1.25	45.0	1.50	0.50	36.5
Sep.	3.85	1.55	58.0	2.50	0.75	46.0	1.95	0.45	42.0
Oct.	3.50	1.50	58.0	2.50	0.70	45.5	1.80	0.48	45.0
Nov.	3.00	1.50	56.0	1.25	0.53	45.0	1.85	0.40	46.0
Dec.	2.80	1.50	46.0	1.00	0.53	35.0	1.50	0.42	38.0

In such systems only air-breathers and supplemental air-breathers are colonized, because of low DO₂ contents and high amount of FCO₂. Therefore, autotrophic biomass exceeds heterotrophic production in these environments. As such there is accumulation of autotrophic production in the system showing successional stage from aquatic to terrestrial environments (Roy, 2007). In chaur swamp the shape of the envelope was vertically steep showing higher DO₂ content and lower FCO₂ content while in doped swamps the shape was horizontally flatter showing lower DO₂ content and higher FCO₂ content in such environment. The Makhana swamp was intermediate between doped and chaur.

2. Biotic components:

The biotic components mainly include macrophytes, phytoplankton, periphyton, zooplankton, macro-invertebrates, air-breathing fishes, molluscs, crabs and migratory as well as local birds.

(a) *Periphyton*: The periphyton communities of the swamps mainly include algae and testaceous rhizopods (e.g., *Euglypha*, *Diffugia*, *Centropyxis*, *Arcella* etc.). Usually the periphytic species prefer highly eutrophic conditions with rich DO₂, high pH and more alkaline medium (Brown and Austin, 1973). Hard testaceous shells of rhizopods were mainly composed of fine sand particles of silica and decomposed diatoms cells. The abundance of Bacillariophyceae and silicate contents of water thus, control the testaceous rhizopod population.

(b) *Phytoplankton*: The phytoplankton communities of swamps were mainly represented by three groups of algae:

- (i) Cyanophyceae (blue-green algae)
- (ii) Chlorophyceae (green algae)
- (iii) Bacillariophyceae (diatoms)

Bacillariophyceae dominated among the phytoplanktonic communities throughout the year.

(c) *Zooplankton*: Zooplankton communities of swamps belonged to Rotifera, Cladocera, Ostracopoda and Copepoda. The rotiferan population always dominate over other zooplankton communities in swamps.

(d) *Macrophytes*: There is general agreement that the fresh water swamps have higher macrophytic productivities than any other natural community (Leith, 1975; Thompson, 1975). The ratio of P/R >1, showing autotrophic community and such environments are on the way of succession (Singh, 1992).

Four characteristic vegetational communities were recognized in swamps. These are: (i) free floating type e.g., *Eichhornia crassipes*, *Trapa bispinosa* (ii) bottom rooted floating type e.g., *Euryale ferox* (iii) submerged type e.g., *Hydrilla verticillata*, *Potamogeton crispus*, *Najas graminea*, *Ceratophyllum demersum* etc. and (iv) emergent type e.g., *Cyperus* sp (Singh, 1992).

(e) *Macro-invertebrate diversity*: The macro-invertebrates fauna belong to three invertebrate phyla: (i) Annelida (ii) Mollusca (iii) (Arthropoda).

Comparative studies on annual averages of total number and percentage of macro-invertebrates per meter square area in different swamps revealed that the Makhana swamp form the most favourable habitat for annelids, molluscs and insects. (Roy, 2007; Roy *et al.*, 2008).

Eco-restoration of doped swamps:

Doped swamps are rich in nutrients and have immense potential energy source, which can be tapped for maximum energy return through detritivore fishes. Fishes feeding on different trophic levels provide enough scope for energy manipulations. The release and deposition of organic matters after death and decay of macrophytes, contributed significantly to the richness of the bottom soil of doped swamps. The low concentration of nutrients in the water phase may be due to the locking of nutrients for longer period by macrophytes. In water bodies the energy fixation at primary level is contributed both by phytoplankton and macrophytes. In the wetlands the abundance and dominance of macrophytes favour detritus production.

Kumar (2007) has suggested that the water bodies with profuse aquatic macrophytes decompose and silt get deposited at the bottom after their death, which play an important role in the aquatic food web. These water bodies have very high rate of detritus production. Thus, the doped swamps can be restored by manipulating detritus feeder fishes in these environments.

Conclusion

It can be concluded that –(i) Wetlands are unstable ecosystems where $P/R > 1.0$; (ii) They may change with season, rate of siltation

and nutrient flux; (iii) They are on the way of succession; (iv) There is operation of complex hydrological and biogeochemical cycle; (v) Due to siltation, eutrophication of wetlands and human habitations surrounding the water systems, there is terrestriation of the large wetlands and chauris in the region of North-Bihar; (vi) For water shed management, a series of reservoirs and canals are to be constructed in the upper reaches of the rivers for the control of flood as well as drought; (vii) Integrated aquaculture programme will help in conservation of these wetlands; (viii) Eco-friendly and eco-tourism programmes will be useful for the conservation and management of the wetlands of Bihar.

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