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Mohammad Faizan and Abdullah

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## Seasonal Variability in the Species Composition of Macrophytes in a Fresh Water Lake, the *Taal Ratoi*

Mohammad Faizan\*<sup>1</sup> and Abdullah<sup>2</sup>

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### ABSTRACT

The *Taal Ratoi* is a shallow fresh water lake having an average depth of about 200 cm. It is situated near village Fatehpur Mandao of Mau district of Eastern Uttar Pradesh, India, spread over an area of 1837 hectare. The present work is carried out to assess the seasonal variability in species composition of lake, as there is no considerable work has been carried out before on ecology and limnology of this lake. The survey, collection and identification of macrophytes were carried out between March 2019 and February 2020. The samples were collected in March and November for pre-monsoon and post-monsoon season, respectively. Ten sampling sites were chosen for collection of samples due to logistic reason. The macrophytes were categorized into Emergent, Submerged, Rooted with Free-floating leaves and free floating along with shoreline species on the basis of habitat. Total twenty-eight species belonging to nineteen families were recorded. In pre monsoon sampling total thirteen species of macrophytes were obtained out of which, four emergent, four submerged, two rooted with floating leaf and one free floating and two shoreline species. Likewise in post monsoon sampling total fifteen species were observed out of which five emergent, two submerged, one rooted with free floating leaves and one free floating along with six shoreline species. The important observation which has been made in present study that in both pre monsoon and post monsoon season *Hydrilla verticillata* and *Potamogeton crispus* were growing so abundantly that in the littoral zone almost bed is total covered with these species.

**Key words:** Fresh water lake, *Taal Ratoi*, Macrophytes, Submerged, Emergent, Free floating, Shoreline, Pre monsoon, Post monsoon

The *Taal Ratoi* is an important fresh water body of the area spread over 1837 hectare. This water body on one hand connected with land mass spread over in its catchment area inhabiting a population of several thousand people which influence the lake and on other hand it is connected with river Ghaghara through Naala. The water of this river was very clean up to 1950s and was the only major source of fresh water of the area for domestic and agricultural consumption. But during recent urbanization and use of recalcitrant material along with agricultural runoff and discharge of domestic sewage this water body got grossly polluted and eutrofied, which change its composition of flora and fauna. Although being an important source of fresh water, no major ecological work has been carried out before to have an understanding of this water body. Keeping in mind the important of water body present study was carried out from 2019-2020 during pre-monsoon and post monsoon season to find seasonal variability in the species composition

of macrophytes. The variability in composition of the macrophytes in water bodies depends on the physical and chemical characteristic of water [19]. These variations depend on the type and nature of the water area, as well as on the eutrophication process or runoff of minerals and chemicals from agriculture wastes [24]. Different macrophytes life forms depend on different nutrient sources perform different functional role and their responses to environmental gradients [23]. Therefore, macrophytes species richness and proportion of various life forms closely reflect the trophic state of lake and eutrophic lake supporting significantly more species than oligotrophic lakes<sup>1</sup>. Several studies have probed relationship between macrophytes diversity and various environmental variables such as water chemistry, surrounding land use and also physical and chemical characteristic of sediments [22]. In aquatic ecosystem allelopathic interaction have been described for all groups of organisms including macrophytes, that effects the composition of species [10]. The macrophytes contribute sedimentation of particulate organic matters [4]. During growths and decay, macrophytes release dissolved organic matter, by product of photosynthesis [20]. These dissolved organic matters constitute a potential source of carbon for

\* Mohammad Faizan

✉ fsheikh82@gmail.com

<sup>1-2</sup> Department of Botany, Shibli National College, Azamgarh - 276 001, Uttar Pradesh, India

water column that strongly effect composition and distribution of macrophytes [7]. Shallow lakes are dynamic system and the distribution and abundance of macrophytes can change due to disturbance in environmental condition [3]. Macrophytes production in lake is significant for primary productivity they contribute general fitness and diversity of lake by favoring in nutrient cycling [17]. Submerged macrophytes produce food for aquatic organism and shelter for insects, fish, and other aquatic and semi-aquatic organisms. The spatial distributions of macrophytes often are regulated by the availability of light which is influence to large extent by suspended materials [5]. The turbulence in shallow lake also effects the distribution and composition of submerged macrophytes directly by damaged mature plants or indirectly by altering nutritional status and stability of the bottom sediments [21]. Shallow lake with a large fetch has a deeper wave-mixed zone resulting in sediments induced turbidity which prevents the growth of submerged macrophytes [14]. The lake remains connected with river Ghaghara throughout the year thereby allow the free mixing stagnant and flowing water therefore exhibit physico-chemical and biological characteristic which support flora and fauna [16]. Macrophytes are affected by many abiotic factors including water and sediment nutrients underwater, light, fetch and water level fluctuation [8]. The growth, propagation and abundance of aquatic and semi-aquatic macrophytes during different season help enhancement of biodiversity and influence their distribution [8]. Flood pulses alter macrophytes richness, composition, productivity and biomass<sup>8</sup>. Therefore, in monsoon season

the macrophytes richness reduce in comparison to pre monsoon and post monsoon season. The species richness of emergent, submerged and free floating macrophytes also reduced at water level fluctuation [13]. Hence the objective of the present study is set to find out species composition of macrophytes communities and analysis of macrophytes with diversity indices to assess the water quality and aquatic health of lake in eastern part of Uttar Pradesh district of Mau in eastern India. This type of study would hopefully be an anthology for future studies on assessment of macrophytes and aquatic health in designing a plan for the sustainable management of the lake.

### MATERIALS AND METHODS

The *Taal Ratoi* is the largest shallow lake having an area of 1837 hectares and an average depth of 200 cm. It is situated near village Fatehpur Mandao of Mau district of Eastern Uttar Pradesh, India. The *Taal Ratoi* lies at North-East (26°09'46.6" N-83°44'16.8" E) Coast of India and connected with Ghaghara River. It is a large fresh water lake. The south and east basin are deeper while north and west basin are comparatively shallow. The south, east and north basins have more diversity in macrophytes population compare to west basin of lake. There were four seasons belong to this area but work done only in two seasons i.e., pre monsoon and post monsoon season. The study covers ten sites of lake which are selected for monitoring of macrophytes. An overview and description of lake are given in (Fig 1a-b).

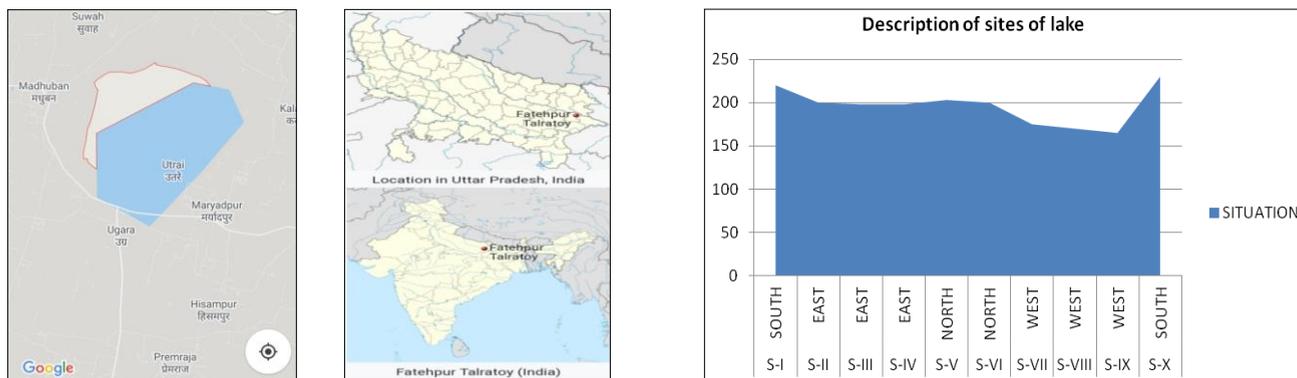


Fig 1(a) An overview of lake; (b) Discription of sites of lake



*Potamogeton crispus*



*Hydrilla verticillata*

For the study, macrophytes from lake were collected in pre-monsoon and post-monsoon season. The occurrence of macrophytes carried out by visualization of the species both aquatic and semi-aquatic for the identification. Unidentified plants viewing was collected and placed between sheet of newspaper, cardboard and wooden slats. Each site was surveyed in March for pre monsoon and in November for post monsoon. The aquatic macrophytes were collected by hand or by using a rake from a boat along entire littoral zone and shoreline. When necessary, the aquatic plants collected by snorkeling. For collecting macrophytes place a sheet of white paper under the plants and left carefully from the water. Let the water drain off and dry

between blotting paper in drying chamber. Small semi-aquatic macrophytes are carefully uprooted and collected while for longer specimen only representative part such as flowers and fruiting twigs or both were collected in minimum three specimens. Immediately after each collection, the collected macrophytes were placed in polythene bag to avoid xeronsis and then carried out in temporary laboratory which is setup in the lab of Department of Botany, Shibli National College, Azamgarh. The collected macrophytes were categorized into emergent, submerged, rooted with floating leaves, free floating and shoreline. For taxonomic identification we followed specialized literature [2], [6], [9], [11], [18].

Table 1 Total macrophytes found in different sites of lake

Scientific name	Family	Common name	Type of macrophytes
<i>Cyperus halpan</i>	Cyperaceae	Dwarf papyrus	Emergent
<i>Elecharis palustris</i>	Cyperaceae	Marsh spike rush	Emergent
<i>Cynodon dactylon</i>	Poaceae	Doobghass	Emergent
<i>Persicaria minor</i>	Polygonaceae	Depresa	Emergent
<i>Polygonum lapathifolium</i>	Polygonaceae	Curlytop knotweed	Emergent
<i>Rumex dentatus</i>	Polygonaceae	<i>Jungali Palak</i>	Emergent
<i>Ipomea aquatic</i>	Convolvulaceae	Karemua	Emergent
<i>Maesillea quadrifolia</i>	Marsileaceae	Susnari	Emergent
<i>Alternanthera sessilis</i>	Amranthaceae	Girni	Emergent
<i>Hydrilla verticillata</i>	Hydrocharitaceae	Sewar	Submerged
<i>Elodea Canadensis</i>	Hydrocharitaceae	waterweeds	Submerged
<i>Vallisneria Americana</i>	Hydrocharitaceae	Tap grass	Submerged
<i>Potamogeton crispus</i>	Potamogetonaceae	Curly leaf pond weed	Submerged
<i>Najas minor</i>	Hydrocharitaceae	Water nymph	Submerged
<i>Ceratophyllum demersum</i>	Ceratophyllaceae	Hornwort	Submerged
<i>Nelumbo nucifera</i>	Nelumbonaceae	Kamalgatta	Rooted floating
<i>Potamogeton nodosus</i>	Potamogetonaceae	Long leaf pondweed	Rooted floating
<i>Ludwigia adscendens</i>	Onagraceae	Water primerose	Rooted floating
<i>Eichhornia crassipes</i>	Pontideriaceae	Jalkumbhi	Free floating
<i>Lemna minor</i>	Araceae	Duck weed	Free floating
<i>Oenanthe javanica</i>	Apiaceae	Water drop wart	Shoreline species
<i>Vicia sativa</i>	Fabaceae	Ankari	Shoreline species
<i>Medicago polymorpha</i>	Fabaceae	Toothed medick	Shoreline species
<i>Commelina diffusa</i>	Commelinaceae	Kanshura	Shoreline species
<i>Rannunculus scleratus</i>	Rannunculaceae	Jaldhania	Shoreline species
<i>Veronica anagalis</i>	Plantiginaceae	Water speedwel	Shoreline species
<i>Gnaphlium uliginosum</i>	Asteraceae	Marsh cudweed	Shoreline species
<i>Xanthium strumium</i>	Asteraceae	Lapetua	Shoreline species

## RESULTS AND DISCUSSION

In present study twenty-eight species of macrophytes have been found in different sites of lake belonging to nineteen families (Table 1). Macrophytes were characterized by dominance of taxa belonging to the family Hydracharatacea (14.29%), Polygonaceae (10.72%), Potamogetonacea (7.15%), Cyperaceae (7.15%), Fabaceae (7.15%) and Asteraceae (7.15%) and so on. There were thirteen species found in pre monsoon season (Table 2) and fifteen species were found in post monsoon season (Table 3). During pre-monsoon season four emergent, four submerged, two rooted with floating leaves, one free floating and two shoreline species were found (Table 4). The emergent species were *Cyperus halpan*, *Eleocharis palustris*, *Cynodon dactylon* and *Persicaria minor* in which *Cynodon dactylon* was abundantly found. The submerged species were *Hydrilla verticillata*, *Elodea Canadensis*, *Vallisneria Americana* and *Potamogeton crispus* in which *Hydrilla verticillata* was abundantly found in all sites. The

rooted with floating leaves species are *Nelumbo nucifera* and *Potamogeton nodosus* in which *Nelumbo nucifera* was abundantly found in site-SI while *Potamogeton nodosus* was abundantly found in site-SVI. *Eichhornia crassipes* was commonly found in site-SX.

The shore line species are *Oenanthe javanica* and *Vicia sativa* in which *Oenanthe javanica* was richest species in sites-SIII and SX. Whereas in post monsoon season five emergent, two submerged, one rooted with floating leaf, one free floating and six shoreline species were found (Table 4). The emergent species were *Polygonum lapathifolium*, *Rumex dentatus*, *Ipomea aquatica*, *Maesillea quadrifolia* and *Alternanthera sessilis* in which *Polygonum lapathifolium* was abundantly found. Submerged species were *Najas minor* and *Ceratophyllum demersum* in which *Najas minor* was abundantly found in sites SII and SV. Rooted with free floating leaves *Ludwigia adscendens* and free-floating species *Lemna minor* in which *Ludwigia adscendens* was dominant in SIII. The shoreline species were *Xanthium strumium*, *Medicago polymorpha*, *Commelina diffusa*,

*Rannunculus scleratus*, *Veronica anagalis*, and *Gnaphalium uliginosum* were found in which *Commelina diffusa* and *Veronica anagalis* were richest species of sites-SIII and SVII while *Gnaphalium uliginosum* was rare species found in only site-SIII. *Ipomea aquatica* was dominant species in site-SI during monsoon season. In this study it was found that the post monsoon species have a significant richness value [15] in community as whole (Table 4) as a result of nutrients loading in sediments and eutrophication<sup>2</sup> process affected by active anthropogenic activities in lake. The submerged species *Hydrilla verticillata*, and *Potamogeton crispus* were practically dominant in all sites throughout the year [16]. They make a bed on the water surface of lake which prevent the movement of other aquatic organism as well as provide shelter to the zooplankton [15]. Similarly, the *C. dactylon* is an emergent species found throughout the year in all sites of lake [16]. Richness of *Eichhornia crassipes* indicates that the site SX is grossly polluted due to disposal of domestic wastes and active anthropogenic activities. Emergent species have a significant richness value

and free-floating species have least richness value in lake (Table 4). In post monsoon season the shoreline species grown abundantly. It was also observed that the species richness of emergent, submerged and free floating macrophytes reduced due to water level fluctuation [13]. Presence of certain bioindicator species such as *Eichhornia*, *Potamogeton*, *Marsilea*, *Lemna* and *Cyperus* species indicate that the sites where these species were predominance is grossly polluted [16]. The allelochemical release has been confirmed for some common submerged macrophytes such as *C. demersum*, *E. candensis* and *N. minor* [12]. These allelochemicals are chemically effect composition of macrophytes due to allelopathic interaction [24]. In this study a significant seasonal variation found in species composition of macrophytes and also found the selected lake is polluted probably due to dissolution of pollutants in rainy season as high anthropogenic activities are taking place in the area as well as the lake connected with river Ghaghara. The high richness of macrophytes confirmed the eutrophic status of lake.

Table 2 Macrophytes obtained in pre-monsoon (PRM) season

Scientific name	Family	Common name	Sites	Type of macrophytes
<i>Cyperus halpan</i>	Cyperaceae	Dwarf papyrus	SII, SIII, SV, SVII, SVIII	Emergent
<i>Elecharis palustris</i>	Cyperaceae	Marshpikerush	SVII, SVIII	
<i>Cynodon dactylon</i>	Poaceae	Doobghass	All sites	
<i>Persicaria minor</i>	Polygonaceae	Depresa	SII, SIII, SIV, SV, SVI	
<i>Hydrilla verticillata</i>	Hydrocharitaceae	Sewar	All sites	Submerged
<i>Elodea Canadensis</i>	Hydrocharitaceae	waterweeds	SI, SVI, SIX	
<i>Vallisneria Americana</i>	Hydrocharitaceae	Tap grass	SII, SIII, SVII	
<i>Potamogeton crispus</i>	Potamogetonaceae	Curly leaf pond weed	All sites	
<i>Nelumbo nucifera</i>	Nelumbonaceae	Kamalgatta	SI	Rooted floating
<i>Potamogeton nodosus</i>	Potamogetonaceae	Long leaf pondweed	SVI, SVIII	
<i>Eichhornia crassipes</i>	Pontideriaceae	Jalkumbhi	SX	Free floating
<i>Oenanthe javanica</i>	Apiaceae	Water drop wart	SIII, SX	Shoreline macrophytes
<i>Vicia sativa</i>	Fabaceae	Ankari	SII, SIII	

Table 3 Macrophytes obtained in post monsoon (POM) season

Scientific name	Family	Common name	Sites	Type of macrophytes
<i>Polygonum lapathifolium</i>	Polygonaceae	Curlytop knotweed	SII, SV, SVI, SVII	Emergent
<i>Rumex dentatus</i>	Polygonaceae	<i>Jungali Palak</i>	SII, SIII	
<i>Ipomea aquatica</i>	Convolvulaceae	Karemua	SI	
<i>Marsilea quadrifolia</i>	Marsileaceae	Susnari	SIV, SVIII	
<i>Alternanthera sessilis</i>	Amranthaceae	Girni	SII, SIII	
<i>Najas minor</i>	Hydrocharitaceae	Water nymph	SI, SVI, SIX, SX	Submerged
<i>Ceratophyllum demersum</i>	Ceratophyllaceae	Hornwort	SVI, SVIII	
<i>Ludwigia adscendens</i>	Onagraceae	Water primrose	SIII, SIV	Rooted floating
<i>Lemna minor</i>	Araceae	Duck weed	SII, SVIII	Free floating
<i>Xanthium strumarium</i>	Asteraceae	Lapetua	SI, SII, SIX	Shoreline macrophytes
<i>Medicago polymorpha</i>	Fabaceae	Toothed medick	SIV, SVIII	
<i>Commelina diffusa</i>	Commelinaceae	Kanshura	SII, SIII, SVI, SVII	
<i>Rannunculus scleratus</i>	Rannunculaceae	Jaldhania	SIII, SIV, SVII	
<i>Veronica anagalis</i>	Plantiginaceae	Water speedwel	SII, SIII, SIV, SVIII	
<i>Gnaphalium uliginosum</i>	Asteraceae	Marsh cudweed	SIII	

Table 4 Seasonal variability in species richness value

Type of macrophyte	Pre monsoon	Post monsoon	Average	SD
Emergent	4	5	5	±1
Submerged	4	2	3	±1
Rooted floating	2	1	2	±1
Free floating	1	1	1	±0
Shoreline	2	6	4	±2
Community as whole	13	15	15	±1

## CONCLUSION

In the present study it has been shown a great variation in species composition of macrophytes in the seasonal frame. The post monsoon macrophytes have comparatively high richness value in the lake than the pre monsoon macrophytes. In pre monsoon season emergent and submerged species indicate a relative growth having high richness value. Similarly in post monsoon season the shore line species have a significant richness value. Twenty-eight

macrophytes species were obtained during present study belonging nineteen families in which *Hydrocharitaceae* was dominant. *Cynodon dactylon*, *Hydrilla verticillata* and *Potamogeton crispus* were abundantly grown throughout the year in the selected lake. Presence of *Eichhornia* (water hyacinth), *Potamogeton*, *Marsilea*, *Lemna* and *Cyperus* species confirmed that the lake is grossly polluted and has high anthropogenic activities. It is evident from the study the lake status is eutrophic. So, regulation and prevention in anthropogenic activities are needed and the highest priority must be given to removal of macrophytes especially water hyacinth for sustainable management and conservation of lake.

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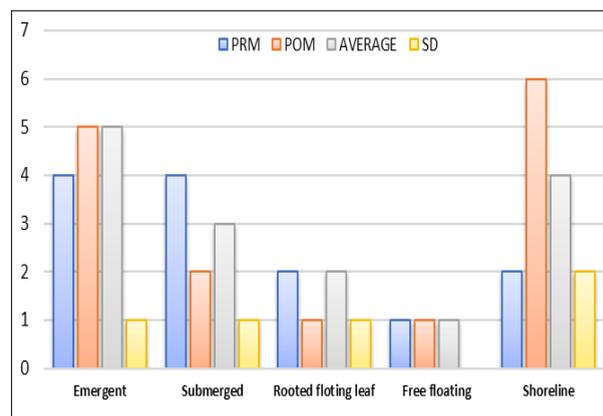


Fig 2 Seasonal variation in species composition of macrophytes

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