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A Study on Aquatic Macrophytes Diversity of Lake Kharungpat, Manipur, India

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ABSTRACT

Aquatic macrophytes are considered as an important component of the aquatic ecosystem not only as food source for aquatic invertebrates, but also act as an efficient accumulator of heavy metals. The infestation of freshwater bodies by aquatic weeds influences water management in waterways, rivers, reservoirs and canals which interfere with the use of water, or in some way constitute a nuisance to man or hazard to human welfare, or growing on a water body where it is not desired.The present study was conducted during September, 2019 to August, 2020 in lake Kharungpat of Manipur which is situated towards the southern lowlands of the central valley of Manipur in the Kakching district. Five numbers sampling Site namely Site 1 (Longitude 93º 92' E and Latitude 24º 58' N), Site 2 (Longitude 93º 91' E and Latitude 24º 56' N), Site 3 (Longitude 93º 93' E and Latitude 24º 54' N), Site 4 (Longitude 93º 96' E and Latitude 25º 55' N) and Site 5 (Longitude 93º 96' E and Latitude 24º 58' N) were selected to make the study statistically sound. A total of 26 aquatic macrophytes were identified from lake Kharungpat during 2019-2020. The identified aquatic macrophytes comprised of 26 species belonging to 23 genera, 15 families and 11 orders. *Phragmites karka* species was the most dominant aquatic macrophytes of the lake in case of species occurrence and percentage contribution, alone contributing 81 percent to the total macrophytes vegetation during the study period. The overall total infestation percentage of macrophytes was recorded maximum (76.67 percent) in the month December, 2019 and March, 2020 with minimum 41.39 percent in the month August, 2020.The Simpson index, Shannon index and Evenness richness index value rangedbetween 0.7398 to 0.9386, 1.712 to 2.956 and 0.8354 to 1.585 respectively. Management of aquatic macrophytes through local participation should be the main focus areas for restoration of the lake by rejuvenating the open water area. These will provide employment opportunities thereby improving the lake environment.

Key words: *Aquatic macrophytes, Diversity, Lake Kharungpat, Manipur, India*

Introduction

Macrophytes serve as a link between the sediment, water, and (sometimes) atmosphere in wetlands, lakes, and rivers. They are also considered as important component of the aquatic ecosystem not only as foodsource for aquatic invertebrates, but also act as an efficient accumulator of heavy metals. The infestation of freshwater bodies by aquaticweeds influences water management in waterways, rivers, reservoirs and canals which interfere with the use of water, or in someway constitute a nuisance to man or hazard to human welfare, or growing on a water body where it is not desired.There is an ecosystem

imbalance between aquatic plants and other aquatic organisms when the plants invade the system and grows excessively to a nuisance level. The excessive growth of aquatic macrophytes restricts fishing, swimming and recreational activities, causes foul taste and odour of drinking water supplies. Thus, researches on wetland macrophytes have started gaining importance not only because systematic stock taking of biodiversity were presently given topmost priority but also because these plants have implications with functional values of wetlands. Aquatic vegetation pattern is likely to control major aspects of wetlands biogeochemistry and tropic dynamics.

Manipur, one of the states of North East India, is a hill state located between 92°58´E to 94°45´E longitudes and 23°50´N to 25°42´N latitudes situated atan elevation of 790m above sea level with a total area of 22,327 km². Hill areas cover about 92% (20,540.84 km²) of the area of the state enclosing a valley area of 1,800 km². It has a rich freshwater resource in form of ponds, lakes, rivers, streams, reservoirs, etc. The fresh water lakes of Manipur are degraded due to excessive influx of sediments through erosion from catchment area, discharge of untreated sewage and solid waste, accumulation of agricultural runoff and over-exploitation through fishing and recreation activities (Sharma *et al.* 2010; Ramesh and Krishnaiah, 2013). Due to high level of degradation, most of the lakes in the state have already reached to the stage of wetlands (Sharma, 1999).

Lake Kharungpat ranks third among freshwater lake of Manipur, situated in Kakching district which is around 3.5 to 4 km from Kakching town and about 35 km from the Imphal, the capital city of Manipur. It lies between longitudes 93° 90' to 93° 97' E and latitudes 24°53' to 24° 60' N. The lake is situated at 781m above mean sea level with an area of 18 sq. km. (MARSAC, 2020). Adequate information about the various components, influencing various parameters and the delicate dynamics sustained by them is of supreme importance to formulate appropriate environmental management strategies and protect the rich biodiversity of the lakes. Thus, for stable management of the lake which have greatly influenced the progress of human societies since times, has to be investigated in detail, especially to know the ecological dynamics of the lake. The present study will be important for the conservation and management of the lake as the quantity and diversity of macrophytes are the important parameters for assessing the health of the ecosystem.

Accordingly, a detailed study was planned for gaining a better insight of aquatic macrophytes diversity of lake Kharungpat in Manipur.The findings would enable in formulating a better ecosystem management for sustaining the lakes' biodiversity and their long-term utility. It would also provide a rational basis for proper planning and implementation of developmental programme not only in lake Kharungpat but also in other lakes of the state and country as a whole.

Materials and Methods

The present study was conducted during September, 2019 to August, 2020 in lake Kharungpat of Manipur which is situated towards the southern lowlands of the central valley of Manipur in the Kakching district. Five numbers sampling site namely Site 1 (Longitude 93º 92' E and Latitude 24º 58' N), Site 2 (Longitude93º 91' E and Latitude 24º 56' N), Site 3 (Longitude 93º 93' E and Latitude 24º 54' N), Site 4 (Longitude 93º 96' E and Latitude 25º 55' N) and Site 5 (Longitude 93º 96' E and Latitude 24º 58' N) were selected to make the study statistically sound. The sampling site were selected in such a way that the distance between sampling Site uniformly covered the entire area of the lake.

Macrophyte specimens were randomly collected and identified (Edmonson, 1959; Adoni, 1985; Singh and Shyamananda, 1994; Trisal and Manihar, 2004). Aquatic macrophytes were collected using a square shaped wooden quadrat sampler (Jhingran, *et al* 1988) having 0.25 m² area. The collected sample were segregated and identified group-wise at the field and those which could not be identified were brought in polythene bags to the laboratory for identification. The collected macrophytes from the lake were segregated in the laboratory and identified up to generic/ species level (Edmonson, 1959; Adoni, 1985; Singh and Shyamananda, 1994; Trisal and Manihar, 2004; Biswas and Calder, 1936; Frassett, 1940). The areas of infestation Site by aquatic macrophytes were recorded in hectare (ha) and in percentage of the total area of the lake. Bhattacharyya (2002) and Bhagabati (2011).

Biodiversity analysis

Species diversity comprised of species evenness and richness. Species evenness represent the distribution of abundance of species among the species whereas

species richness is indicated by the species numbers. The following diversity indices have been calculated by using a computer-based software 'PAST version. 2.02' to assess the macrophytes diversity of the lake Kharungpat.

Results

A total of 26 aquatic macrophytes were identified from lake Kharungpat during 2019-2020. The identified aquatic macrophytes comprised of 26 species belonging to 23 genera, 15 families and 11 orders (Table 1). *Cynodon dactylon, Brachiuria mutica, Echinochloa stagnina, Phragmites karka and Alternanthera philoxeroides* was found to be highly dominant species of the lake followed by *Hydrilla verticillata and Sagittaria sp.*

Table 1. Aquatic Macrophytes species observed in Lake Kharungpat during 2019-2020.

Sl. No.	Macrophytes Species	Relative Abundance
	Order COMMELINALES	
	Family PONTEDERIACEAE	
1.	*Eichchornia crassipes*	+
	Order SALVINIALES	
	Family SALVINIACEAE	
2.	*Azolla pinnata*	+
3.	*Salvinia natans*	+
	Order ALISMATALES	
	Family ARACEAE	
4.	*Pista stratiotis*	+
	Family LEMNACEAE	
5.	*Lemna minor*	+
6.	*Lemna major*	+
	Family HYDROCHARITACEAE	
7.	*Hydrilla verticillata*	+ +
	Family PLANTAGINACEAE	
8.	*Alisma palntagoaquatic*	+
	FamilyPOTAMOGETONACEAE	
9.	*Potamogeton crispus*	+
	FamilyALISMATACEAE	
10.	*Sagittaria sp.*	+ +
	Order NYMPHAECLES	
	Family NYMPHAEACEAE	
11.	*Euryle ferox*	+
12.	*Nymphaea pubescens*	+
13.	*Nymphaea stellata*	+
	Order POALES	
	Family POACEAE	
14.	*Cynodon dactylon*	+ + +
15.	*Zizania latifolia*	+
16.	*Brachiuria mutica*	+ + +
17.	*Echinochloa stagnina*	+ + +
18.	*Phragmites karka*	+ + +
19.	*Oryza sativa*	+
	Order CARYOPHYLLALES	
	Family AMARANTHACEAE	
20.	*Alternanthera philoxeroides*	+ + +
	Family CERATOPHYLLACEAE	
21.	*Ceratophyllum demersum*	+
	Order PROLEALES	
	Family NYMPHAEACEAE	
22.	*Nelumbo nucifera*	+
	Order SOLANALIS	
	Family CONVULVULACEAE	
23.	*Ipomoea aquatica*	+
	Order ASTERALES	
	Family ASTERACEAE	
24.	*Enhydra fluctuans*	+
	Order HYDROPTERIDALES	
	Family SALVINIACEAE	
25.	*Salvinia cucullata*	+
	Order FABALES	
	Family FABACEAE	
26.	*Neptunia prostrate*	+

Note: + = Sparse; ++=Abundant; +++=Highly Abundant

Among the recorded eleven orders Alismatales formed one of the most dominant order as compared to all other orders recorded in the present study comprising of 27 percent of the total macrophytes species of the lake. The aquatic macrophytes identified from the lake Kharungpat were represented by fifteen families in which Poaceae family was found to be the most dominant comprising of 23 percent of the total macrophytes species. *Phragmites karka* species was the most dominant aquatic macrophytes of the lake in case of species occurrence and percentage contribution, alone contributing 81 percent to the total macrophytes vegetation during the study period (Table 2).

Monthly variation in infestation site percentage of aquatic macrophytes in lake Kharungpat during 2019-2020 is presented in Table 3. The overall total infestation site percentage of macrophytes was recorded maximum (76.67 percent) in the month December, 2019 with minimum 41.39 percent in the month August, 2020.

Biodiversity Indices

The biodiversity indices of aquatic macrophytes calculated in percentage were presented in Table 4. Site wise biodiversity indices calculated of the lake during the study period showed that, the Dominance index 'D' was found maximum in Site 1 with an in-

Table 2. Aquatic Macrophytes species occurrence and percentage contribution in Lake Kharungpat during 2019-2020.

Sl. No.	Species	Occurrence Composition (%)
1	*Eichchornia crassipes*	Rare -
2	*Azolla pinnata*	Rare -
3	*Salvinia natans*	Rare -
4	*Pista stratiotis*	Rare -
5	*Lemna minor*	Rare -
6	*Lemna major*	Rare -
7	*Hydrilla verticillata*	Common -
8	*Alisma palntagoaquatic*	Rare -
9	*Potamogeton crispus*	Rare -
10	*Sagittaria sp.*	Common -
11	*Euryle ferox*	Rare -
12	*Nymphaea pubescens*	Occasional -
13	*Nymphaea stellata*	Occasional -
14	*Cynodon dactylon*	Common 10
15	*Zizania latifolia*	Occasional -
16	*Brachiuria mutica*	Common 4
17	*Echinochloa stagnina*	Common 3
18	*Phragmites karka*	Common 81
19	*Oryza sativa*	Rare -
20	*Alternanthera philoxeroides*	Common 2
21	*Ceratophyllum demersum*	Rare -
22	*Nelumbo nucifera*	Occasional -
23	*Ipomoea aquatica*	Rare -
24	*Enhydra fluctuans*	Rare -
25	*Salvinia cucullata*	Rare -
26	*Neptunia prostrate*	Occasional -

dex value of 0.2602.The Simpson index, Shannon index and Evenness richness index value ranges between 0.7398 to 0.9386, 1.712 to 2.956and 0.4236to 0.8354 respectively.

Discussion

Wetlands act as a hotspot for any biotic diversity and vital for sustaining aquatic life. Macrophytes act as a ''biological engineer'' in aquatic ecosystem for restoring the water quality (Byers *et al.* 2006). Aquatic macrophytes act as a substrate for growth of algae, act as primary producers, act as fish breeding ground, check inflow of silt, reduces nutrient load through algal blooms development, ensure nutrient cycling, help in stabilizing lakes shoreline, provides home to many aquatic animals, help in oxygenating water and uphold the water quality of the ecosystem Naskar (1990) and Panda *et al.* (2018). Exotic plants invasion in water bodies facilitate extinction of indigenous species (Stallings *et al.* 2015). Luxuriant growth of aquatic macrophytes in water bodies also affect the human activities and lead to degradation of physico-chemical and biological characteristic of the ecosystem (Basak *et al*. 2015). A total of 26 aquatic macrophytes belonging to 23 genera, 15 families and 11 orders were identified from lake Kharungpat during 2019-2020. The present finding is conformity with the finding of Devi and Sharma (2007) in Hidenkompat lake, Manipur, Usha *et al.* (2010) in Poiroupat lake, Manipur, Dhanam and Elayaraj (2015) in Santhapettai lake, Tamil Nadu and Madhavi *et al.* (2018) in Kondakarla lake, Andhra Pradesh. Naskar (1990) reported a total of about 140 aquatics weed which attained a status of aquatic weeds and many of them was found in lake Kharungpat. Seasonal variation in the biomass of aquatic macrophytes in lake Kharungpat observed in the present study may be due to the seasonal variation of the water level in the lake. This is in con-

Table 3. Monthly variation in infestation site percentage of aquatic macrophytes in Lake Kharungpat during 2019-2020.

Macrophytes Months	*Phragmites karka*	*Cynodon dactylon*	*Brachiuria mutica*	*Echinochloa stagnina*	*Alternanthera philoxeroides*	Others	Total
September (2019)	22.22	8.33	8.33	8.33	17.78	2.78	67.78
October	21.11	8.89	8.89	8.33	18.33	3.89	69.44
November	22.22	11.11	8.33	11.11	16.67	2.78	72.22
December	22.22	13.89	11.11	11.11	13.89	4.44	76.67
January (2020)	19.44	8.33	8.33	10.00	11.11	2.22	59.44
February	23.33	13.89	11.11	12.78	10.00	2.78	73.89
March	21.11	13.89	11.11	13.89	14.44	2.22	76.67
April	17.78	8.89	11.11	8.33	14.44	3.33	63.89
May	19.44	11.11	8.33	11.11	13.89	3.33	67.22
June	21.11	4.44	4.72	2.78	13.89	1.11	48.06
July	14.44	4.17	3.89	2.78	19.44	0.83	45.56
August	16.67	3.33	3.61	1.67	15.56	0.56	41.39

Table 4. Site wise biodiversity indices calculated of aquatic macrophytes (Percentage) of Lake Kharungpat during 2019-2020.

	Site 1	Site 2	Site 3	Site 4	Site 5
Dominance_D	0.2602	0.0614	0.2238	0.1272	0.1516
Simpson_1-D	0.7398	0.9386	0.7762	0.8728	0.8484
Shannon_H	1.78	2.956	1.712	2.275	2.298
Evenness_e^H/S	0.4236	0.8354	0.6924	0.695	0.6221
Brillouin	1.599	2.621	1.585	2.068	2.065
Menhinick	1.4	2.3	0.8	1.4	1.6
Margalef	2.823	4.777	1.52	2.823	3.257
Equitability_J	0.6745	0.9427	0.8232	0.8621	0.8288

formity with the finding of Da Silva and Esteves (1993), Bhattacharyya (2002) and Pirini *et al* (2011).

Phragmites karka species was the most dominant aquatic macrophytes of the lake in case of species occurrence and percentage contribution, alone contributing 81 percent to the total macrophytes vegetation followed by *Cynodon dactylon* (10 percent), *Brachiuria mutica* (4 percent), *Echinochloa stagnina* (3 percent)and *Alternanthera philoxeroides* (2 percent). Similar pattern of aquatic macrophytes occurrence in Powai lake, Mumbai with different species was also reported by Rasal *et al* (2014). The dominant macrophytes species of lake Kharungpat was found to be very similar with the dominant macrophytes species of Loktak in Manipur Bharati (2013). The luxuriant growth of aquatic macrophytes especially *Phragmites karka* in dense population in lake Kharungpat indicates that the lake is eutrophic in nature. Luxuriant growth of aquatic macrophytes making the lakes eutrophic in nature was also reported in India and elsewhere by Uka *et al.* (2009), Pirini *et al.* (2011), Usha *et al.* (2010), Azzella *et al.* (2013), Rasal *et al.* (2014), Sharma and Singh (2017), Korai *et al.* (2008) and Panda *et al.* (2018). Site wise biodiversity indices calculated of aquatic macrophytes (Percentage) of lake Kharungpat during 2019-2020 showed that the highest Dominance index 'D' was recorded in site 1 (0.2602) and lowest value in site 2 (0.0614). This showed that site 2 has higher dominance of aquatic macrophytes as compared to other sites during the study period.

The Shannon index value of Macrophytes lake Kharungpat during the study period ranged from 1.712 to 2.956. Khan *et al.* (2004) reported, a health environment Shannon's index value ranged between 2.5 to 3.5. Thus, the lake Kharungpat fall under less healthy environment.

Conclusion

Lake Kharungpat is the third largest natural freshwater lake of Manipur. Earlier, the lake was recognised for its rich aquatic flora and fauna and also for its socio-economic importance. However, over the past years, deforestation in catchment area and denudation of aquatic vegetation has been responsible for increased in rate of soil erosion leading to siltation of the lake. Due to the heavy infestation of aquatic macrophytes, the well-being of the lake ecosystem has been threatening. Extensive encroachment of lake catchment area is another serious problem facing by the lake.

Taking into consideration the problems face by the lake, it is high time for the people living in an around the lake and concerned authority to realize the necessity for revival measure of the lake. Unless conservational measures are taken up in the nearest future the deterioration of the lake ecosystem would progress at the highest pace which might ultimately lead to the death of these lake. Management of aquatic macrophytes through local participation should be the main focus areas for restoration of the lake by rejuvenating the open water area. These will provide employment opportunities thereby improving the lake environment.

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