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Comparative assessment of zooplankton diversity in fresh water lentic ecosystem of Patna, Bihar, India

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Abstract

The present investigation deals with the comparative study of zooplankton diversity in two different lentic ecosystem of Patna, Bihar classified as pristine (Sanjay Gandhi Biological Park) and disturbed (Nalanda medical college and hospital) pond which deals with the interrelationship between composition of zooplankton community and various physiochemical parameters of water. The study was carried out from July to September 2015 and three groups of zooplankton taken into consideration that includes Rotifera, Cladocera and Copepoda. A total of 38 species of zooplanktons were observed from the study sites and dominated by Rotifera by 18 species (47.36%), followed by the species of Cladocera and Copepoda by 11 species (28.94%) and 9 species (23.68%), respectively. Out of the total of 38 species, about 8 species (21%) were common in both ponds. The diversity and richness of zooplankton are higher in unmanaged pond. However, both ponds are considered as polluted based on the physiochemical characteristics of water and presence of pollution indicating zooplankton species which exhibit eutrophication.

Keywords: Cladocera, Copepoda, India, pristine, Rotifera, disturbed

Introduction

Organisms living in the aquatic ecosystem are under the influence of different parameters of the water (Ovie, 1997; Ghantaloo *et al.*, 2011) ^[16, 9]. Zooplanktons are heterotrophic micro-organism, that feed on bacterioplankton, phytoplankton, nektonic organisms and even on other zooplankton (Ghantaloo *et al.*, 2011) ^[9]. They play a vital role in recycling nutrients and energy in their environment (Kar and Kar, 2016) ^[10]. However, Many omnivores and planktivorous fishes feed on them as their essential food item and very essential for culturing larvae of fishes (Alam *et al.*, 1987; Kar and Kar, 2016) ^[14, 10]. They are very important in fresh water ecosystem as they play a significant role in food chain (Chanchala *et al.*, 2017) ^[6].

Zooplankton consider as bio-indicator as they support in understanding the pollution status (Ahmad, 1996; Contreras *et al.*, 2009) ^[3, 8] because they are affected by physiochemical and environmental condition of water body and respond accordingly. Their occurrence and abundance depend on the abiotic factors and nutrients present in the water (Redmond, 2008) ^[18]. The diversity and richness of zooplankton vary as the physiochemical aspects of water changes and is also very sensitive to anthropogenic impact (Khanna *et al.*, 2012) ^[13]. As the industrialization increases, the problem of dumping wastage is also increasing. An objectionable elements are continuously discharging in the lake water system that mortifying the water quality. Water quality comprises the physical, chemical and biological elements of water (Lawson, 2011; Shukla *et al.* 2013) ^[15, 25].

Present study deals with interrelationship between different parameters of water and zooplankton diversity and richness in managed and unmanaged pond in the time interval of three months from July to September 2015 and the 3 groups taken into consideration that includes Rotifera, Cladocera and Copepoda.

Material and Methods

Study area

Patna is the capital and largest city of Bihar state, lies at to GPS Coordinates: 25°38'51.06"N to 25°33'10.79"N latitude and 85°16'24.44"E to 85°4'32.64"E longitude, facing towards southern bank of the Ganga River. It covers an area of 99 km². The sampling of zooplankton was

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conducted at two different ponds of Patna as follow (Fig. 1):

Sanjay Gandhi Biological Park (SGBP)

It lies at to GPS Coordinates: 25°35'50.01"N and 85°5'57.73"E with average 58 metre of elevation which is strictly supervised by the park authorities, and except boating, no other domestic or commercial activities were allowed. Therefore this pond is considered as "Pristine Pond".

Nalanda Medical College and Hospital (NMCH)

It lies at to GPS Coordinates: 25°36'5.31"N and 85°12'6.46"E with an average 52 metre of elevation. Various anthropogenic activities were noticed in this pond such as fishing, bathing, washing, garbage dumping, discharge of domestic waste etc. Since no care taken to stop the pollution or there is no such prohibition for such activities, therefore this pond is considered as "Disturbed Pond" (by the author).

Material and methods

Study was conducted for a period of 3 months from July to September of 2015, at every weekend during early hours of the day (7AM to 10 AM) on the fortnightly basis (Khan *et al.*, 2016). Water samples (100 litres) were collected with the help of planktonic net (made of bolting silk) having mesh size 64 μ then samples were transferred to specific air tight Borosil storage bottle. 4% formalin solution was added for its fixation and preservation and kept safely at <25 °C in dark and dry place (Sharma *et al.*, 2011) [22]. Sample were taken in a Sedgwick-Rafter Cell and observed under compound microscope (Olympus model BX41-CCD) at 10X to 40X magnification and further identification were done by the following literature, Adoni *et al.* (1985) [2]; Verma and Munshi (1987) [29]; Battish (1992) [5]; Sampaio *et al.* (2002) [19]; Sharma and Sharma (2012) [23]; Phan *et al.* (2015) [17].

Species diversity indices like Dominance, Simpson Index, Shannon Wiener Index, and Evenness were calculated by given formulae:

- Dominance (D) = $\sum n(n-1)/N(N-1)$
- Simpson Index = 1-D
- Shannon Wiener Index (H) = $-\sum [(n/N) * \ln(n/N)]$
- Evenness (J) = H/ H_{max}

Where, n= number of individual of a particular species

N= Total number of individual

Where, H_{max} = ln (number of species)

Different physiochemical parameters of water were analysed as per the procedure given in Trivedy and Goel (1986) [27] and APHA (1998) [1]. The physical parameters like Temperature (Temp), pH, Electrical conductivity (EC), Salinity, Total dissolved solids (TDS) and Turbidity are estimated with the help of multi-tester of HANNA (model no. - HI 98194).

Following are the different methods for the determination of various chemical parameters includes:

- Hardness was detected by EDTA titrimetric method. In 25ml of the water sample 1ml of buffer was added then 25ml of distilled water was added. A pinch of erichrome T black indicator was added and titrated against EDTA. The end point of the experiment was marked with the change of the colour of the solution from purple to blue.
- Calcium (Ca) was also estimated by EDTA titrimetric method. 25ml of water sample is taken and 1ml of buffer was added to it. The indicator used was methylene red and the result was change of the solution from purple to pink.

- Magnesium (Mg) was calculated by subtracting calcium from total hardness of the water sample.
- Nitrate (NO₃) was determine using vernier nitrate Ion Selective Electrode (ISE).
- Chloride (Cl) was estimated by titrating the given sample with silver nitrate solution. Two drops of potassium chromate was added which acted as the indicator. The end of the titration was indicated by formation of red silver chromate obtained from excess of silver nitrate.
- Bicarbonate (HCO₃) was calculated by the sulphuric acid titrometric method. 10ml of sample was taken, titrated against 0.05(N) sodium carbonate and phenolphthalein acted as indicator then this colourless solution was titrated against 0.02(N) sulphuric acid. The indicator used was methyl orange and the result was change of the solution colour from yellow to red.

Results

The physiochemical characteristics of water bodies are shown in Fig. 2 and Table 1. The water is more alkaline in Nalanda Medical College and Hospital, indicating high rate of photosynthesis of micro-macro organism whereas conductivity, total dissolved solid and salinity is greater for SGBP than NMCH. The level of chemical parameters such as hardness, calcium, magnesium, nitrate, chloride and bicarbonate were higher at NMCH.

Data obtained from the present study indicates that a total of 38 species of zooplankton were encountered from both ponds (Figs. 3 and Table 2) that include 18 species of Rotifera, 11 species of Cladocera and 9 species of Copepoda. In SGBP, a total 17 species were found out of which 8 species belongs to phylum Rotifera, 5 species from order Cladocera and 4 species belongs to order Copepoda; whereas in NMCH, a total 29 species were found, out of which 15 species are from Rotifera, 8 species from Cladocera and 6 species belongs to Copepoda. Out of the total of 38 species, 8 species were common in both ponds* (shown in Figs. 3).

Monthly variation of rotiferans in pond SGBP and NMCH was highest in July and lowest in August, cladocerans in SGBP was highest in July and lowest in August while in NMCH it was highest in August and lowest in July. For copepods, monthly variation in SGBP was highest in July and lowest in August whereas in NMCH, it's vice versa (Figs. 3).

In both Ponds, the highest species richness (almost half of the total diversity) was belonging to Phylum Rotifera throughout the months, followed by the Cladocera and Copepod, respectively (Figs. 4). Rotifera>Cladocera>Copepoda.

The species diversity indices and evenness of the three orders of zooplanktons did not vary much between the two sites (Table 3). Number of species of all the three orders were higher at NMCH.

Discussion

The concept of this study was to investigate the variation in zooplankton diversity in managed (SGBP) and unmanaged (NMCH) pond. Some species present throughout the months of study period whereas some occurred irregularly. Species diversity indices were studied to measure the status of water quality in Pond and also for determining the relationship that existed with the physiochemical characteristics.

Rotiferans were dominated during the whole study period in both the ponds followed by cladoceran and copepods, similar as reported in other studies like, Sharma *et al.* (2011) [22] recorded 29 species of Rotifera, 17 cladocera and 6 copepoda

from the wetlands of North Bihar. Karuthapandi *et al.* (2012) [11] found 27 Rotifera, 13 cladocera and 5 copepoda from pond of Attapur, Hyderabad. Sinha and Singh (2016) [26] observed 12 species of Rotifera, 5 cladocera and 9 copepoda from perennial pond of Jharkhand. Kar and Kar (2016) [10] detected 22 species of Rotifera, 14 cladocera and 4 copepoda from Cachar lake, Assam. Kumari and Pathak (2018) [14] perceived 11 species of Rotifera, 4 cladocera and 4 copepoda from pond of Muzaffarpur, Bihar. Chitra (2018) [7] detected 19 species of Rotifera, 11 cladocera and 3 copepoda from wetlands of Jharkhand.

In present study, the value of Shannon Index for SGBP is 0.8692 and for NMCH is 0.1464 which indicates that the both ponds come under polluted criteria because the value of H is less than 1 (Kumari and Pathak, 2018). NMCH found to be more polluted as its Shannon Index value is lower than SGBP. The Evenness index affirms equitable abundance of various

species and agrees with the result of Sharma and Sharma (2008, 12), and Sharma and Hussain (2001) [21]. Species diversity implies equitability for both species richness and species evenness among the two ponds.

The chemical analysis showed greater value for unmanaged pond which is directly or indirectly based on the population diversity of zooplankton i.e. Unmanaged Pond had relatively high zooplankton species diversity as well as population diversity. This may be due to eutrophication which occurs in water body rich in nutrients and chemicals especially Nitrates (Wilfred Werner, 2009). The concentration of nitrate in unmanaged pond was found to be more thereby indicating the eutrophic condition. Presence of various pollution indicator species in both ponds like, *B. falcatus*, *Keratella cochlearis*, *K. tropica*, *Bosmina* sp., *Daphnia* sp., *M. leuckarti* (Sampaio *et al.*, 2002) [19] brings to a dark future of those ponds if no safety measures were taken.

Table 1: The results of various physiochemical parameters of water sample from the SGBP and NMCH Pond, India.

Sl. No.	Physiochemical Parameters	SGBP (Mean \pm S.D)	NMCH (Mean \pm S.D.)
1	Temperature ($^{\circ}$ C)	23.75 \pm 1.60	24.85 \pm 1.84
2	pH	8.7 \pm 0.005	9.13 \pm 0.017
3	Electrical conductivity (μ S)	991.3 \pm 0.877	545.6 \pm 0.877
4	Total dissolved solids (μ S)	697 \pm 0.577	390.3 \pm 0.877
5	Salinity (ppm)	341 \pm 0.577	188.6 \pm 0.877
6	Turbidity (NTU)	16.21 \pm 0.005	17.33 \pm 0.005
7	Hardness (mg/l)	280.96 \pm 2.11	300.18 \pm 1.04
8	Calcium (mg/l)	89.87 \pm 1.15	91.5 \pm 1.14
9	Magnesium (mg/l)	20.13 \pm 1.03	30.87 \pm 0.83
10	Nitrate (ppm)	0.73 \pm 0.035	1.17 \pm 0.145
11	Chloride (ppm)	80.23 \pm 1.03	99.04 \pm 1.19
12	Bicarbonate (mg/l)	190.5 \pm 1.82	324 \pm 20.98

Table 2: Species diversity of zooplankton and their abundance in SGBP and NMCH ponds, India.

Phylum	Species	SGBP			NMCH		
		July	August	September	July	August	September
Rotifera	<i>Aplanchna abrightweli</i> (Gosse)	0	0	0	3	0	0
	<i>Brachionus angularis</i> (Gosse)	32	4	8	0	2	9
	<i>Brachionus bidendata</i> (Gosse)	0	3	0	13	0	9
	<i>Brachionus calyciflorus</i> (Pallas)	21	12	0	19	0	0
	<i>Brachionus caudatus</i> (Wulfert)	0	0	7	68	43	13
	<i>Brachionus falcatus</i> (Wulfert)	0	0	0	27	8	28
	<i>Brachionus forticula</i> (Wierzejski)	0	0	0	0	6	12
	<i>Brachionus personatus</i> (Wulfert)	13	0	6	0	0	0
	<i>Brachionus quadridendata</i> (Barrios and Daday)	14	7	18	0	0	0
	<i>Brachionus terminalis</i> (Barrios and Daday)	0	0	0	39	4	20
	<i>Conchilus arboreus</i> (Stokes)	0	0	0	0	21	17
	<i>Conchilus madurai</i> (Stokes)	0	0	0	0	3	0
	<i>Filinia terminalis</i> (Ehrenbergh)	0	0	0	11	2	0
	* <i>Keratella cochlearis</i> (Gosse)	15	16	6	5	0	2
	<i>Keratella lenzi</i> (Hauer)	0	0	0	31	7	18
	<i>Keratella tropica</i> (Apstein)	0	0	0	80	12	35
<i>Keratella quadrata</i> (Apstein)	0	0	0	0	0	4	
<i>Testidunella</i> sp.	4	0	1	0	0	0	
Cladocera	<i>Alonella</i> sp.	0	0	0	33	25	13
	<i>Bosmina</i> sp.	0	0	0	7	0	22
	<i>Daphnia pulex</i> (Sars)	0	0	0	12	7	15
	* <i>Daphnia carinata</i> (Sars)	13	3	19	30	16	20
	<i>Diaphanosoma birgei</i> (Fischer)	18	9	4	0	0	0
	<i>Diaphanosoma excisum</i> (Sars)	0	0	0	2	0	0
	* <i>Diaphanosoma</i> sp.	2	6	7	0	9	7
	<i>Moina brachiata</i> (Jurine)	0	0	0	18	3	5
	<i>Moina dubia</i> (Ishikawa)	0	0	0	2	20	9
	<i>Moina macrocopa</i> (Straus)	7	10	8	0	0	0
<i>Moina minuta</i> (Kurz)	4	0	0	0	0	0	

Copepoda	<i>Acanthocyclops vernalis</i> (Herman)	3	0	0	0	0	0
	<i>Cyclopoida</i> sp.	15	8	19	0	0	0
	<i>Cyclops</i> sp.	0	0	0	0	16	30
	<i>Diaptomus</i> sp.	0	0	0	32	84	23
	<i>Mesocyclops leuckarti</i> (Rehberg)	7	0	3	0	0	0
	* <i>Nauplius</i> larvae (O. F. Muller)	3	18	11	98	82	93
	<i>Thermocyclops</i> sp.	0	0	0	15	0	21
	<i>Tropocyclops</i> sp.	0	0	0	11	18	14
	<i>Eucyclops</i> sp.	0	0	0	6	0	0
	Total	171	96	117	562	388	439

Table 3: Monthly variation in zooplankton species diversity indices in the SGBP and NMCH ponds, India.

Study sites	Month	Dominance	Simpson	Shannon	Evenness
SGBP	July	0.09±0.12	0.87±0.90	2.33±2.51	0.68±0.82
	August	0.10±0.15	0.84±0.89	2.09±2.30	0.73±0.90
	September	0.09±0.13	0.86±0.90	2.21±2.41	0.70±0.86
NMCH	July	0.08±0.10	0.89±0.91	2.58±2.71	0.60±0.68
	August	0.10±0.14	0.85±0.89	2.35±2.53	0.52±0.63
	September	0.07±0.09	0.90±0.92	2.73±2.88	0.66±0.77

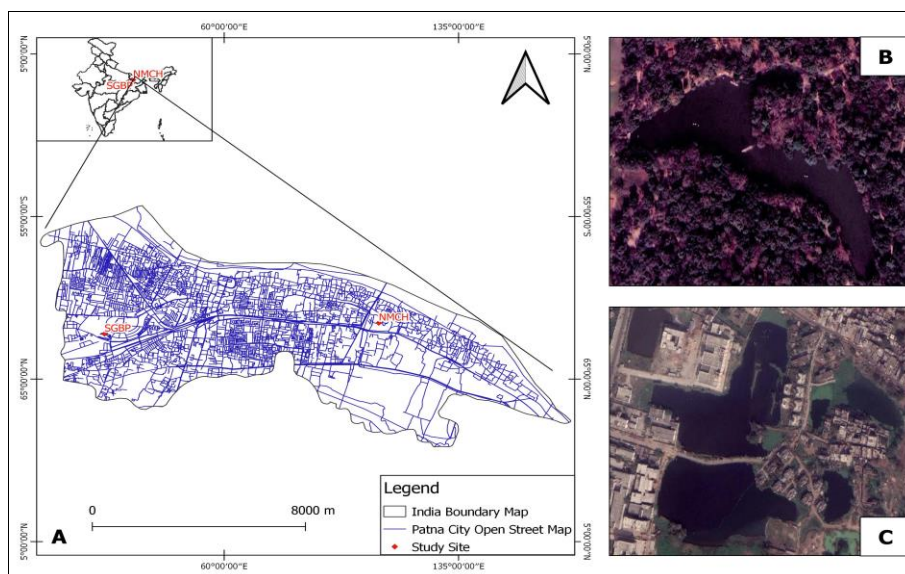


Fig 1: This map representing the study area with aerial view of the pond: A) Patna city open street map, B) Aerial view of SGBP pond and C) Aerial view of NMCH pond.

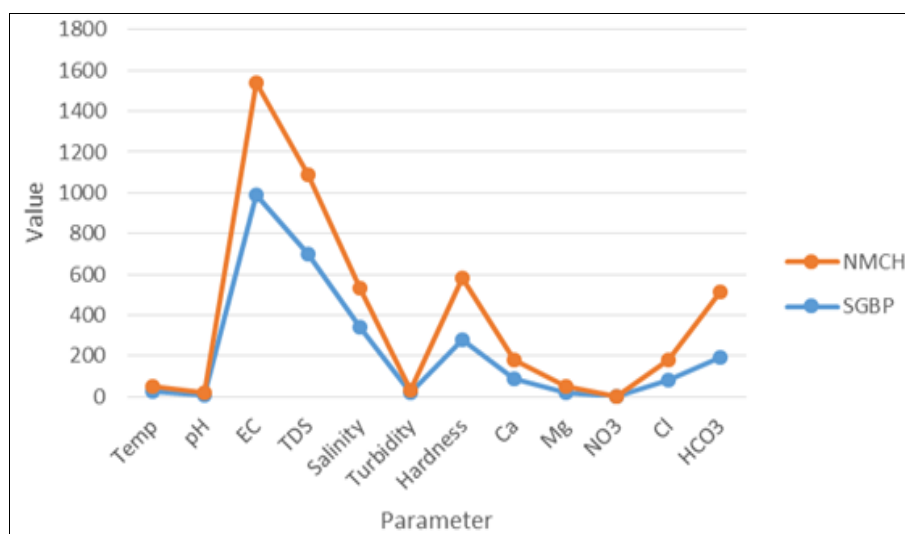


Fig 2: Comparison of mean physiochemical parameters among the SGBP and NMCH Ponds, India.

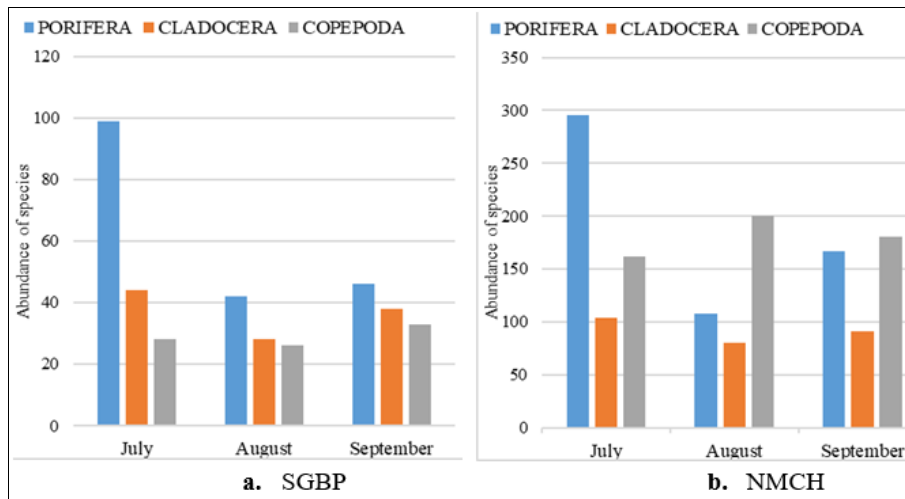


Fig 3: Variation of abundance of zooplankton species with month in a. SGBP and b. NMCH, India.

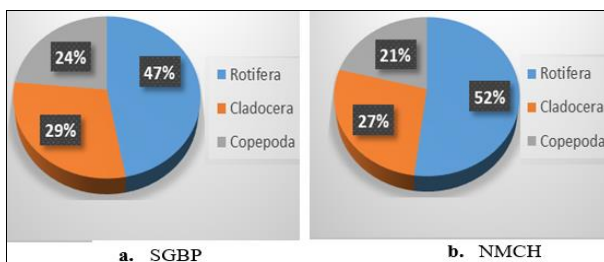


Fig 4: Percentage composition of Zooplankton in a. SGBP and b. NMCH Pond, India.

Conclusion

A total of 38 species were recorded in both the managed (SGBP) and unmanaged (NMCH) ponds. The species diversity in managed pond was lesser than that in unmanaged pond by 17 and 29 species, respectively. Even the abundance was greater in unmanaged pond. All the three groups were present in both ponds throughout the months where the rotiferans were dominated.

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