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ORIGINAL ARTICLE

Summer Cumulative Effects Turns Coveted Tropical Rural Lake With Nominal Provision For Water Bird Populations

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ABSTRACT
The most attractive vertebrates, avifaunal components includes less water dependent and highly water dependent groups.The water depended birds are fronting many seasonal possessions. Especially, because of alternative home for most of the migratory and local migratory birds modifications of characters in tropical freshwater ponds are measured as most valuable ecological process to study. Due to highly varied seasonal physicochemical parameters, the tropical lakes are considered as sensitive ecosystem. Which results in undesirable alterations in biological quality of the lake, especially summer effects are most distinguished. Eventually the water bird communities are very much impaired due to the summer effects. In view of conservation, researchers of India and other Asian countries were expressly toiled on the status of endangered and other critical population of water birds. Regarding the fact of seasonal impacts on birds merely limited studies were conducted. Therefore,the present study indented to find the cumulative summer effects on the water bird communities of Vellode Lake located at between 11⁰8′04.04″ N and 77⁰37′52.42” E. Ornithological studies tinted the presence of 38 species of water birds. Exclusively presence of vulnerable Pelecanus crispus, near threatened Mycteria leucocephala, Threskironis melanocephalus and Anhinga melanogaster were noteworthy recordings of the bird survey. Limnological studies uttered that the fluctuations of water level and nutrient release alters the chemical quality of the lake water especially dissolved oxygen, pH and total Kjeldhal nitrogen and sequential modifications among biological oxygen demand and chlorophyll-a. Present study enlighten the superfluous difficulties of the lake ecosystem and refurbishing strategies.
Key words: *Vellode Lake – 38 water birds – water level fluctuations – Nutrient release.*

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INTRODUCTION

Birds are both visually and acoustically conspicuous components of ecosystem. Over long period of the time, they are the best studied class of organisms and exhibit the most diverse range of ecological functions among vertebrates [1, 2, 3, 4, 5, 6]. As member of ecosystems, birds play many important rolessuch as seed dispersers, scavengers, nutrient depositors, insectivores, pollinators, raptors and ecosystem engineers [7, 8, 9]. Birds have been considered useful biological indicator because they are ecologically versatile and live in all kinds of habitats as herbivores, carnivores and omnivores [10]. Biological monitoring by using birds has two main advantages over non biological monitoring of an ecosystem. Because, it is possible to detects unpredictable environmental changes and their cumulative effect on biological organisms [11, 12].

Birds benefit humans by providing important ecosystem services such as, provisioning services via game, meat for food, down for garments and guano for fertilizers, regulating services by scavenging carcasses and waste, by controlling populations of weeds and pests, by pollinating and dispersing the seeds of plants, cultural services, as exemplified by the prominent roles of birds in art and religion and by spent lot of money on bird watching and supporting services by cycling of nutrients and by controlling to soil formation [6, 13, 14, 15, 16].

Researchers suggested additional research regarding role of birds in pollination, pest control and most importantly in nutrient cycling of aquatic ecosystems will make the importance of avian population in light among the world [17, 18, 19, 20].The role of birds on hydrology has rarely been studied in freshwater ecosystems. Some interesting studies on the effects of bird aggregation on the physiochemical conditions of lake water and vice versa have been published [21, 22, 23, 24, 25].A dominant trend of bird count exercises undertaken in India has been focus on endangered birds, wetland birds, heronries and

bird found be conservational significant [26]. However, only a less attention is given to seasonal impacts over specific bird communities. The present investigation exclusively focus on the summer effects of tropical rural lakes are water bird communities.

Vellode lake of Erode district, South India was the study area, which is situated 12 km away from Erode and lies between11^{0}8′04.04″ N and 77^{0}37′52.42" E with the elevation of 764 ft. In the total area of 75.935 ha, only 35 ha has water throughout the year i.e., the eastern region of the lake. Remaining area has moist deciduous forest with *Acacia nilotica indica* trees as main vegetation inter-spread with other trees like *Palmyra*, *Prosobis julifora* and *Euclyptus* etc. The water level of the lake is very high during rainy and winter seasons and it will set decreased in early summer until the late summer up to 50 % of water.

Vellode Lake provides space for wide range of avifaunal diversity. The bird communities of the sanctuary depend on the lake water for their current activities like feeding, nesting, resting and excreting. The present study envisioned to elucidate the role of limnological characteristics of the lake on water bird populations through incorporating the results of ornithological studies and limnological studies. Because of various unpredictable alterations in the lake water quality during summer, the lake managers got stressed and they projects depletion of dissolved oxygen as a major factor. However, the prime motive of the present study is to explores and identify the potential factors responsible for cumulative summer effects and actual process in the lake ecosystem.

MATERIALS AND METHODS

Bird Survey

Materials used for of bird counting: For conducting the present bird survey binocular with magnification 8x50 was used.Note book, pencil and sound recorder were also used.

Methods of bird counting: To reduce the difficulties birds can be counted by wide range of methods. In the present study 'Bird counting methods' by Bibby *et al*.,(27) were employed. The methods followed for the bird counting were point counting, direct counting method, look down method, line transects method, nest searching method, interview with locals, sky watching method and canopy watching method.

Bird watching time: The morning and evening time were been ideal time to record maximum of the bird populations, while day time recording was applied to only few species.

Bird identification: Birds were identified by the help of standard field guides of Ali [28] and Ali and Dillon Ripley, [29]. Few species were identified with help of internet sources.

Categorization of birds: The birds of the lake were classified into three categories including migratory (M), local migratory (LM) and resident (R) birds.

Migratory birds: The birds from other continents were considered as the migratory birds for the lake. Especially the birds from Siberia, Australia, Austria, Newzland and England, etc were visited to the lake.

Local migratory birds: Birds visited from Asian countries were considered as local migratory birds to the lake. The Vellode lake has been visited by local migratory birds from Iran, Iraq, Andaman-Nicobar Islands, Sri Lanka, Philippines and Malaysia. In addition birds from Northern states including Himachal Pradesh and West Bengal, etc are also categorized under local migratory birds.

Resident birds: The birds of South Indian states like Andra Pradesh, Telugana, Karnataka and Kerala were mostly reside within lake. Therefore, they categorized as resident birds. The resident birds may be permanent or temporary. The temporary resident birds may have alternative home within the southern states of India.

Measurement of biodiversity: Biological communities vary in the number of species they contain and knowledge of this number is important in understanding the structure of the community. The number of species in a community is referred to as species richness.

Water Quality Monitoring

Collection of water samples: During the study period from 2011 to 2015, every month water samples were collected at the depth of about one foot from four sampling points of the lake. After the collection containers were properly labeled by permanent marker with information including name of the site, time, date, month and year of the sample.For the analysis of dissolved oxygen (DO) and biological oxygen demand (BOD) water samples were collected separately without air bubbles in well sterilized bottles.

Physicochemical and biological analysis of water samples: All the parameters were analyzed as per the procedure of American Public Health Association [30, 31].

Calculation of water quality index: Based on the results of analysis water quality indices were calculated. For the calculation water quality index Consumer support group online calculators software was used.

RESULTS

Diversity of water birds: The Vellode lake supports wide range of avifaunal diversity. Media reports revealed that the lake ecosystem supports wide range of avifaunal communities. It includes water birds, parrots, hens, etc. The present study exclusively focus on water birds alone. In the bird survey nine migratory, twelve local migratory (table 1) and seventeen residential water birds (table 2) were recorded andidentified as 11 pelecaniiformes, 2 charadiiformes, 6 ciconiiformes, 1 passeriformes, 8 anseriformes, 1 podichiformes, 5 gruiformes and 4 corachiiformes (Fig. 1). Among the water bird communities one vulnerable (*Pelecanus crispus*), three near threatened (*Mycteria leucocephala*. *Threskironis melanochephalus* and *Anhinga melanogaster*) and 34 least concern species were identified with the reference of IUCN (2013).

Usually the lake supports wide range of migratory birds during winter season. However, based on water quality, availability of food and temperature extend their population in the lake. During summer months of 2013, the diversity of water bird population was highly reduced and annual the bird population also. Species richness of the water bird populations were presented in fig. 2.

Water Quality Monitoring: During the study period of five years, water quality of the lake was estimated (table 3). Depletion of water quality was recorded during 2012 and 2013. In particular, dissolved oxygen, total dissolved solids, turbidity and chlorophyll-a were not within the permissible level of WHO (2005) (33). Water quality index clearly elucidate poor status of the lake during summer.

In table 4, correlation between physicochemical parameters of Vellode Lake water and diversity of water bird communities were presented.

Table 1: Taxonomic details of recorded migratory and local migratory avifaunal diversity of Vellode Lake

S. N.	Scientific name & Species authority	Common name	Vernacular name	IUCN category	Family	Order
MIGRATORY						
1	*Pelecanus crispus* (Bruch, 1832)	Dalmatian pelican	Vellai kada	**VL**	Pelecanidae	Pelecaniformes
2	*Phalacrocorax carbo* (Lin., 1758)	Great cormorant	Periya neer narai	**LC**	Phalacrocoracidae	Charadiiformes
3	*Mycteria leucocephala* (Pennant, 1769)	Painted stork	Manjal mokku narai	**NT**	Ciconiidae	Ciconiiformes
4	*Anastomus oscitans* (Boddaert, 1783)	Asian open bill stork	Nathai kuthi narai	**LC**	Ciconiidae	Ciconiiformes
5	*Ciconia ciconia* (Lin., 1758)	European white stork	Vennarai	**LC**	Ciconiidae	Ciconiiformes
6	*Threskiornis melanocephalus* (Latham, 1790)	Oriental white ibis	Kalakkathiya mookan	**NT**	Threskiornithidae	Passeriformes
7	*Pelecanus onocrotalus* (Lin., 1758)	Great white pelican	Periya vellai kada	**LC**	Pelecanidae	Pelecaniformes
8	*Anas Penelope* (Lin., 1758)	Eurasian wigeon	Namma thalai vatthu	**LC**	Anatinae	Pelecaniformes
9	*Tringa nebularia* (Lin., 1758)	Common green shank	Pachai kaali	**LC**	Scopacidae	Pelecaniformes
LOCAL MIGRATORY						
1	*Casmerodius albus* (Sibely, 1990)	Large egret	Periya kokku	**LC**	Ciconiidae	Ciconiiformes
2	*Ardeola grayii* (Sykes, 1832)	Indian pond heron	Kurutu kokku	**LC**	Ardeidae	Pelecaniformes
3	*Bubulcus ibis*(Lin., 1758)	Cattle egret	Unni kokku	**LC**	Ardeidae	Pelecaniformes
4	*Mesophoyx intermedia* (Wagler, 1827)	Median egret	Vellai kokku	**LC**	Ardeidae	Pelecaniformes
5	*Egretta garzetta* (Lin., 1758)	Little egret	Chinna kokku	**LC**	Ciconiidae	Ciconiiformes
6	*Nettapus coromandelianus* (Gmelin, 1789)	Cotton teal	Kulla thara	**LC**	Anatidae	Anseriformes
7	*Alcedo atthis* (Lin., 1758)	Small blue king fisher	Siraal meenkothi	**LC**	Alcedinidae	Coraciiformes
8	*Anas crecca*(Lin., 1758)	Common teal	Kiluvai	**LC**	Anatinae	Anseriformes
9	*Anas ferina* (Lin., 1758)	Common pochard	Oosival vathu	**LC**	Anatinae	Anseriformes
10	*Anas acuta* (Lin., 1758)	Northern pintail	Vadakkathiya oosival vathu	**LC**	Anatinae	Anseriformes
11	*Anas clypeata* (Lin., 1758)	Northern shoveler	Andivatthu	**LC**	Anatinae	Anseriformes
12	*Anas gibberifrons* (Lin., 1758)	Sunda teal	Varri kiluvai	**LC**	Anatinae	Anseriformes

Table 2: Taxonomic details of recorded residential avifaunal diversity of Vellode Lake

S. N.	Scientific name & Species authority	Common name	Vernacular name	IUCN category	Family	Order
1	*Tachybaptus ruficollis* (Pallas, 1764)	Little grebe	Mukkulippan	**LC**	Podicipididae	Podiciformes
2	*Microcarbo niger* (Vieillot, 1817)	Little cormorant	Chinna neer kagam	**LC**	Phalacrocoracidae	Pelecaniformes
3	*Anhinga melanogaster* (Lin., 1766)	Darter or Snake bird	Pambu thara	**NT**	Anhingidae	Anseriformes
4	*Aredea cinerea* (Lin., 1758)	Gray heron	Sambal narai	**LC**	Ardeidae	Pelecaniformes
5	*Ardea purpurea* (Lin., 1766)	Purple heron	Sen narai	**LC**	Ardeidae	Pelecaniformes
6	*Butorides striatus* (Lin., 1758)	Little green heron	Chinna Pacchi narai	**LC**	Ciconiidae	Ciconiiformes
7	*Nycticorax nycticorax* (Lin., 1758)	Black crowned night heron	Erakokku	**LC**	Ardeidae	Pelecaniformes
8	*Anas poecilorhyncha* (Foster, 1781)	Spot billed duck	Pullivaittru vatthu	**LC**	Anatidae	Anseriformes
9	*Amournis phoenicurus* (Pennant, 1769)	White breasted water hen	Kambul kozhi	**LC**	Rallidae	Gruiformes
10	*Gallicrex cinerea* (Gmelin, 1789)	Water cock	Thanner kozhi	**LC**	Rallidae	Gruiformes
11	*Gallinula chloropus* (Lin., 1758)	Common moorhen	Thaazhai kozhi	**LC**	Rallidae	Gruiformes
12	*Porphyrio porphyrio* (Lin., 1758)	Purple moorhen	Neela thaazhi kozhi	**LC**	Rallidae	Gruiformes
13	*Fulica atra* (Lin., 1758)	Common coot	Naamak kozhi	**LC**	Rallidae	Gruiformes
14	*Sterna aurantia* (Gray J.E., 1831)	River tern	Aatru aala	**LC**	Sternidae	Charadriiformes
15	*Ceryle rudis* (Lin., 1758)	Lesser pied king fisher	Karuppu vellai meenkothi	**LC**	Cerylidae	Coraciiformes
16	*Halcyon capensis* (Lin., 1766)	Stork billed kingfisher	Periya alagu meenkothi	**LC**	Halcyonidae	Coraciiformes
17	*Halcyon smyrnensis* (Lin., 1758)	Whitebreasted kingfisher	Venthondai meenkothi	**LC**	Halcyonidae	Coraciiformes

Table 3: Water quality of Vellode Lake during the period from 2011 to 2015 (All are mean values)

S.N.	Parameter	Unit	2011		2012		2013		2014		2015	
			Summer	Annual	Summer	Annual	Summer	Annual	Summer	Annual	Summer	Annual
1	**Atmp. Temperature**	^{0}C	33.6	26.8	33.5	27	35.5	26.5	34.2	27.4	36.5	27.7
2	**Water Temperature**	^{0}C	29.5	23.5	29.8	23.3	30.2	24.5	29.2	24.2	30.1	25
3	**pH**	-	7.92	7.4	8.23	7.5	8.4	7.8	7.9	7.48	8.19	7.62
4	**Turbidity**	NTU	3.5	3.1	6.2	5.6	10.7	6.9	8.7	6.7	7.6	6.9
5	**Total Dissolved Solids**	mg/l	318	290	325	305	418	385	393	374	402	380
6	**Dissolved Oxygen**	mg/l	4.3	5.2	4.3	5.3	4.1	4.9	4.7	5.5	4.5	5.3
7	**BOD**	mg/l	23	19	29	19	38	26	34	24	29	26
8	**Total Kjeldhal Nitrogen**	mg/l	5.3	4.8	5.6	4.8	5.9	5.2	4.9	4.6	5.6	5.2
9	**Chlorophyll – a**	µg/l	18.6	8.5	19.5	9.1	29.5	11.7	21.8	11.3	19.9	9.3
10	**Water Quality Index**	-	43	46	40	46	42	45	46	56	44	53

Note: *Summer values are Mean of March, April, May and June; Annual values are mean of fromJanuary to December*

Table 4: Correlation between physicochemical parameters of Vellode Lake water and diversity of water bird communities

S.N.		1	2	3	4	5	6	7	8	9	10
Parameter		**Atmp. Temp.**	**Water Temp.**	**pH**	**Turbidity**	**TDS**	**DO**	**BOD**	**TKN**	**Chl – a**	**WQI**
Pelecani.	**Sum.**	-0.36	-0.86	-0.77	-0.1	-0.09	-0.92	-0.07	-0.93	-0.46	-0.33
	Anl.	-0.81	-0.79	-0.33	-0.82	-0.77	-0.4	-0.78	-0.28	-0.36	-0.78
Charadrii.	**Sum.**	-0.98	-0.64	-0.46	-0.56	-0.76	-0.14	-0.34	-0.39	-0.25	-0.59
	Anl.	-0.69	-0.92	-0.47	-0.83	-0.88	-0.21	-0.88	-0.43	-0.42	-0.72
Ciconii.	**Sum.**	-0.76	-0.22	-0.22	-0.84	-0.93	-0.45	-0.69	0.02	-0.44	-0.2
	Anl.	0.75	0.35	-0.33	0.32	0.41	0.8	0.32	-0.46	0.26	0.97
Passeri.	**Sum.**	-0.23	0.41	0.29	-0.66	-0.66	-0.69	-0.61	0.56	-0.29	0.12
	Anl.	0.81	-0.12	-0.57	0.02	-0.22	0.83	-0.28	-0.35	-0.54	0.52
Anseri.	**Sum.**	-0.65	-0.18	-0.27	-0.94	-0.95	-0.33	-0.86	0	-0.62	-0.02
	Anl.	-0.42	-0.67	-0.56	-0.98	-0.88	-0.18	-0.79	-0.19	-0.75	-0.69
Podichi.	**Sum.**	-0.75	-0.22	-0.18	-0.68	-0.81	-0.55	-0.53	0.04	-0.21	-0.21
	Anl.	0.56	-0.06	-0.71	-0.19	-0.06	0.83	-0.13	-0.73	-0.07	0.75
Grui.	**Sum.**	-0.33	-0.29	-0.25	-0.52	-0.5	0.48	-0.44	-0.31	-0.77	-0.37
	Anl.	0.42	0.52	0.52	0.96	0.73	0.19	0.63	0.2	0.59	0.47
Corachi.	**Sum.**	-0.07	-0.37	-0.59	-0.63	-0.41	0.65	-0.75	-0.49	-0.94	0.29
	Anl.	0.14	-0.53	-0.58	-0.64	-0.8	0.2	-0.73	-0.11	-0.98	-0.31

Fig. 1: Recorded diversity of water bird communities in Vellode Lake

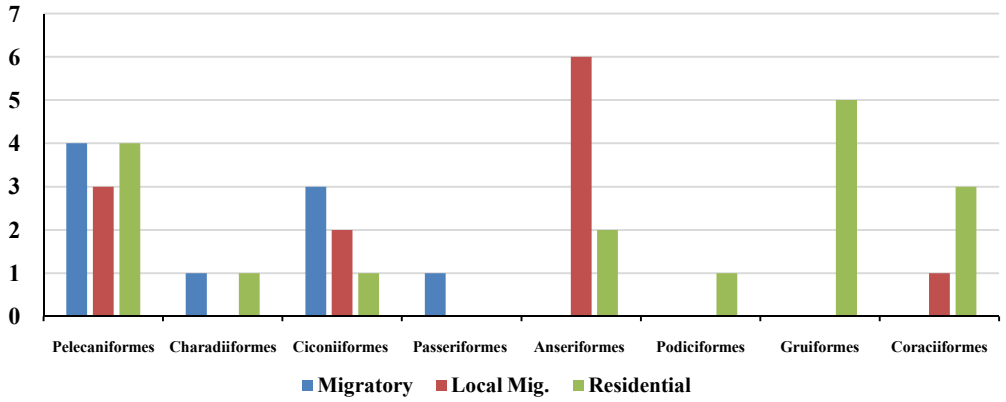
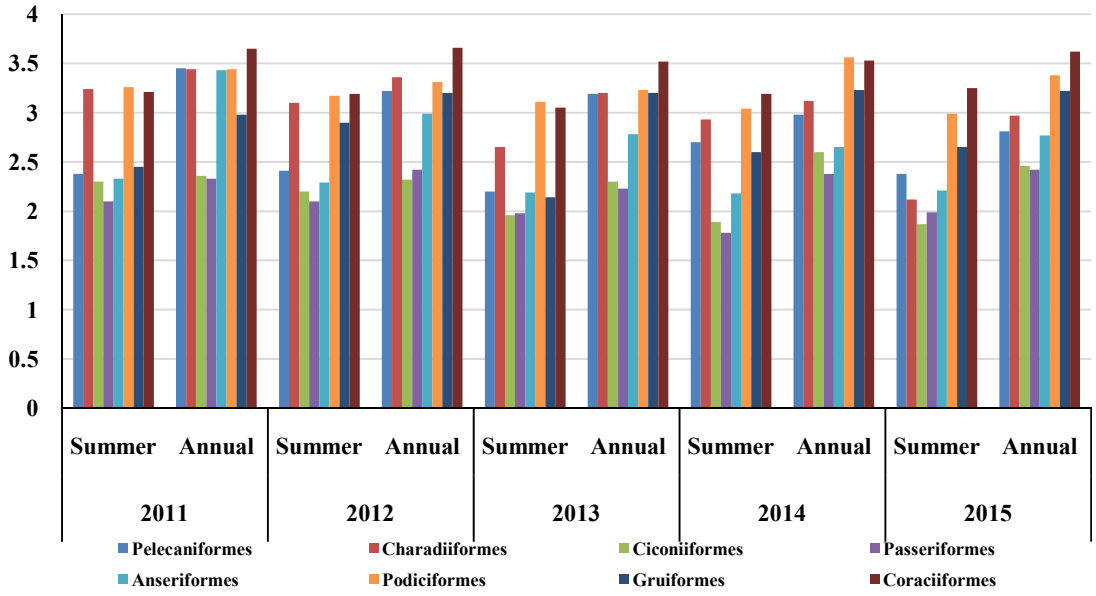


Fig. 2: Recorded Species richness of water bird communities in Vellode Lake



DISCUSSION

Limnological Studies

Every biotic components affected by the physico-chemical characteristics of an ecosystem. Water bird communities of Vellode Lake is not exceptional. Present study clearly explains the impact of depleted summer water quality pressures the water bird communities.

Due to typical tropical geological position ($11^0 8' 04.04''$ N and $77^0 37' 52.42''$ E) high atmospheric temperature was recorded in the lake area. In addition with atmospheric temperature, high turbidity was also responsible for the higher water temperature, because suspended particles absorb heat from sunlight making the water warm [34]. Influence of season and the absence of shadow also played a major role in deciding the water temperature.

pH of the lake water remained in basic range during summer monthsand this may be due to high algal growth and decomposition of dead biota. Due to increased surface algal growth, presumably under water photosynthesis activity got reduced and resulted in the increase of CO_2 and carbonates assimilation. The observation regarding summer maximum pH was supported by Kelly and Linda and Sawane *et al.,* [35, 36].

Increased temperature, high amount of algal growth increased rate of organic decomposition and increased coliforms bacterial populations were collectively responsible for depletion of DO level.Reduced water volume and increased water temperature were collectively reduced the dissolving rate of atmospheric oxygen in the lake water (37,38). Depletion of DO of the lake water during summer may also be due to 'red drop', the process in which the photosynthesis is inhibited at higher temperature resulting in a negligible release of oxygen. The red drop phenomenon was also reported by Satpathy *et al.,* [39].During winter, more than 20,000 birds were resides in the lake and which may results on deposition

of the high amount of organic matter. Reduced water volume and high wind actions during the post summer season favor the high rate of microbial activity in the lake bottom [40]. This process may also be the responsible for the depletion of the DO levels in the lake water during post summer season. The fact was supported by increased biological oxygen demand and enhanced population of the coliforms.

In most part of the study period, due to reduced inflow and outflow, turbidity of the lake water was measured above 7 NTU. Because of increased algal concentration and high bio-turbation activities it was measured more than 10 NTU during summer. This particular aspect of the lake water turbidity was supported by the study of Mehrotra [41] and Parashar *et al.,* [42].Concentration effect and increased algal population were the major factors responsible for the increase of the lake water TDS during summer [43]. High populations of algae, total and fecal coliforms, reduction of the water volume and less rainfall were collectively may act as the major factors for the summer higher BOD concentrations Devaraju *et al.,* [44]. The high BOD concentrations indicate less availability of dissolved oxygen to aquatic organism. Sources for TKN of the lake water were the dead and decomposed plant materials [45] and addition of bird droppings [46].

During the study period, summer algal blooms were sequentially followed by spring blooming. At some times, spring blooming is highly dense than summer blooming. Similar observations were recorded by Kelly and Linda [35].

The water quality index of the lake was highly influenced by the high water temperature, reduction in water volume, addition of high volume of bird droppings, availability of nutrients, increased populations of algae and coliform bacteria and high bio-turbation activities.

The sediment of the lakes may be in direct contact with the photic zone during the summer season that together with a higher sediment surface per volume of water as water depth decreases which increased the importance of sediment-water interactions [47]. Therefore, exchange of P between water and sediment was influenced by biological (bacterial activity, mineralization process, and bioturbation), chemical (Redox conditions, pH, nitrate availability) and physical (Resuspension, sediment mixing) factors [48]. Bio-turbation from benthic invertebrates, fishes and birds or though gas bubbles produced in deeper sediment layers during the microbial decomposition of process matter could also significantly enhanced the process [49].

Addition of bird droppings and dead aquatic biota were the major factors for the enrichment of nutrients like nitrogen and potassium of the lake sediment [50]. During summer, these factors in their abundance level exchange their fractions with water column of the lake. Thus, the availability of these primary nutrients enhanced the algae bloom [51].

Micronutrients such as chlorides, sulphates, calcium, magnesium and sodium of lake sediment were share their contributions with the lake water due to reduced water volume during summer [52, 53]. Thus, the lake sediment plays quite a silent role when the water volume is high, where as it controls the lakes process as its own, when the water volume reduces. High degree of contact with atmosphere and bio-turbid actions were ultimately led to the high rate of microbial activities and release of nutrients.

During the study period, the lake received only less than 20 cm of average annual rainfall. Due to less record of North-East monsoon, the release of LBP canal water from Lower Bhavani dam was also mostly delayed to late September, where it usually opened in mid- August. In addition, absence of separate sluice delays the lake to retain the water level.High fluctuations in the water level affected the physicochemical and biological characteristics of the lake water. In particular, release of nutrients from sediment to water column, reduced rate of photosynthesis, changes in the composition of planktons and other aquatic biota and high level of human interventions to the core area where the birds prefer to nesting were highly notable observations.The present investigation also found that fall of water level to the very less quantity caused the high degree of problems for the lake to attain its high level. The problems included increased permanent plant coverage on the way of seepage water, formation of new land masses, blockings in outlets and damages to the boundaries.

Ornithological Studies:

The monthly bird survey during the period from 2011 to 2015revealed that the population of resident birds were steadily increased from late monsoon and attains maximum during mid-winter season. In most part of summer months the populations of resident, local migratory and migratory birds were very much reduced due to low water level and less availability of food sources. The correlation between physicochemical quality and water bird population expounded that every parameters have their own kind of relationship with different orders of water birds. Ultimately, itis proved that common management strategy with single factor concept like depletion of dissolved oxygen are not precisely fitted to the lake ecosystem.

Observations:

Even though most of the migratory and local migratory birds are winter visitors, they may extend their period in the lake depended on availability of food and water quality. During the period of five years of the study, for these birds no amount of support was provided by the lake ecosystem. Actual physicochemical conditions of the lake is intimidating to the populations of the water birds. Conversely, except water birds remaining communities were not much accepted due to availability of alternative feeding sites.

Suggestions:

In view of promoting the growth of native and ecologically valuable *Acacia nilotica indica* in the lake, the invasive *Prosofis julifora* could be removed from the lake. Development and maintenance of the fruit trees at lake shore area and quality of nearby water bodies as the alternative feeding sites are considered as diversion to birds from spending lot time in the water body. In addition, by the increased area of shadow over the water body may keep the lake water temperature cool during summer.Proper maintenance of inlets and outlets would encourage the water flow and can reduce the retention time of water in the lake. Encroachment of the lake area by the nearby farming community and construction of leisure houses around the lake disturb natural bird movement and such activities should be curbed.

Periodic removal of ever growing aquatic weeds like *Eichhornia* and*Azolla* through manual operations would help to maintain the aesthetic value of the lake ecosystem. Adoption of the bio-manipulation of the aquatic organisms like fishes, shrimps and other suitable organisms could improve the process of the ecosystem. Proactive public education and association of scientists and researchers with broader training are needed for maintenance of the aquatic ecosystem.

CONCLUSION

Population of water bird communities of the lake ecosystem are considerably scratched by the cumulative summer effects. The cumulative effects are enhanced by fluctuations of water level and abundance of bottom sediment. Consequently the alteration in the physicochemical features of lake water leads to less availability of the food in the lake area for water birds. High level of turbidity made that the lake water as an unfit to even swimming of the birds. Expounded observations and suggestions of the study should help the lake managers and policy makers to retain the naturalistic features of the lake.

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