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Investigation on Cyanobacteria and algal community structure in soil around Jakrem hot spring, Meghalaya

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Abstract

In this investigation, Cyanobacteria and soil algal community structure in and around Jakrem hot spring, Meghalaya was recorded. Sites selected were located at three different distances from the hot spring. Soil parameters like pH, conductivity, moisture content and temperature were significantly different and were also observed to be higher in Site 1 and lower in Site III. No significant variation was observed for organic carbon, nitrate and phosphate. A total of 52 species were recorded in which Chlorophyceae was the dominant group (19 species) followed by Bacillariophyceae (17 species) and Cyanobacteria (14 species). The maximum number of Cyanobacteria observed in Site I was significantly positively correlated with pH, conductivity, moisture content, temperature and phosphate but diatoms were negatively correlated with pH. In Site III, the presence of Chlorophyceae was correlated with acidic nature of the soil.

Algae are found in almost all type of ecosystem and are the first community to colonise bare soil thereby enabling the subsequent establishment of higher plant communities[18]. Soil habitats are the most important non-aqueous ecosystems for algae[20]. One of the major benefits of algal functions in terrestrial habitats is the product of their photoautotrophic nutrition, the generation of organic matter from inorganic substances[1]. They also serve as a food source for bacteria and invertebrates, and biologically active compounds produced by algae can affect other components of soil communities, including plants[12, 15]. Significant ecological roles of soil algae include nutrient conservation in soils and support in natural soil formation process[19,21].

Meghalaya which is situated in the Northeast region of India has emerged as a popular tourist attraction site. About 15 kms from Mawkyrwat and 60 kms from Shillong

at Iawblei (Jakrem) on the Shillong - Mawkyrwat road is the Jakrem hot spring. Jakrem in Meghalaya is fast gaining popularity among tourists as it is a wonderful health resort. It is believed that the water of the hot spring is endowed with curative medicinal properties. Algae have been observed in many different extreme environments especially in thermal spring. Since the study on effect of hot spring on soil and algae around it are rare therefore the present work is undertaken in order to study the composition of soil algal community in and around Jakrem hot spring.

Study site description :

Soil samples were collected from three selected areas near Jakrem hot spring.

Site I: It is located near the hot spring in which the soil is covered with thin algal mat and the soil is blackish in colour.

Site II: It is located at around (0.5 m) from the hot spring in which the soil surface is covered with grass and the soil is blackish in colour.

Site III: It is located at around (1 m) away from the hot spring with blackish coloured soil, covered with grasses.

Algal analysis :

Soil samples were collected randomly from 3 different quadrats (20x 20 cm) marked within a 1m x 1m quadrat. Around 5-10 quadrats of 1m x 1m were placed randomly. Replicates were taken and then mixed thoroughly to make a composite soil sample. 10 g of composite soil were put in conical flasks for culturing soil algae. Different media like Bold's Basal Medium (BBM), BG-11 and Gulliard medium for culturing green algae, Cyanobacteria and diatoms were used respectively. All the algae were observed under microscope (Motic B1 series) and were identified to the possible lower taxonomic level following standard books and monographs[6, 5, 13, 14, 7, 10]. Taxonomy was updated[8].

Soil analysis :

Soil moisture content was determined by oven dry basis, where 10 g of freshly collected soil was dried in hot air oven at 105^{o}C for a period of 24 hours. Soil pH and conductivity were read using an electronic digital pH meter (pHtestr 20) and conductivity meter (Model 611). Soil organic carbon was estimated[2]. Estimation of nutrients like nitrate

and phosphate were carried out using brucine method and Stannous chloride method[3].

Data Analysis :

ANOVA test ($P<0.05$) was carried out for the physicochemical parameters. Pearson's Correlation was conducted between the physico-chemical parameters with the Cyanobacteria and algal groups.

Different indices used :

Shannon Index (H') for Species diversity

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

S = total number of species, Pi = ni/N, Ni = Number of individuals belonging to i^{th} species, N = total number of individuals of all species.

Simpson's Index (D) for Dominance

$$D = 1 - \sum_{i=1}^{s} (p_i)^2$$

S = Total number of Species, Pi = ni/N, N = Total Number of individual of all the species, ni= Number of Individuals belonging to i^{th} species.

Pielou's Evenness Index (J)

$$J = \frac{H'}{\ln(S)}$$

J = Eveness, H'= Species Diversity

Soil parameters like pH, conductivity, moisture content and temperature were significantly different at different sites and were also observed to be higher in Site 1 and lower in Site III. Nutrients like nitrate, phosphate and organic carbon did not vary significantly. The value of nitrate was observed at 0.51 mg g^{-1}, 0.41 mg g^{-1} and 0.31 mg g^{-1} in Site I, Site II and Site III respectively. The higher value of phosphate was 0.04 mg g^{-1} and it was the same for Site I and Site II while value of 0.03 mg g^{-1} was observed at Site III. Organic carbon also did not vary significantly with a value of 0.22% observed both at Site I and Site III and value of 0.15% observed in Site I (Table-1).

A total of 52 species were recorded. Out of 52 species, Chlorophyceae was represented by 19 species, Bacillariophyceae with 17 species, Cyanobacteria by 14 species

Table-1.Physico-chemical parameters of the soil around Jakrem hot spring

Parameters	Site I	Site II	Site III	p-value
pH	7.89±0.25	7.22±0.59	6.12±0.97	0.04*
Conductivity (mS cm^{-1})	0.09±0.03	0.06±0.02	0.04±0.005	0.01*
Moisture content (%)	58.09±8.07	50.13±2.55	38.83±3.25	0.01*
Temperature (^oC)	31.67±0.58	29.67±0.58	24.67±1.15	0.00*
Organic carbon (%)	0.22±0.07	0.15±0.05	0.22±0.06	0.32
Nitrate(mg g^{-1})	0.51±0.02	0.41±0.06	0.31±0.12	0.06
Phosphate(mg g^{-1})	0.04±0.03	0.04±0.00	0.03±0.00	0.80

(*) indicates significant at $p<0.05$

and a single species each of Xanthophyceae and Euglenophyceae. In the Site I, members of Cyanobacteria were recorded as maximum while in Site II, members of Bacillariophyceae members were the most dominant group. Chlorophyceae members were maximum and most diversed compared to the other classes in Site III. Xanthophyceae and Euglenophyceae were represented by only one species and were present only in Site II and Site III (Table-2). Simpson's Dominance Index (D), Shannon's Diversity Index (H') and Pielou Evenness Index (J) were higher in Site II (Table-3).

Cyanobacteria were observed with high relative abundance (<500) as compared to other group. Some of the species with high abundance were *Oscillatoria curviceps* and *Synechococcus aeruginosus*. Chlorophyceae was observed with abundance of <400. Species with high abundance were *Chlamydomonas* sp and *Scendesmus quadricauda*. However the diatoms were observed with low abundant (<70) (Table-2). Analysis of soil from all the sites showed a significant difference in the pH, moisture content, conductivity and temperature of the surface of the soil which might be one of the reasons for diverse distributional pattern of algae in different sites. Edaphic factors and soil characters together with some specific features within the algal organisms themselves constituted the main factors responsible for the existence of algae in the soil[9].

Table-2. Distribution of Cyanobacteria and algae in Jakrem hot spring

Species	Site I Abundance (10^3 g^{-1} soil)	Site II Abundance (10^3 g^{-1} soil)	Site III Abundance (10^3 g^{-1} soil)
Cyanobacteria			
Anabaena sp	330	164	-
Anabaena spiroides	442	283	148
Chrococcus minutus	345	335	108
Chrococcus turgidus	263	-	-
Microcystis sp	272	426	337
Nostoc linckia	386	207	96
Osciillatoria agardhii	184	166	88
Oscillatoria curviceps	503	504	158
Oscillatoria chalybea	406	-	-
Oscillatoria acuminata	187	-	-
Oscillatoria princeps	218	222	-
Phormidium ambiguum	324	183	-
Synechococcus aeruglnosus	489	404	165
Synechococcus elongatus	412	252	-
Bacillariophyceae			
Achnanthes sp	-	48	45
Cymbella angustata	-	40	43
Cymbella minuta	64	41	43
Encyonema sp	65	38	-

Gomphonema sp	40	54	40
Gomphonema sphaerophorum	-	45	34
Gomphonema vibrio	79	47	31
Navicula borealis	63	51	-
Navicula cryptocephala	71	57	-
Navicula salinarum	-	34	-
Navicula viridis	58	35	32
Nitzschia sp	-	41	35
Pinnularia intermedia	36	41	36
Pinnularia major	43	33	48
Pinnularia stauroptera	47	41	-
Rhopalodia gibba	41	28	-
Surirella biseriata	39	24	32
Chlorophyceae			
Ceratium sp	-	64	110
Chlamydomonas sp	435	334	425
Chlorella mirabilis	-	255	314
Chlorella vulgaris	207	273	304
Chlorococcum sp	-	-	205
Closterium sp	144	196	276
Coelastrum cabricum	65	177	127
Cosmarium sp	188	256	337
Dictyochloropsis splendida	278	275	308
Haematococcus sp	166	286	248
Microspora sp	-	-	94
Scendesmus denticulatus	107	-	187
Scendesmus incrassatulus	-	186	256
Scendesmus quadricauda	205	273	387
Scenedesmus bijugatus	-	105	217
Scenedesmus obliquus	186	225	-
Scenedesmus obtusus	-	-	165
Sphaerocystis sp	-	105	156
Ulothrix sp	-	135	265
Xanthophyceae			
Tribonema sp	0	188	112
Euglenophyceae			
Euglena polymorpha	-	285	354
Total number of species	**36**	**45**	**38**

(- indicates absent)

Table-3. Different Index Values for Cyanobacteria and algae in Jakrem hot spring

Indices	Site I	Site II	Site III
Simpson's Dominance Index (D)	0.96	0.97	0.96
Shannon's Diversity Index (H)	2.50	2.75	2.51
Pielou's Evenness Index (J)	0.92	0.94	0.90

Table-4. Pearson's Correlation Coefficient between the physico-chemical parameters with the Cyanobacteria and algae

Parameters	pH	Conduc-tivity	Moisture content	Temper-ature	Nitrate	Phosphate
Cyanobacteria	0.99*	0.93*	0.89*	0.98*	0.76	0.66*
Bacillariophyceae	-0.78*	-0.03	0.25*	0.38	0.65*	0.87
Chlorophyceae	-0.96*	-0.98	0.97*	-0.92	0.45*	0.67
Xanthophyceae	-0.79	-0.94	-0.81	-0.72	0.23	0.34
Euglenophyceae	-0.79	-0.94	-0.81	-0.72	0.12*	0.23

(*) indicates significant at $p<0.05$

Correlation between Cyanobacteria and algae to soil characteristics showed that Cyanobacteria was significantly correlated to pH (0.99), conductivity (0.93), moisture content (0.89), temperature (0.98) and phosphate (0.66). Chlorophyceae was significantly correlated to moisture content (0.97) and show negative correlation to pH (-0.96) and temperature (-0.92). Bacillariophyceae did not show significant correlation to pH (-0.78) (Table-4). In general, Cyanobacteria, preferred to grow in neutral to alkaline pH, while acidic soils were more favourable for development of green algae[4, 17, 16]. Diatoms were observed in soil of neutral to alkaline pH[11].

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