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STUDY ON PHYTOPLANKTON DIVERSITY AND PHYSICOCHEMICAL PARAMETERS IN THE THREE EPHEMERAL STREAMS OF LAKHIMPUR DISTRICT OF ASSAM, INDIA

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ABSTRACT

An assessment has been made on phytoplankton density and diversity and also physicochemical parameters of the three forested ephemeral streams situated on the Lakhimpur district of Assam. A total of 17 phytoplankton species belonging to three groups, Chlorophyceae, cyanophyceae and bacillariophyceae has been recorded from the three streams with monthly fluctuation in the percentage composition of (57-61%:, chlorophyceae), (15-17%, cyanophyceae), (24-26%, bacillariophyceae). Monsoon showed comparatively more numbers of phytoplankton than post monsoon. The value of different diversity indices clearly indicated that the three studied streams were moderately polluted. Correlation analysis was also performed among physicochemical parameters and phytoplankton density.

Keywords: Density, Diversity Indices, Ephemeral, Monsoon, Post Monsoon, Phytoplankton

I. INTRODUCTION

Phytoplanktons are the primary producers of any aquatic ecosystem. Phytoplankton could be used as the indicator of physicochemical status of any water body [1]. Besides serving as a primary producer, the free-living phytoplankton serves as feed and caters for the energy needs of planktonivorous organisms and is the key factor capable of determining the fishery potential of the region [2]. Phytoplanktons are recognized worldwide as bioindicator organisms in the aquatic environment [3]. The most revealing components of the bioindicator-based methods used to identify the ecological state of surface waters are the species richness of algae and their diversity, abundance, and biomass [4,5]. The main objective of the present study was` to assess the health status of the three forested ephemeral streams through phytoplankton density, diversity indices along with analysis of physicochemical parameters.

II. MATERIALS AND METHODS

2.1 STUDY AREA

The three different ephemeral streams viz. Baghjan, Singijan and Ghagorjan originate from the foothills of Arunachal Pradesh and located about 20-25 kilometres away from North Lakhimpur of Assam traversed through

Dulung reserve forest in the Assam Arunachal border region. Baghjan lies within 27 $^{0}26'522''$N and $94^{0}12'599''$E, while Singijan is located within $27^{0}26'701''$N and $94^{0}12'869''$E and Ghagorjan lies between $27^{0}26'608''$N and $94^{0}12'691''$E. Since the streams are ephemeral, so they completely dependent on monsoon rain. Monsoon starts from June and from the end part of November the streams starts dry up. Therefore the analysis of physicochemical parameters and biological assemblages were done only for two seasons viz. monsoon and postmonsoon.

2.2 STUDY PERIOD

All the selected parameters were studied for consecutive three years (June 2011-May 2014) on monthly (June, July, August, September, October and November) basis.

2.3 PHYTOPLANKTON

Collection of phytoplankton and qualitative study of species conducted in accordance with the standard methods of [6,7,8]. For quantitative study of plankton species Sedgewick-Rafter counting chamber was used. Population densities were calculated in units per litre (Ul^{-1}).

2.4 PLANKTONIC QUANTIFICATION

Plankton abundance and density was calculated in counts/ml of the original sample using the equation: [9, 10]

$D = [T(1000)\times Vc] / (AN\times Vs)$

Where, D= Density of plankton (ind/ml)

T= Total number of plankters counted

A= Area of grid in mm^2

N= Number of grids employed

1000= Area of counting chamber (mm^2)

Vc and Vs= Volumes of concentrate and sample respectively

2.5 Biological Indices

Four diversity indices, Shannon diversity index [11] Simpson diversity index [12] Margalef diversity index [13] and McIntosh diversity index [14] and two evenness indices Pielou evenness index [15] and McIntosh evenness index[14] were used in this study.

2.6 Measurement of Water Quality (Physical and Chemical Variables)

The location of the three study sites were measured by GPS (GarminGPSMAP76), water temperature was measured by using a Mercury thermometer graduated up to 110°C, pH was measured by portable pH meter (Cyber scan pH 300 series), conductivity was measured by Digital conductivity meter (CD600, Milwaukee), current velocity was measured by Digital flow meter (Swoffer 3000 Flow Meter, GeoScientific Ltd.). Dissolved

Oxygen was measured by following the Winkler's modified method [16], free carbondioxide, total acidity, total alkalinity and chloride were measured titrimetrically following the method of [17] and [16].

III. RESULT

A total of 17 phytoplankton species have been recorded of which Chlorophyceae include 9 species, *Chlorella sp., Oedogonium sp., Ulothrix sp., Volvox sp., Zygnema sp., Spirogyra sp., Chlamydomonus sp., Hydrodictyon sp., Chara sp.*; Cyanophyceae include 4 species *Anabaena sp., Nostoc sp., Oscillatoria sp., Spirulina sp*.; Bacillariophyceae include 4 species, *Diatoma sp., Fragilaria sp., Navicula sp., Amphora sp.*

Table 1: Percent composition of phytoplankton in three ephemeral streams

Group	Streams		
	Baghjan	Singijan	Ghagorjan
Chlorophyceae	61	57	58
Cyanophyceae	15	17	17
Bacillariophyceae	24	26	25

Percent composition of different groups of phytoplankton is given in **Table 1**. In Baghjan, Chlorophyceae was recorded to be the dominant group constituting about 61% of total phytoplankton which is followed by Bacillariophyceae (24%) and Cyanophyceae (17%). In Singijan, Chlorophyceae was recorded to be the dominant group constituting about 57% of total phytoplankton which is followed by Bacillariophyceae (26%) and Cyanophyceae (17%). In Ghagorjan, Chlorophyceae was recorded to be the dominant group constituting about 58% of total phytoplankton which is followed by Bacillariophyceae (25%) and Cyanophyceae (17%).

3.1 Phytoplankton Density

The monthly mean variations of phytoplankton density (no./l) are given in **Table2**

Table 2: Monthly mean variation of phytoplankton density (no./l)

Fam	Streams	Months					
		Jun	Jul	Aug	Sep	Oct	Nov
Chl	Baghjan	18.37 ±3.74	23.74± 3.16	26.34 ±3.21	19.67± 2.54	18.81± 2.54	15.56± 1.60
	Singijan	21.69± 2.29	22.51± 1.25	25.49 ±1.68	25.67± 3.32	17.01± 1.29	15.21± 1.36
	Ghagorjan	15.59± 3.68	20.05± 3.05	24.27± 2.91	21.62± 2.77	15.68± 1.67	15.01± 2.81
Cya	Baghjan	5.68± 1.01	8.85 ±1.65	9.80± 2.11	11.61± 2.45	9.45± 1.12	8.50± 0.62
	Singijan	5.61± 1.25	7.13± 1.81	8.31± 1.05	9.14± 1.51	8.15± 1.61	5.61± 1.50
	Ghagorja	6.28± 2.29	6.35± 1.95	6.78± 3.09	5.61± 2.37	4.28± 1.60	5.66± 3.12

	n						
Bac	Baghjan	6.01± 1.68	6.72 ±1.12	11.25 ±1.92	5.77± 0.89	5.13± 0.69	6.02± 1.30
	Singijan	2.85± 1.29	3.71± 1.45	3.21± 0.98	5.25± 1.51	5.83± 2.07	5.19± 1.69
	Ghagorjan	7.15± 2.85	6.19± 2.68	6.35± 3.33	4.01± 0.89	3.14± 1.05	2.01± 0.91
Tot	Baghjan	33.74± 6.56	31.71± 5.07	43.36 ±4.79	37.66± 6.91	28.03 ±5.61	23.39± 4.76
	Singijan	29.72± 2.91	28.44± 3.41	35.66± 2.07	37.69± 3.46	28.02± 2.98	25.11± 3.62
	Ghagorjan	28.55± 6.91	25.67± 5.97	32.59± 4.87	36.49± 7.36	19.37± 3.75	21.37± 5.49

Key: Fam=Family**, Chl=**Chlorophyceae, **Cya=**Cyanophyceae**, Bac=**Bacillariophyceae**, Tot=**Total

Highest density of chlorophyceae was recorded in August (26.34±3.21 no./l) at Baghjan and lowest in November at Ghagorjan (15.01±2.81 no./l). Highest density of cyanophyceae was recorded at Baghjan in September (11.61±2.45 no./l) and lowest in October at Ghagorjan (4.28±1.60 no./l). Highest density of bacillariophyceae was recorded in August at Baghjan (11.25±1.92 no./l) and lowest in November at Ghagorjan (2.01±0.91 no./l). Total density of phytoplankton was recorded highest at Baghjan in August (43.36±4.79 no./l) and lowest at Ghagorjan in October (19.37±3.75 no./l).

3.2 Phytoplankton Diversity and Evenness Indices

Table 3: Monthly mean variation of phytoplankton diversity and evenness indices

Indices	Streams	Months					
		Jun	Jul	Aug	Sep	Oct	Nov
Ĥ	Baghjan	2.15	2.24	2.41	2.21	2.26	2.10
	Singijan	2.11	2.27	2.40	2.23	2.28	2.12
	Ghagorjan	2.17	2.21	2.44	2.26	2.25	2.14
J	Baghjan	0.93	0.94	0.97	0.96	0.98	0.95
	Singijan	0.96	0.91	0.97	0.93	0.96	0.97
	Ghagorjan	0.92	0.97	0.94	0.96	0.97	0.94
1-D	Baghjan	0.90	0.90	0.88	0.91	0.92	0.86
	Singijan	0.89	0.94	0.90	0.89	0.87	0.93
	Ghagorjan	0.92	0.91	0.88	0.92	0.89	0.93
Ma	Baghjan	2.60	2.71	2.80	2.60	2.55	2.59
	Singijan	2.62	2.69	2.78	2.63	2.51	2.58
	Ghagorjan	2.61	2.70	2.83	2.58	2.53	2.55
Mc	Baghjan	0.78	0.77	0.80	0.80	0.81	0.81

	Singijan	0.77	0.78	0.82	0.78	0.76	0.82
	Ghagorjan	0.80	0.77	0.88	0.81	0.80	0.86
McE	Baghjan	0.93	0.92	0.96	0.96	0.98	0.95
	Singijan	0.91	0.94	0.97	0.97	0.99	0.96
	Ghagorjan	0.95	0.92	0.98	0.94	0.96	0.93

Key: Ĥ = Shannon diversity index**, J=** Pielou evenness index**, D=** Simpson's diversity index**, Ma=**Margalef diversity index, **Mc=** McIntosh diversity index**, McE=** McIntosh evenness index

Shannon-diversity index (Ĥ) was recorded highest in August at Ghagorjan (2.44) and lowest at Baghjan in November (2.1). Pielou evenness index (J) was recorded highest in October at Baghjan (0.98) and lowest in July at Singijan (0.91). Simpson's index of diversity (1-D) was recorded highest in July at Singijan (0.94) and lowest in November at Baghjan (0.86). Margalef diversity index (Ma) was recorded highest in August at Ghagorjan (2.83) and lowest in October at Singijan (2.51). McIntosh diversity index (Mc) was recorded highest in August at Ghagorjan (0.88) and lowest in October at Singijan (0.76). McIntosh evenness index (McE) was recorded highest in October at Singijan (0.99) and lowest in June at Singijan (0.91).

Table 4: Monthly variation of physicochemical parameters of the three streams

Parameter	Streams	months					
		Jun	Jul	Aug	Sep	Oct	Nov
Temp(^{0}C)	Baghjan	26.08±0.08	26.79±0.21	26.37±0.20	25.72±0.55	25.88±0.38	25.63±0.52
	Singijan	24.91±0.13	25.89±0.32	26.01±0.24	25.26±0.16	24.72±0.33	25.43±0.11
	Ghagorjan	25.62±0.12	25.48±0.26	25.31±0.21	25.04±0.53	25.08±0.33	25.13±0.22
pH	Baghjan	5.88±0.03	5.80±0.10	5.71±0.01	6.22±0.04	6.36±0.10	6.46±0.02
	Singijan	6.01±0.06	5.91±0.16	5.77±0.04	6.02±0.04	6.14±0.12	6.13±0.04
	Ghagorjan	5.46±0.05	5.57±0.05	5.51±0.04	6.07±0.03	6.07±0.07	6.11±0.03
Current velocity(m/sec)	Baghjan	0.39±0.02	0.54±0.07	0.63±0.02	0.37±0.02	0.48±0.08	0.57±0.05
	Singijan	0.63±0.03	0.82±0.07	0.84±0.11	0.58±0.01	0.59±0.02	0.31±0.15
	Ghagorjan	0.46±0.03	0.55±0.02	0.56±0.05	0.46±0.03	0.48±0.04	0.44±0.03
Conductivity(µS/cm)	Baghjan	618.19±1.04	618.19±1.33	620.68±2.63	593.21±4.72	597.06±4.39	586.99±2.55
	Singijan	584.51±6.0	577.92±7.2	588.86±1.7	568.72±1.7	574.69±7.1	576.81±19.

		6	2	3	7	3	77
	Ghagorjan	579.66±2.21	580.91±1.77	570.46±3.56	559.03±1.14	565.12±2.48	569.72±4.11
D.O.(mg/l)	Baghjan	3.07±0.16	3.01±0.26	3.16±0.31	5.28±0.24	4.83±0.53	4.36±0.09
	Singijan	4.18±0.12	3.79±0.14	4.01±0.11	4.71±0.18	4.53±0.5	4.61±0.16
	Ghagorjan	3.34±0.28	3.86±0.38	4.16±0.22	3.36±0.24	4.61±0.22	3.54±0.26
FCO_2.(mg/l)	Baghjan	13.64±0.61	16.15±2.61	18.79±1.11	13.14±0.52	13.94±0.67	14.51±0.39
	Singijan	18.08±1.14	18.66±0.49	17.44±1.06	13.66±0.34	14.34±1.28	17.26±1.31
	Ghagorjan	21.23±0.86	19.52±0.72	19.71±1.22	18.61±0.56	18.62±0.59	20.72±0.74
Total Acidity(mg/l)	Baghjan	19.54±0.59	20.96±0.79	19.32±0.18	18.21±0.31	19.43±1.49	20.09±1.13
	Singijan	19.31±0.76	19.93±1.43	21.16±0.88	15.81±0.31	17.12±1.17	18.55±0.31
	Ghagorjan	28.52±1.11	23.84±2.86	22.23±0.86	20.21±1.64	21.11±1.73	20.86±1.43
Total Alkalinity(mg/l)	Baghjan	21.16±0.88	67.17±1.07	68.57±2.31	73.29±0.96	77.31±3.99	82.78±3.01
	Singijan	15.81±0.31	54.52±2.06	55.97±1.08	68.67±1.11	71.87±2.05	71.42±1.15
	Ghagorjan	17.12±1.17	60.07±3.01	61.64±1.37	72.46±1.61	73.89±1.41	70.64±1.37
Chloride(mg/l)	Baghjan	18.55±0.31	19.44±0.77	19.52±0.61	23.41±0.33	22.56±1.19	21.62±0.69
	Singijan	21.26±0.37	20.67±0.72	19.87±1.15	20.93±3.12	22.78±1.01	21.48±0.78
	Ghagorjan	15.84±0.65	15.77±0.39	14.15±0.64	20.15±0.64	19.10±0.52	19.97±0.36
Stream depth(m)	Baghjan	0.38±0.05	0.37±0.04	0.39±0.03	0.29±0.01	0.29±0.01	0.26±0.01
	Singijan	0.41±0.01	0.45±0.05	0.40±0.06	0.36±0.04	0.37±0.01	0.28±0.05
	Ghagorjan	0.35±0.02	0.35±0.07	0.36±0.01	0.34±0.01	0.33±0.01	0.32±0.02
Stream width(m)	Baghjan	10.54±0.41	9.81±1.16	8.16±0.77	7.31±0.32	7.55±0.41	7.86±0.36
	Singijan	5.23±0.11	5.46±0.25	5.77±0.26	4.18±0.19	4.14±0.12	3.04±0.48
	Ghagorjan	3.51±0.16	4.04±0.22	3.80±0.14	2.26±0.08	2.46±0.15	2.21±0.11

IV. DISCUSSION

Phytoplankton density was found positively correlated with current velocity ($p<0.05$). The increased density of phytoplankton during monsoon may be attributed to impacts of nutrients through surface run off at high precipitation rate, maximum sunlight and high temperature. Phytoplankton population largely dependent on nutrient availability, light penetration and mixing with in the water column however nutrient availability is frequently referred as key factor regulating phytoplankton biomass and species composition [18]. Since the

studied three streams are ephemeral, hence precipitation plays a crucial role in renewing of water and bringing nutrients to these water bodies. Temperature also provides an important role in phytoplankton density and abundance. A positive correlation was observed between phytoplankton density and water temperature ($p<0.01$). Phytoplankton density showed positive correlations with FCO_2 ($p<0.05$), total acidity ($p>0.05$), conductivity ($p<0.05$), stream depth ($p>0.05$), stream width ($p>0.05$). Again negative correlations was recorded with DO ($p<0.05$), total alkalinity ($p>0.05$), chloride ($p>0.05$) and pH ($p<0.05$).

Chlorophyceae was recorded to be the dominant group both qualitatively and quantitatively in all the three ephemeral streams followed by bacillariophyceae and cyanophyceae. It was found to be most abundant during both the season and comparatively more in monsoon than postmonsoon which may be due to nutrient enrichment. Bacillariophyceae has been reported to dominate water with low nutrient levels while cyanophyceae identifed with water of high organic nutrient level but chlorophyceae was identified with water of moderate nutrient [19]. Water with high relative abundance of chlorophyceae has been identified as being productive [20]. Cyanophyceae was recorded to be the least abundant in all the three streams among the three phytoplankton groups. High abundance of cyanophyceae normally signifies polluted water as observed by [21].

Species diversity is a measure of the diversity within an ecological community that incorporates both species richness and the evenness of species abundances. In the present study, Shannon diversity index ranges 2.1-2.44. This reveals that the three ephemeral streams are moderately polluted [22], the value of Simpson's index ranges 0.86-0.94, which indicates nearly satisfactory diversity status [23]. The value of Margalef index ranges 2.51-2.83 and clearly indicate moderate to clean condition of the studied streams [24]. The value of McIntosh diversity index ranges 0.76-0.88, which fairly indicates that the individuals under phytoplankton community are not homogeneously distributed [14].

In the present study, the value of Pielou's evenness index ranges from 0.91-0.98 indicates that the individuals were evenly distributed [15]. McIntosh evenness index ranges 0.91-0.99 which reveals that the individuals were equally distributed [25].

V. CONCLUSION

Chlorophyceae was recorded to be the most abundant group in all the three studied streams during both monsoon and post monsoon indicating a productive aquatic habitat. Since the three streams are ephemeral hence precipitation plays a very important role in maintain the life period and food chain between the entire ecosystems starting from the phytoplankton. The value of density and diversity indices of phytoplankton clearly revealed less stable and moderately polluted condition of the studied three streams which may be due to different anthropogenic activities.

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