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Assessment of ecological changes from anthropogenic activities in a fresh water lake the *Taal ratoi*

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Abstract
The *Taal Ratoi*, a fresh water lake in Mau district of Uttar Paradesh situated on North-East (26°09'46.6"N-83°44'16.8"E) coast of India. Up to 1950s this water body was clean and major source of domestic and agricultural use. Now it has been the worst victim of anthropogenic pressure and got enormous ecological changes. In recent two three decades the ecological condition of the lake badly affected and getting enriched with plants nutrients and other pollutants of agricultural runoff and improper disposal of sewage. Due to this lake became more afflicted with macrophytes and the water quality has been deteriorated. Therefore to assess the impact of anthropogenic activities on the ecology this study was carried out from June to April 2019-2021. In the present study physico-chemical parameters and species diversity of macrophytes were analyzed from ten sampling stations of the four basins along the littoral and catchment area of lake. A significant ecological change has been observed due to huge anthropogenic pressure. The lake contains high concentration of Nitrate (5.83mg/L), Phosphate (3.26mg/L), Total Dissolve Carbon (12.50mg/L), Calcium (2.99mg/L), Magnesium (2.03mg/L), Sodium (2.56mg/L), Iron (1.10mg/L), Silicon (0.94mg/L), concentration of Hydrogen ion (8.97), Dissolve oxygen (14.12mg/L), Electric conductivity (212.23µs/cm), Total Dissolve Solids (95.40mg/L), and Salinity (221.95mg/L). In regards of species diversity total thirty three species belonging to twenty two families were recorded. It was found that, the lake became polluted and ecology has been changed due to ecologically unsound management practices. It was revealed that agricultural activities, sewage dredging, aqua culturing, unplanned deweeding, skimming of free floating macrophytes undertaken during past several years. The aquatic plants in the lake have reached at nuisance level and unknown invasive species such as *Azolla pinnata*, *Medicago polymorpha*, and *Pistia stratiotes* has got widely distributed. The catchment area total covered with a bed of *Hydrilla verticillata* and *Potamogeton crispus* [10]. This study was included all environmental aspects and socioeconomic which necessary for framing an ecologically well balanced conservation strategies for this lake.

Keywords: anthropogenic activities, fresh water lake, macrophytes, littoral zone, eutrophic, socio-economic

Introduction

The lake *Taal Ratoi* is a shallow fresh water lake connected with River Ghaghara and influenced by about twenty five thousand people inhabiting around it. Up to 1950s the water of this lake was very clean and was the only major source of fresh water of the area for agricultural and domestic use (Faizan; *et al*. 2021 [10]. Now itbecame polluted and ecology has been changed due to recent year urbanization, agricultural runoff and discharge of domestic sewage. Therefore, present study was carried out to assess the ecological changes which are under stress of anthropogenic activities.

In recent decades the ecology of lake generally influenced with human settlements, industries and agriculture (Doetterl; *et al*. 2012) [7]. Globally, 80% of untreated wastewater and million Tones of heavy metals, solvents, toxic sludge and other wastes dumped into water bodies by industries each year (WWAP; 2017) [31]. About 70% of waste such as agrochemicals, organic matter, drug residues, sediments and saline drainage discharge into water bodies from agriculture (FAO; 2017) [11]. Agriculture and urban activities are major source of Phosphorous and Nitrogen in the aquatic ecosystem (Carpenter; *et al*.1998) [4]. Nitrogen contents increases with increase in population, expanded land development and agriculture (Khan; *et al*. 2005) [18]. These Nitrogen contents support growth of phytoplankton and macrophytes species (Patil Shilpa; *et al*. 2012) [25] while phosphorous content and organic load in lake help to the growth of weeds (Patra; *et al*. 2010). Household detergent, domestic sewage, leaching of phosphate fertilizers increases the level of phosphate. Nitrate from agriculture is now the most common contaminant in the worlds (FAO; 2017) [11]. Discharge of domestic waste, aquaculture, urbanization, and use of recalcitrant materials deteriorated water quality of lakes and wetland (Villafane; *et al*. 2020) [30]. In last two decades the emerging pollutants such as animal feed, growth promoter, pesticides, antibiotic and hormones are badly affect the ecology of water bodies (Norman; 2016) [24]. Millions of tonnes of active pesticides, herbicides and fungicides ingredients are used in agriculture per year (FAO; 2016a) [12].Which can pollute water resources with carcinogens and other toxic substances that can affect biodiversity by killing weeds

and insects with negative impact up the food chain (Schreinemachers; *et al*. 2012) [29]. The feedlots are often constructed on shore of lake from which animals waste such as urine and dung released directly into lake. Due to this organic load increases along the risk of eutrophication and algae blooms. It consumes dissolve oxygen in water as it degrades, contributing strongly to hypoxia in lake. Due to more deposition of domestic sewages dissolve oxygen fluctuated in lake (Kumar; et.al. 2008) [19]. In lake or other water resources, salinization is the result of excessive ground water extraction for agriculture (Mateo-Sagasta; *et al.* 2010) [23] that alter the geochemical cycle of major elements such as Carbon, Sulphur, Phosphorous, Nitrogen, Iron and Silicon, (Herbert; *et al.* 2015) [15]. It affects the ecology of lake by causing changes within species, in community loss and migration. In general when salinity increases the biodiversity of microorganisms, algae, plants and animals decline (Lorenz; *et al*.2014) [21]. The anthropogenic activities in lake, greatly affect the species richness, spatial distribution and production of fishes (Scheuerell; *et al*. 2004) [28]. Nutrient loading increases the natural food for fishes but a certain level it will cause death of fishes due to hypoxia and toxicity. The shoreline development causes loss of littoral habitats for submerged macrophytes and littoral reed beds (Elias; *et al*. 2003) [9]. Aquaculture disrupts nutrient cycles, as a result degradation of water quality and ecological balance in lake (FAO; 2016b) [13]. Actually shallow lakes are dynamic system and change in environmental conditions may change the ecological balance (Capers; *et al*. 2003) [3]. The lake *Taal Ratoi* remain connected with river Ghaghara throughout the year which allow the free mixing of stagnant and flowing water, therefore exhibit physico-chemical and biological characteristic which support flora and fauna (Joshi; *et al*. 2012) [16]. The objective of the present study is to find out the consequences of anthropogenic activities on water quality and species diversity of macrophytes.

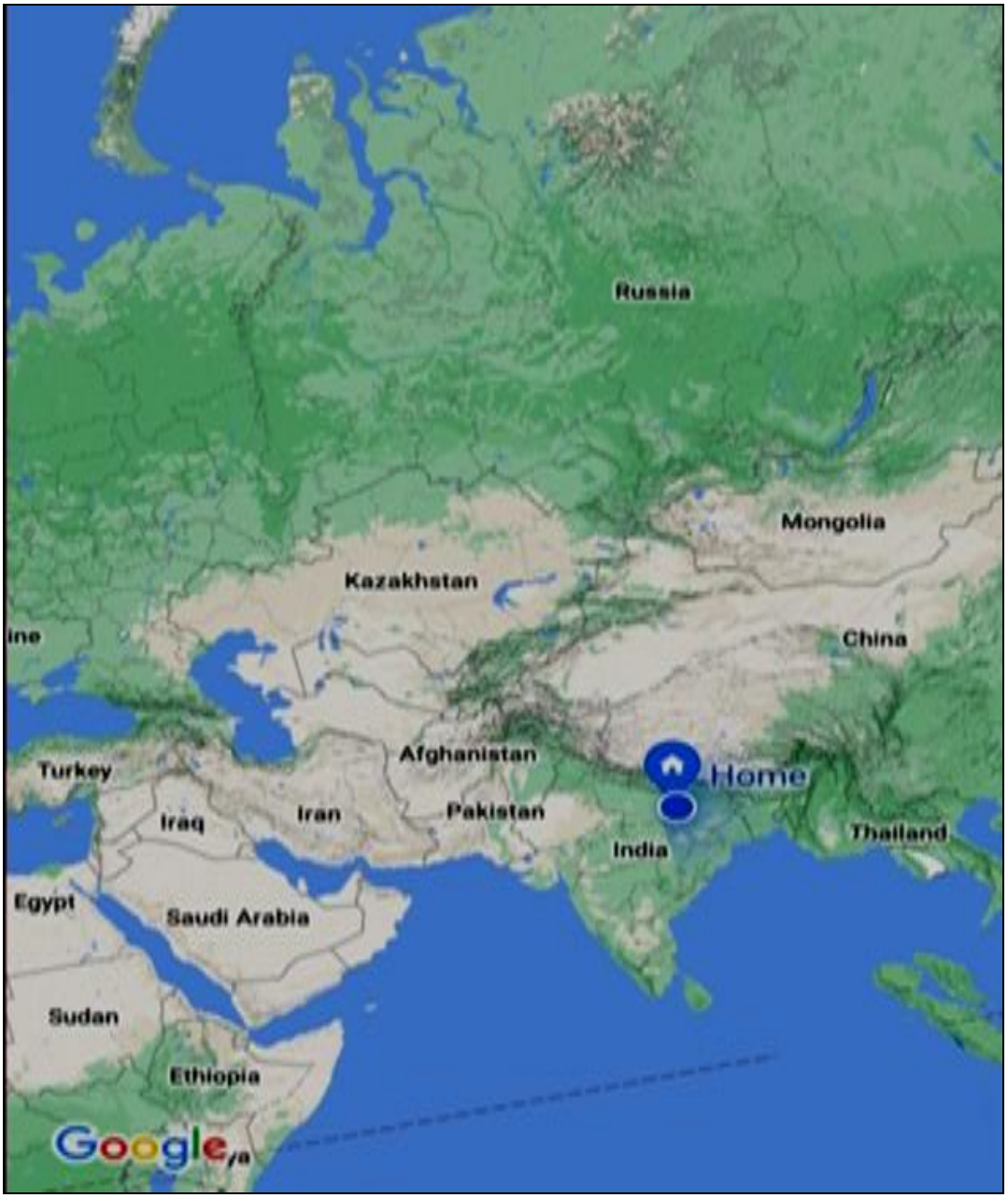

Fig 1(a): Location of *Taal Ratoi*

Fig 1(b): Specific sites of *Taal Ratoi*

Material and Methods

The *Taal Ratoi* is situated near Fatehpur mandaon, a village of Mau district in eastern Uttar Pradesh. It is located on the North-East (26°09'46.6"N-83°44'16.8"E) Coast of India and connected with River Ghaghara (Sarayu). For study a total of ten sites were selected with three sites in east basin, three in west basin, two in north and two in south basin. Sampling had been done from all sites in 2L polyethylene bottles during morning hours from 8:30 to 12:00 noon. The samples were analyzed in the laboratory within 48 hours for different physico-chemical parameters through standard methods. Concentration of hydrogen ions (pH) and Electric Conductivity (EC) were analyzed on site by Hanna digital meter (HI-98107 and HI-99300), Total dissolve solid (TDS) in laboratory by evaporation method at 180°c (APHA). Dissolve oxygen estimated by Winkler titration method, Nitrate and Phosphate measured Spectrophotometrically using Ascorbic acid and mixed reagent at 880 nm and Carbon analyzed by Carbon Analyzer, untreated sample used for total Carbon where as H_2O_2 treated sample used for Inorganic Carbon and the difference of both considered as Organic Carbon. Silicon analyzed by Shapiro solution 'A' (NaOH & Hcl) and metals are by Solution 'B' (HNO_3 & H_2SO_4). Macrophytes were collected from various sites of the four basins by rake and visual survey method. The aquatic macrophytes were collected by placing a sheet of white paper under the plants and left carefully from the water. After water drain off, plants dry between blotting paper in drying chamber. Semi-aquatic macrophytes uprooted carefully with their representative parts such as flowers and fruiting twigs or both. The collected macrophytes were sorted and identified up to genus or species level with the help of standard works (Joshi; *et al*. 2012, B.Gopal 1990, Cook; *et al*. 1996, Biswas; *et al*. 1937, Dutta; *et al*. 2002, Fasseit; *et al*. 1957, Madsen; *et al*. 2001) [16, 1, 5, 2, 8, 14, 22]. These were categorized into free floating, rooted floating, submerged, emergent and shoreline species (Table-2). For assessing the socio-economic status of the lake, the information was collected directly from the inhabitants. An overview (Fig-2), location and specific site are given in Fig.1- (a) and (b).

Fig 2: A overview of *Taal Ratoi*

Effect on Water Quality

The water quality of *Taal Ratoi* has been unassertive due to anthropogenic activities such as discharge of waste water, sewages and agricultural runoff. A remarkable change has taken place in the concentration of Nitrogen, Phosphorus and Carbon content of all the sites of lake. From the statistical analysis (Table-1) it was revealed thatthe water continues to be alkaline because there was no significant fluctuation in pH observed. The increasing trend of Nitrogen, Phosphorous and Carbon content was attributed to the untreated sewage and agricultural runoff received by lake. The Nitrate and Phosphate receive by the lake from household detergent, domestic sewage and fertilizers. The mean value of Nitrate 5.10mg/L fluctuated between 3.99 to 5.83mg/L during month of June to April. Maximum Nitrate 5.83mg/L obtained in month of January at Fatehpur site in southern basin while minimum value of Nitrate 3.99mg/L in month of October at Doobari site in North-West basin of lake. Phosphate obtained during June to April fluctuated between 2.59 to 3.26mg/L with mean value2.98mg/L. Maximum Phosphate 3.26mg/L was found in January at Fatehpur and Machariyahwa site in south-east basin while minimum Phosphate 2.59mg/L found in October was found between pH and Dissolve Oxygen, as same correlation was also observed in Anchar Lake, Kashmir (Salim; *et al*. 2013) [27]. Important observation of this study was that the Fatehpur, Machariyahwa, Maryadpur and Utrai sites in the South-East basin of lake was grossly polluted and insult with more anthropogenic activities because this basin direct interact to the inhabitant. The Calcium, Magnesium, Sodium, Iron and Silicon (Table-1) were also analyzed which favored well growth of macrophytes. the water continues to be alkaline because there was no significant fluctuation in pH observed. The increasing trend of Nitrogen, Phosphorous and Carbon content was attributed to the untreated sewage and agricultural runoff received by lake. The Nitrate and Phosphate receive by the lake from household detergent, domestic sewage and fertilizers. The mean value of Nitrate 5.10mg/L fluctuated between 3.99 to 5.83mg/L during month of June to April. Maximum Nitrate 5.83mg/L obtained in month of

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Table 1: Analysis of physico-chemical parameters of surface water of *Taal Ratoi* in mg/L

	pH	EC	TDS	DO	Salinity	NO_3^-	PO_4^{---}	TDC	Ca^{2+}	Mg^{2+}	Na^+	Fe	Si
June	8.89	212.23	94.15	12.05	221.95	5.61	3.11	7.63	2.10	1.89	2.56	0.21	0.17
Oct.	7.61	205.21	94.20	11.77	214.90	3.99	2.59	8.43	2.35	1.05	2.12	0.39	0.31
Jan.	8.23	196.75	95.40	14.12	204.40	5.83	3.26	12.50	2.99	1.43	2.34	1.10	0.94
April	8.97	95.40	94.30	13.28	209.70	4.97	2.96	9.64	2.24	2.03	2.51	0.68	0.41
Mean	8.43	203.58	94.51	12.81	212.74	5.10	2.98	9.55	2.42	1.60	2.38	0.60	0.46
SD	0.64	6.73	0.59	1.09	7.49	0.83	0.29	2.13	0.39	0.45	0.20	0.39	0.34
Max.	8.97	212.23	95.40	14.12	221.95	5.83	3.26	12.50	2.99	2.03	2.56	1.10	0.94
Min.	7.61	196.75	94.15	11.77	204.40	3.99	2.59	7.64	2.10	1.05	2.12	0.21	0.17

Fig 3 (a): Species diversity of *Taal Ratoi*

Fig 3 (b): Species diversity of *Taal Rato*

Effect on Species Diversity of Macrophyte

The anthropogenic activities leading to eutrophication causes nutrients loading in water and sediments which affects the composition, diversity and species succession of macrophytes along with change in trophic state (Divya; *et al*. 2019) [6]. The most distinctive attribute observed by this research was that, in the months of January and April before lock down of COVID-19 pandemic, the anthropogenic activities are active. At this time the community was dominated by the species were found abundantly such as *Eichhornia crassipes, Rumex dentatus, Azolla pinnata, Polygonum lapathifolium, Lemna minor, Cyperus halpan, Wolfiya spp., Potamogeton crispus, Pistia spp.* and *Typha spp* (Fig-3: a&b). These species are characteristic of water which is grossly polluted with organic matter. When the anthropogenic activities reduced during lockdown of COVID-19 pandemic water got self purified to a great extant and polluted water species was replaced by the species found abundantly in purified water such as *Hydrilla verticillata, Elodea Canadensis, Najas minor, Vallisnaria Americana, Alternanthra sessilis, Chara and Ceratophyllum demersum etc.* Due to anthropogenic pressure *Hydrilla verticillata,Potamogeton crispus,* and *Ceratophyllum demersum* got to form monospecific stands in the lake (Kundangar; *et al.* 1987). Total thirty three species belonging to twenty two families were recorded (Table-2). In which unknown invasive species such as *Azolla pinnata, Medicago polymorpha,* and *Pistia stratiotes* has got widely distributed in the East and North basin. It was observed that *Potamogeton crispus, Hydrilla verticillata* and *Elodea canadensis* grown richly in the catchment area (Faizan; *et al*. 2021) [10]. Undue growth of *Eichhornia crassipes* at Fatehpur site in south basin was evidence of active anthropogenic activities (Faizan; *et al.* 2021) [10]. It was found that the selected lake is polluted because the high anthropogenic activities such as fisheries and agricultural activities are taking place in the area. The dissolution of pollutants in rainy season was also taking place because the lake connected with river Ghaghara. This study would certainly be helpful for coming researchers to assess the macrophytes and aquatic health of water body to design a model for sustainable utilization of lake. It will also provoke the 2030 Agenda for Sustainable Development Goal (SDG) which

strongly support to future policies and strategies to control the anthropogenic activities in international and national priorities.

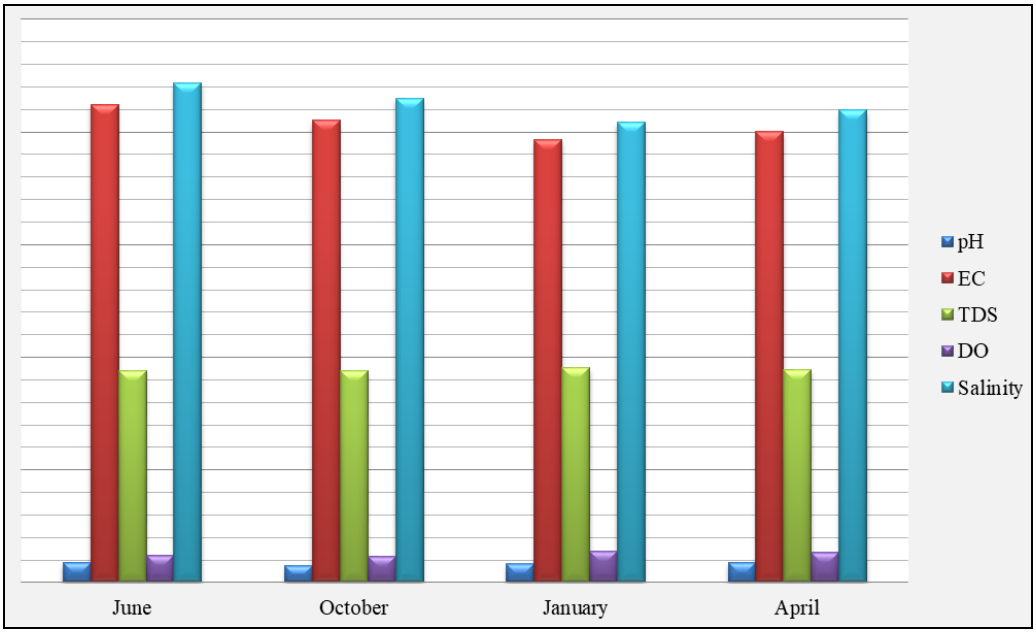

Fig 4 (a): Physical parameters of *Taal Ratoi*

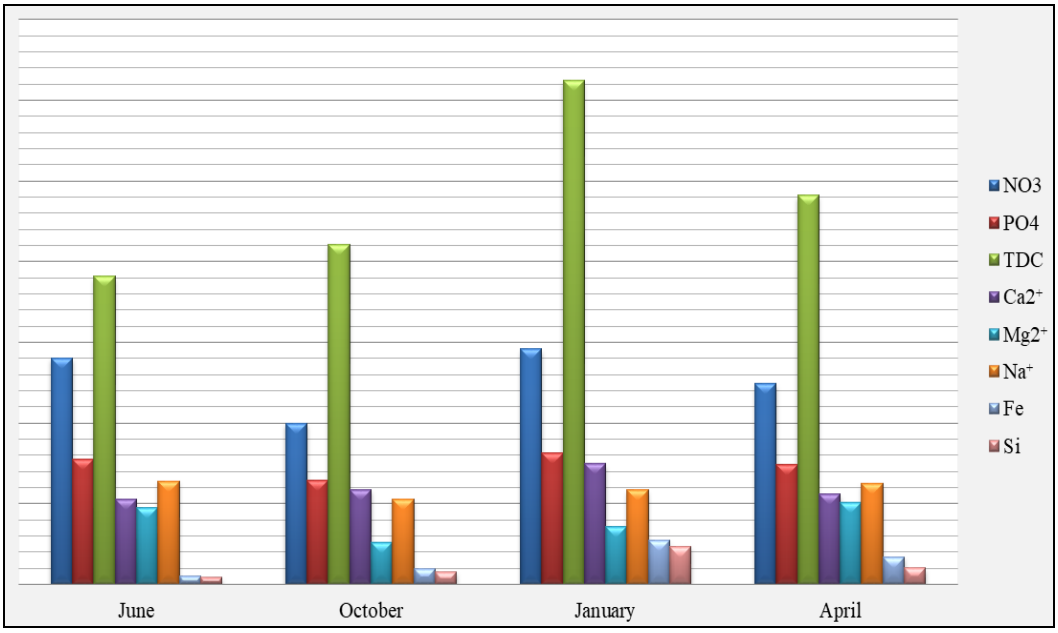

Fig 4 (b): Chemical parameters of *Taal Ratoi*

Table 2: Macrophytes species obtained from *Taal Ratoi*

SN	Scientific Name	TOM	SN	Sceintific Name	TOM
1	*Azolla pinnata*	Free floating	18	*Cyperus halpan*	Emergent
2	*Eichhornia crassipes*		19	*Elecharis palustris*	
3	*Lemna minor*		20	*Ipomea aquatica*	
4	*Pistia species*		21	*Marsilea quadrfolia*	
5	*Wolfiya species*		22	*Persicaria minor*	
6	*Ludwigia adscendens*	Rooted floating leaf	23	*Polygonum lapathifolium*	
7	*Nelumbo nucifera*		24	*Rumex dentatus*	
8	*Potamogeton nodosus*		25	*Typha species*	
9	*Ceratophyllum demersum*	Submerged	26	*Commelina diffusa*	
10	*Chara species*		27	*Gnaphlium uliginosum*	Shoreline
11	*Elodea Canadensis*		28	*Medicago polymorpha*	
12	*Hydrilla verticillata*		29	*Oenanthe javanica*	

13	*Najas minor*		30	*Rannuculus scleratus*	species
14	*Potamogeton crispus*		31	*Veronica anagalis*	
15	*Vallisnaria americana*		32	*Vicia sativa*	
16	*Alternanthra sessilis*	Emergent	33	*Commelina diffusa*	
17	*Cynodon dactylon*				

Conclusion

In the present study a remarkable change found in the ecology of lake. The most striking observation was that the South-East basin of lake is grossly polluted due to active anthropogenic activities. The lake being alkaline throughout the year because the high pH of the water due to the presence of total carbon in the form of carbonates and bicarbonates while nitrate was due to fertilizers used in agriculture. Due to the high population density, connection with river Ghaghara and intake of sewages from domestic wastage, the high organic pollution loading has been found. Total thirty three macrophytes species were obtained during the investigation belonging twenty two families in which *Hydrocharitaceae* was dominant (Table-2). The aquatic plants in the lake have reached at nuisance level and unknown invasive species such as *Azolla pinnata*, *Medicago polymorpha*, and *Pistia stratiotes* (Fig-4b) has got widely distributed. The catchment area total covered with a bed of *Hydrilla verticillata* and *Potamogeton crispus* (Faizan; *et al*. 2021) [10]. Presence of *Eichhornia species* confirmed that the lake is polluted and has high anthropogenic activities. This lake has a great socio-economic status for farmer and poor uneducated people as an income of source. So there is a need to formulate proper ecologically benignant plan for the lake to embrace all the environmental components of the lake ecosystems and thus help to conserve the lake in a real ecological sense.

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Conflict of Interest

Authors did not have any conflict of interest.

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