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Comparative Study on the Physico Chemical Parameters and Avifaunal Diversity of Vaduvur Bird Sanctuary, Thiruvarur District, Tamil Nadu, India

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Abstract

The physico chemical and microbial analysis of the lake water of Vaduvur bird sanctuary was carried out during the period of pre monsoon, monsoon and post monsoon periods. The study revealed that the levels were found to be higher during the pre-monsoon and post monsoon period. but the statistical analysis revealed that it was found to be insignificant ($p<0.05$). The microbial analysis revealed that during monsoon period it was found to be higher bacterial count, among the bacteria observed the *vibrio* counts were found to be less but other heterotrophic bacteria were found to be higher. Avifaunal diversity status and abundance of Vaduvur bird sanctuary is composed of small man-made reservoirs interconnected by an ancient network of canals and fed by the Vennaru reservoir, in the semi-arid district of Thiruvarur. The Vaduvur Lake in Tamil Nadu, India, is one such wetland that is home to a diverse range of migratory and resident birds. Despite the fact that this lake has just been designated as an Important Bird Area (IBA) by the Indian Bird Conservation Network, no attempt has been made to research it or the avifaunal species that rely on it. Thus, the water of reservoir is favorable for faunal diversity, rich in dissolved oxygen and supports variety of aquatic weeds and fishes, it has been found to be suitable habitat for bird fauna. *Acacia nilotica* (planted), *Prosopis chilensis, Azadirachta indica, and Tamarindus indica* comprised the vegetation in and around the lake. The prime breeding habitat was produced naturally.

***Key words*:** Migratory Birds, heterotrophic bacteria, water quality, Vaduvur Bird Sanctuary. Avian diversity, Vennaru reservoir, Abundance

Vaduvur Bird Sanctuary is located in Thiruvarur district of Tamil nadu. The nearest city Thanjavur is located 25 kms from the sanctuary, created in July 1999. The sanctuary attracts more than 4 species of water birds like Ibis, painted stork, grey pelican, pintail, comrant, teals herons etc. The sanctuary is a large irrigation tank which receives water from Mettur dam especially from the Northeast Monsoon from Auguest to December it remains dry from April to August. Vaduvur Bird sanctuary is located in Thiruvarur district. Tamil Nadu, at the heart of Sanctuary is a large lake which lies alongside the running Sri Kothandaramswamy temple in Vaduvur. The forest department has created mounds along the shore and it's such an amazing spectacle to see thousands of trees. Vaduvur was located 25kms away from Thanjavur. On the Thanjavur-Mannarkudi state highway the irrigation tank receives water from November to April every year which attracts a numerous foreign bird from Europe and America, the main attraction is the fertile Wetlands in the region. There are also numerous lakes which provide the most required variety of fishes for the birds the sanctuary is free for visitors and the government has provided basic facilities for an overnight stay towards located in the sanctuary for the ease of visitors more than 38 species of water birds found here.

Wetlands are highly productive and biologically diverse systems that enhance water quality, control erosion, maintain stream flows, sequester carbon and provide a home to at least one third of all threatened and endangered species. Wetlands act as natural water purifiers, filtering sediment and absorbing many pollutants in surface waters. In some wetland systems, this cleansing function also enhances the quality of groundwater Supplies. Wetlands are defined as "lands transitional between terrestrial and aquatic eco-systems where the water table is usually or near the surface or the land is covered by shallow water". According to the Ramsar convention of the IUCN at Iran in 1981, Wetlands are "submerged or water saturated lands, both natural and man-made, permanent or temporary with water, that is static or flowing, fresh, brackish or salt including areas of marine water."

Birds live in a variety of different habitats. Birds that live in different habitats will encounter different foods and different predators. Birds can be carnivorus (feeding on other animals). Herbivores (feeding on plants), or generalists (feeding on variety of foods). The lifestyle of the bird can affect what it looks like. India has wealth of wetland ecosystems distributed in different geographical region. Most of the wetlands in India are directly or indirectly linked with major river systems such

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as Ganges, Godavari, Tapti and Cauvery. India has totally 27403 wetlands of which 23444 are inland wetlands and remaining 3959 are coastal wetlands. Wetlands occupy 18.4% of the countries area (excluding rivers) of which 70% are under paddy cultivation. In India, it has been estimated that 4.1 million hectares are man-made. The coastal wetlands occupy 67,650 sq.km and are largely determined by mangrove vegetation. In Tamil Nadu it has been estimated that 31 natural wetlands covering an area of 58,068 hectares and 20,030 man-made wetlands with an area of 201,032 hectares.

The Vaduvur Bird Sanctuary is situated in Thiruvarur district of Tamil Nadu. Vaduvur is divided into three Panjayat for administrative convenience. But all along the area known as "Thannarasu Nadu" (Thannarasu country). It is located 24 km from Thanjavur and 15 km from Mannargudi. The lake has the depth of 2.5 m and receives water mainly from the North east monsoon and the Vennaru river. The lake irrigates about 1.36 acres of agricultural land. Neyvasal and Vaduvur villages are situated around the sanctuary. The road to Mannargudi borders one side of the lake. The other sides are protected by huge bunds. Migratory birds start to arrive by October and stay still February to March. The sanctuary is well known for several species, notably the Spot Billed Pelican. Several thousand migratory birds congregate in Vaduvur during the winter.

Vaduvur lake is one of the fresh water ecosystems in Tamil Nadu which is inhabited by birds. The lake water is mostly enriched by nutrients compared to other aquatic environments. Vaduvur lake is famous for migratory birds viz., Flamingos, Waders, Ducks, Pelican, Crane and Gulls, etc. The quality of water in the ecosystem provides significant formation about the available resources for supporting life in that ecosystem. A river water mixed in the lake water resource is one of the major components of environmental resources that are under threat either from over exploitation or pollution, exacerated by human activities lake water is ultimate, most suitable fresh water resource with nearly, balanced concentration of the salts for birds. Aquatic bio network plays vital component on the earth since the origin of life. Many researches are being carried out till now [1-5] analyzed the physico-chemical characteristics of Vaduvur lake, Thanjavur District. Vaduvur Bird Sanctuary was established in the year of 1999. It can be pinpointed at coordinates 10.698943 degrees North and 79.322469 degrees East. It receives annual rainfall of about 1400mm. The Sanctuary has been designated as a protected "Ramsar Site" since 2022. Migration is a seasonal phenomenon and becomes a necessity for certain birds for survival, when the temperature intensifies or becomes severe in countries like Europe and North America. This sanctuary has an irrigation tank which receives water from November to April every year. Abundance of water in this irrigation tank also draws a plethora of birds from Europe and North America. The farmers in the sanctuary consider visitation by migratory birds favourable, as the excreta of these birds improves the quality of irrigation water.

The sanctuary commonly attracts around 30,000 to 50,000 birds from different continents during the month of October to March. The bird assemblages are affected by various factors like the food availability, the size and the biotic changes in the wetlands. The quality of water in the ecosystem prevents significant information about the available resources for supporting life in that ecosystem. The sanctuary set in a 128.10 hectare property in Vaduvur Agraharam Panchayat. The tank receives water from Cauvery basin and North East Monsoon from August to December making it a heaven for birds [6]. Birds will nest wherever there is a regular supply of food and water. So, a Black Ibis, for example will seek out a mound and a shallow pool for its nest. These conditions are available in both the Paddy field and the sanctuary. The bird will shift to the field only when its regular place is fully occupied. Farmers in the area have been very co-operative in protecting the birds. Some of the visiting birds are common Keat, Open bill stork, Kingfisher, Cattle egret, Little egret, Little tern, Night heron, Darter and Grey pelican. Babul trees are dominated the floral population in the sanctuary.

The sanctuary is well known for several species, notably the Spot billed pelican *Pelecanus philippensis*. Several thousand migratory birds congregrate in Vaduvur during the winter. Bird migration is a seasonal phenomenon and when the temperature escalates in Europe and in the North America. The birds start seeing for a location that will be suitable for survival. The wetlands in this region are quite suitable for the survival environment for food, shelter and reproduction. Bird community evaluation has grown in importance as a tool for biodiversity conservation and identifying conservation measures in places with high human and environmental pressures. Animals put a strain on resources, particularly aquatic resources. The Indian subcontinent is well renowned for its unique and rich bird variety, the taxonomy, distribution, and general habitat features of which are well recorded. Both temperate and tropical forest bird groups have been pretty well investigated. However, very little is known about the structure and dynamics of bird communities in India. Understanding the richness, structure, and niche linkages of bird communities is critical for determining the significance of regional or local landscapes for avian conservation. Furthermore, seasonal monitoring is essential for tracing the dynamic movement of birds in such settings.

The study of biodiversity is significant. The variability among living organisms from all sources including, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are apart this includes diversity within species, between species and of ecosystems [7]. Birds are warm blooded animals and the body is covered with non-conducting feathers that helps in thermoregulation. Their rate of metabolism is higher than mammals and they lack sweat glands. Aves are extensively distributed throughout the world as compared to other vertebrates. Avifauna is categorized according to their behavior, habitat and feeding mechanism. Birds are found from pole to equator almost everywhere on the earth and exhibit great diversity by their habitat and geographical conditions. Birds represent an important ecological component of global biodiversity.

Aves are one of the most prominent species of Earth's biodiversity and being sensitive to environmental changes [8]. Certain parameters including species richness, abundance and community composition are often used by Ecologists to understand the diversity of species in their natural occurrence [9]. Ornithological research has always played a pivotal role in the development of certain aspects of our science. Birds have attracted more than their fair share of our Zoological attention. Waterfowls and other wildlife rely on wetlands to collect and store runoff and groundwater discharge, which is required to mitigate the effects of drought and flooding, preserve natural vegetation and crops, prevent erosion, and cleanse water. However, wetlands as wildlife habitats are deteriorating rapidly over the world as a result of increased human activity leading to urban, industrial, and agricultural expansions, which has jeopardised the integrity of this unique ecosystem. The consequence of this habitat degradation has had a major impact on the species that rely on wetlands; fall in bird populations has resulted in numerous species being listed as threatened. Identification of water bird numbers and nesting status;

identification of risks to water birds and the lake. Conservation efforts focused on habitat restoration, sustainable land use practices, and international cooperation are crucial for addressing the challenges faced by bird species and other organisms in degraded wetland ecosystems.

Many researchers have examined bird fauna in the Marathwada region of Maharashtra since this area is rich in natural habitats such as rivers. Reservoirs, hills, forests, and grassland are all examples of natural areas. [10] identified 64 bird species at Salim Ali Lake, Aurangabad. [11] identified 151 bird species in and around Nanded. In the Dongarkheda irrigation tank, [12] discovered 18 Piscivorous bird species. Hingoli District. [13] identified 93 bird species in Shikhachiwadi Wadi, reservoir district of Nanded; [14] identified 62 bird species in woodland Jaldhara, Kinwat district of Nanded. [15] recorded 53 bird species on the Godavari near Dhangar Takli; [16] recorded 50 bird species near Dhangar Takli. The study of avifaunal diversity is an important ecological technique that serves as an important indicator to evaluate different habitats statistically and qualitatively. Nowadays, avifaunal diversity is diminishing as a result of human-caused anthropogenic activities such as habitat degradation, pollution, and natural disasters. Many bird species may be compelled to live in cities and are unable to reproduce there. Birds are animals. A trophic level is maintained by an important animal group in an ecosystem. As a result, there is a need for detailed research on avifauna and their Ecology. Keep them safe. Birds play an important and varied role in religion and popular culture. They have a functional role in the ecosystem as potential pollinators and scavengers and are appropriately referred to as bio indicators of nature. The convention entered into force in late 1975 following the accession of the seventh party, Greece. It now has contracting parties from all regions throughout the world. The convention covers a very wide variety of wetland habitats including rivers, lakes, ponds, marshes, coastal areas, estuaries, bogs and even coral reefs. Tamil Nadu has maximum number of Ramsar sites 14 in India. Vaduvur Bird Sanctuary is one of the Ramsar sites which is recently added. It is a large human-made irrigation tank and shelter for migratory birds. Indian Pond Heron, *Ardeola grayii* occurred in most of the surveyed tanks. Large concentrations of wintering waterfowl such as Eurasian *Wigeon anas penelope*, Northern pintail *Anas acuta*, *Spatula querquedula*, were recorded in tanks.

Birds are one of the most beautiful, widely admired, entertaining and most studied group of animals on earth since they are conspicuous and significant component of an ecosystem. Thorough observation of the habitat leads to diverse understanding of Avifauna and its relationship with the ecosystem as Avifaunal diversity is one of the important ecological indicators of a healthy habitat. Despite their most enviable migrating nature, birds remain threatened by all the environmental evils like pollution, high land conversion rate for urban use and increasing anthropogenic pressure on biodiversity due to rapid growth of human population. But the major factor is continuous natural habitat fragmentation by cutting down the trees for commercial use of wood and land which ultimately narrow down the breeding and nesting habitat of Avifauna.

Thus, Avifauna may be forced to reside in urban green spaces. Parks and other green spaces present within cityscape have been regarded as protection centre as urbanization is actively associated with loss, fragmentation and disturbance of natural habitat. In an urban area, ecological functions and the ecosystem services of biodiversity mostly influence by the environment present in and around an urban green space. However, during the past decade research on urban biodiversity has become crucial and pivotal not only because of the increasing impact of urbanization on natural ecosystems, but also because of the growing recognition of urban areas as hosts for innovative ways to conserve and promote biodiversity. The bird community is an important component of the ecosystem, and its health signals the health of the ecosystem. Birds are ecologically adaptable and can live in a variety of settings. They are vital members of the environment as potential pollinators, scavengers, and indicators [17]. Birds naturally regulate insect and pest populations by feeding on them; they also aid in plant seed distribution. However, ongoing deforestation, widespread agriculture, pollution, and human involvement have reduced natural bird habitats, causing certain bird species to decline. It takes time to conserve them; else, certain species will become extinct.

Many researchers studied on the diversity, distribution, status, and quantity of birds throughout India, including a checklist of 453 bird species [18], 127 avian species from 38 families from Dindori District [19], and 140 species from the Madhya Pradesh TERI campus [20]. Approximately 113 species from the Siltanpur National Park in Gorgaonm, Haryana [21,] 109 species from the Guvahati University Campus in Assam [22,] 304 species from the Pond Dam Wetland in Himachal Pradesh [23], 99 species from the Vansada National Park in Gujarat [24] and 93 species from the University of Jammu [25]. Maharashtra [26], approximately 450 bird species reported from western Maharashtra [27], 64 species listed from Salim Ali Lake Aurangabad [28-29], and 151 species listed from Nanded city [29]. Total of 165 species from Osmanabad district [30], 53 species from Parbhani district [31-32], 55 species from Chandrapur district's Ghotnimbala lake [33], 50 species from Higoli district's Aundha Nagnath [34], and 84 species from Majalgaon district [35]. However, no accurate statistics on the variety, distribution, status, and abundance of the Jalna district's bird species are known. With this in mind, we ran this survey to study the matter. This study would serve as a benchmark for future research.

Bird migration is a seasonal phenomenon and when the temperature escalates in Europe and in the North America. The birds start seeing for a location that will be suitable for survival. The wetlands in this region are quite suitable for the survival environment for food shelter and reproduction [36] analyzed the biological parameters of lake Patna bird sanctuary. Phytoplankton forms the vital source of energy as primary producers and serves as a direct source of food to the other aquatic plants and animals [37]. Systematic and ecological studies on *Chlorophyceae* of North India and their relationship with water quality were made [38] Phytoplankton is small organisms that play a crucial role in food chain while increased amounts of phytoplankton provide more food for organisms at higher tropic levels, too much phytoplankton can harm the over health of the bay [39-40]. [41] analyzed the Physico chemical parameters and land use patterns of Pulicate lake. [42] studied the seasonal variation of parameters of lakes of Rainpet.

MATERIALS AND METHODS

The water sample were collected during the pre-monsoon, monsoon and post-monsoon period (2021-2022) the four different places of the vaduvur lake (site I) - near the river mouth, (site II) – Vaduvur - Mannarkudi road side, (site III) - Birds less dense area of interior lake region and (site IV) - birds heavy dense area of interior lake region. Analysis of physiochemical (Colour, Odour, Turbidity, (NTU) TDS, pH, Electrical conductivity, BOD, Bicarbonate, COD, Silicon,

Fluoride, Calcium, NO_3) properties the collected samples brought to the laboratory for the estimation of various physico chemical and biological parameters. Such as microbes count [43]. The procedures for estimation of different parameters were performed by using [44] standard protocols. The microbial analysis was performed by using standard and Vaduvur Lake water birds were studied from January 2021 to December 2022. Birds were tallied using the direct count method from various vantage points, as described by [45-46]. Counts were taken four times a month, during which time birds were observed from 0600 to 1000hrs in the morning and 1600 to 1800hrs in the evening, when they were most active. During harsh weather conditions, no count was performed. Field guides were used to identify birds [47-48] were used to determine the common and scientific names of birds in India. During the fieldwork, anthropogenic activities such as hunting, illegal fishing, and woodcutting (if any) were seen and quantified (if possible) in accordance with [49] we conducted formal and informal interviews with the individuals involved in the aforementioned acts in order to obtain widespread perception on the need for them to do this and find out alternate solutions if possible [50] were used to calculate the bird diversity.

Fig 1 Study area of Vaduvur Bird Sanctuary

Study area

The Vaduvur lake, located at 100 42' 19" N and 790 18' 53" E and spanning c.128 acres (1.28 km^2) in Tiruvarur District, Tamil Nadu, India, is one such wetland that supports a huge variety of migratory and resident species. In July 1999, the Forest Department designated it as a bird refuge. The lake's vegetation consists of *Prosopis chilensis, Azadirachta indica, Tamarindus indica, and Acacia nilotica*, with the forest department planting *A. nilotica* under the Sanctuary Management Programme.

In addition to the northeast monsoon, the Vennaru River is the main source of water. The lake is surrounded by a wide bund on the southern side, whereas the bund on the northern side is short because the elevation serves as a natural barrier. These bunds aid in the retention of water in the lake to a depth of approximately 2.5m. The two settlements located around the lake are Nayvasal and Vaduvur. Despite the fact that no attempt has been made to research this wetland or its dependent avifaunal species, the Indian Bird Conservation Network has designated it as one of India's Important Bird Areas (IBA).

Fig 2 Species diversity

RESULTS AND DISCUSSION

During the pre-monsoon period to be lower in all the four sites as compared to the post monsoon and monsoon period. Among the physico chemical factors analyzed the levels are even though the migratory birds were to be more during Oct-Feb (Table 1-3).

The lake water of Vaduvur bird sanctuary revealed that during the pre-monsoon, the study revealed that the pH was found to be higher 8.3±0.03 during pre-monsoon in site IV and was low during monsoon 6.5±0.01 in site I. During the pre-monsoon, the turbidity level of the study revealed that the turbidity was found to be higher15 during pre-monsoon in site III and IV was low during monsoon in site III and IV low during post-monsoon 4 in the site I.

Table 1 Physicochemical parameter of Vaduvur bird sanctuary lake - (Pre monsoon)

Parameters	Site-I $\bar{x}$ ± SD	Site-II $\bar{x}$ ± SD	Site-III $\bar{x}$ ± SD	Site-IV $\bar{x}$ ± SD
Colour	≤	≤	≤	≤
Odour	Ag	Ag	Ag	Ag
Turbidity (NTU)	5	5	13	5
TDS	750±1.5	728±1.9	760±1.8	769±1.9
pH	7.9±0.01	7.9±0.01	8.1±0.02	8.3±0.03
Electrical conductivity	1.45±0.01	1.43±0.01	0.43±0.02	0.47±0.01
BOD (mgl^{-1})	113±2.02	121±2.03	129±0.01	131±1.02
Bicarbonate (mgl^{-1})	283±1.81	231±1.32	139±1.72	152±1.94
COD (mgl^{-1})	36±1.02	39±1.08	43±1.09	41±1.32
Silicon (mgl^{-1})	5.43	5.21	5.73	5.49
Fluoride (mgl^{-1})	3.12±0.12	3.16±0.13	3.47±0.14	3.59±0.13
Calcium (mgl^{-1})	121±0.02	110±0.01	127±0.02	135±0.01
NO_3(mgl^{-1})	0.03±0.32	0.05±0.42	0.08±0.03	0.07±0.41

$\bar{x}$ = Mean; ±SD= Deviation

Table 2 Physicochemical parameter of Vaduvur bird sanctuary lake - (Monsoon)

Parameters	Site-I $\bar{x}$ ± SD	Site-II $\bar{x}$ ± SD	Site-III $\bar{x}$ ± SD	Site-IV $\bar{x}$ ± SD
Colour	≤	≤	≤	≤
Odour	Ag	Ag	Ag	Ag
Turbidity (NTU)	5	5	15	15
TDS	825±2.2	831±2.5	893±1.9	879±2.7
pH	6.5±0.01	7.2±0.01	7.8±0.02	7.6±0.01
Electrical conductivity	1.36±0.01	1.39±0.02	0.45±0.01	0.43±0.02
BOD (mgl^{-1})	123±1.32	125±1.75	131±1.69	139±1.32
Bicarbonate (mgl^{-1})	275±2.2	226±2.6	139±2.1	147±2.4
COD (mgl^{-1})	51±1.6	53±1.79	59±1.32	72±1.92
Silicon (mgl^{-1})	5.13	5.01	5.15	5.39
Fluoride (mgl^{-1})	3.01±0.13	3.5±1.12	3.19±1.32	3.15±1.02
Calcium (mgl^{-1})	110±0.12	123±0.03	139±0.03	145±0.04
NO_3(mgl^{-1})	0.07±0.32	0.03±0.41	0.02±0.42	0.06±1.31

$\bar{x}$ = Mean
±SD= Deviation

Table 3 Physicochemical parameter of Vaduvur bird sanctuary lake (Post monsoon)

Parameters	Site-I $\bar{x}$ ± SD	Site-II $\bar{x}$ ± SD	Site-III $\bar{x}$ ± SD	Site-IV $\bar{x}$ ± SD
Colour	≤	≤	≤	≤
Odour	Ag	Ag	Ag	Ag
Turbidity (NTU)	4	5	14	14
TDS	909±1.9	870±1.7	910±1.3	923±2.7
pH	7.8±0.1	7.63±0.2	7.82±0.3	7.91±0.2
Electrical conductivity	1.42±0.003	1.36±0.01	0.59±0.01	0.69±0.02
BOD (mgl^{-1})	125±1.21	137±1.21	147±1.29	156±1.32
Bicarbonate (mgl^{-1})	289±2.42	247±2.3	136±2.9	152±1.72
COD (mgl^{-1})	93±1.03	92±1.02	98±1.09	97±1.03
Silicon (mgl^{-1})	5.69	5.29	5.36	5.59
Fluoride (mgl^{-1})	3.12±1.01	3.16±1.02	3.41±1.03	3.58±1.04
Calcium (mgl^{-1})	126±0.03	132±0.03	138±0.01	156±0.02
NO_3(mgl^{-1})	0.02±0.39	0.06±0.72	0.09±0.31	0.07±0.39

$\bar{x}$ = Mean
±SD= Deviation

The pre-monsoon, the TDS level of the study revealed that the TDS was found to be higher 910±1.3 during post-monsoon in site III and was low during than 728±1.9 per-monsoon period site II. The pre-monsoon, the BOD level of the study revealed that the BOD value to higher 156±1.72 during post-monsoon in site IV and was low during 113±2.02 pre-monsoon period in site I. During the pre-monsoon, the COD level of the study revealed that the COD was found to be higher 98 ±1.09during post-monsoon in site III and was low during 36±1.02 pre-monsoon site I. During the pre-monsoon, the NO_3 level of T the NO_3 was found to be higher 0.09±0.31 during post-monsoon in site III and was low during 0.02±0.42 monsoon period in site I are other parameters were found to be very low during the study period. Nitrate is the most highly oxidized form of nitrogen compounds commonly present in natural waters, because it is a product of aerobic decomposition of organic nitrogenous matter. Significant sources of nitrates are fertilizers, decayed vegetable and animal matter, domestic and industrial effluents and atmospheric washouts [51]. (Table 1-3) The microbial analysis revealed that the yellow and green colonies were found to be very low in all the sites studied but other colonies were found to be higher in all the sites analyzed (Table 4-6).

The proliferation of living organisms in the water body is largely dependent on temperature, turbidity, nutrition, hardness, alkalinity, and dissolved oxygen, to name a few. The relationship between a water body's physical, chemical, and biological characteristics is referred to as its water quality. Physico-chemical, biological, and microbiological indicators that indicate the biotic and abiotic status of ecosystems are therefore analyzed as part of the process of assessing water quality. [52] In the forest findings the minimum depth of lake of Vaduvur bird sanctuary was recorded during the summer season this may be due to the fact when the amount of lake water decreases was observed in the rainy season which might to due to the influx of rain and flood water into the lake [36] in present investigations a higher pH was observed during the summer season this may be due to the fact when the amount of lake water decreases in the summer the mud concentrated in to the water which resulted in the summer the mud concentration in to the water which resulted in increase of pH.

The high turbidity during summer season may also be responsible for the high-water temperature because suspended particles absorb heat from the sun light making the water warm the higher Turbility value affects the aesthetic quality of lake water of Vaduvur bird sanctuary. According to [53] reported maximum turbidity was observed during the summer season at all the experimental sites. The dissolved oxygen (DO) is the most important sources of the aquatic atmosphere and photo synthetic process for the green plants and also determining factor of the water quality of an aquatic ecosystem the availability of oxygen to living organisms decreases with increase of BOD in water. A higher value of BOD indicates maximum consumption of oxygen and higher pollution load [54]. High BOD values suggest a greater amount of organic material requiring decomposition.

Table 4 Microbial colonies observed during pre-monsoon

Dilution	Pre-monsoon											
	Site I			Site II			Site III			Site IV		
	Colour			Colour			Colour			Colour		
	Yellow	Green	Others	Yellow	Green	Others	Yellow	Green	Others	Yellow	Green	Others
10^{-4}	TFC	TFC	80±1.6	TFC	TFC	125±1.72	TFC	TFC	75±1.7	TFC	TFC	192±1.75
10^{-5}	TFC	TFC	76±1.9	TFC	TFC	100±1.7	TFC	TFC	132±1.73	TFC	TFC	172±1.92
10^{-6}	TFC	TFC	64±1.3	TFC	TFC	76±1.9	TFC	TFC	82±1.9	TFC	TFC	141±1.92

TFC - Too few to count

Table 5 Microbial colonies observed during monsoon

Dilution	Monsoon											
	Site I			Site II			Site III			Site IV		
	Colour			Colour			Colour			Colour		
	Y	G	O	Y	G	O	Y	G	O	Y	G	O
10^{-4}	40±1.9	43±1.3	143±2.4	42±1.9	49±1.3	145±1.72	47±1.2	39±1.9	163±1.7	47±1.9	34	172±3.2
10^{-5}	38±1.7	45±1.13	127±2.9	36±1.3	32±1.9	139±1.7	32±0.1	TFC	129±1.9	32±1.62	TFC	159±1.7
10^{-6}	30±1.9	TFC	108±1.7	TFC	TFC	115±1.72	TFC	TFC	107±1.9	TFC	TFC	121±1.2

TFC - Too Few to Count; Y – Yellow; G – Green, O - Others

Table 6 Microbial colonies observed during post monsoon

Dilution	Post monsoon											
	Site I			Site II			Site III			Site IV		
	Colour			Colour			Colour			Colour		
	Y	G	O	Y	G	O	Y	G	O	Y	G	O
10^{-4}	TFC	TFC	181±1.7	TFC	TFC	182±1.72	TFC	TFC	135±1.9	TFC	TFC	182±1.37
10^{-5}	TFC	TFC	163±1.7	TFC	TFC	163±1.92	TFC	TFC	127±2.9	TFC	TFC	112±1.70
10^{-6}	TFC	TFC	135±1.9	TFC	TFC	112±1.31	TFC	TFC	163±1.7	TFC	TFC	107±1.32

Species diversity

S. No.	Common name	Scientific name	Order	Family	Ecological group	Food habit
1	Darter	*Anhinga melanogaster*	Pelecaniformes	Anhingidae	Driver	P
2	Little Grebe	*Podiceps ruficollis*	Podicapediformes	Podicipedidae	Driver	P
3	Eurasian Wigeon	*Anas penelope*	Anseriforms	Anatidae	Swimming bird	P
4	Spot-billed duck	*Anas poecilorhyncha*	Anseriforms	Anatidae	Swimming bird	P
5	Northern Pintail	*Anas acuta*	Anseriforms	Anatidae	Swimming bird	P
6	Common Teal	*Anas crecca*	Anseriforms	Anatidae	Swimming bird	P
7	Pheasant- tailed Jacana	*Hydrophasianus chirurgus*	Charadriiforms	Charadriidae	Small wader	O
8	Common Redshank	*Tringa tetanus*	Charadriiforms	Scolopacidae	Small wader	I
9	Green Sandpiper	*Tringa ochropus*	Charadriiforms	Scolopacidae	Small wader	I
10	Wood Sandpiper	*Tringa glareola*	Charadriiforms	Scolopacidae	Small wader	I
11	Common Sandpiper	*Actitis hypoleucos*	Charadriiforms	Scolopacidae	Small wader	I
12	Little Stint	*Calidris minuta*	Charadriiforms	Scolopacidae	Small wader	I
13	Large Egret	*Egretta garzetta*	Ciconiiformes	Ardeidae	Large wader	P.I
14	Grey Heron	*Ardea cinerea*	Ciconiiformes	Ardeidae	Large wader	P
15	Cattle Heron	*Bubulcus ibis*	Ciconiiformes	Ardeidae	Large wader	P
16	Pond- Heron	*Ardeola grayii*	Ciconiiformes	Ardeidae	Large wader	P.I
17	Painted Stork	*Mycteria leucocephala*	Ciconiiformes	Ciconiidae	Large wader	P
18	Glossy Ibis	*Plegadis falcinellus*	Ciconiiformes	Threskiornitidae	Large wader	P
19	White Ibis	*Threskiornis melanocaphalus*	Ciconiiformes	Threskiornitidae	Large wader	P
20	Spoon Bill	*Platalea leucorodia*	Ciconiiformes	Anatidae	Large wader	P
21	Little Tern	*Sterna albifrons*	Charadriiforms	Laridae	Aerial forager	P
22	Whisker Tern	*Chlidonias hybrid*	Charadriiforms	Laridae	Aerial forager	P
23	Small Blue Kingfisher	*Alcedo atthis*	Coraciiformes	Alcedinidae	Aerial forager	P
24	Pied Kingfisher	*Ceryle rudis*	Coraciiformes	Alcedinidae	Aerial forager	P
25	White Breasted Kingfisher	*Halcyon smymensis*	Coraciiformes	Alcedinidae	Aerial forager	P
26	Tree Swallow	*Tachycineta bicolour*	Passeriforms	Hirundinidae	Aerial forager	P

P- Piscivore C-Carnivore I-Insectivore O- Omnivore

The chemical oxygen demand (COD) is also considered as the amount of oxygen consumed by the chemical breakdown of organic and inorganic mainly server to measure the ability of organic substances to consume oxygen in water. The lower concentration of COD in the water season was probably due to higher value of COD as low temperature promotes the

concentration of COD in the lake water hence the requirement of oxygen of lake water is decreases. COD levels between 98±1.09mg/L are satisfactory for survival and growth of aquatic organisms. The low COD during post-monsoon in Korattur lake could be related to lesser input of freshwater and also due to the biochemical oxidation of organic matter and the combined effects of temperature and photosynthetic activity [55]. Both Phytoplankton's and Zooplanktons are the chief producers of any aquatic body and directly affect the growth of other herbivorous and carnivorous animals. Physiochemical factors directly influence the growth of planktons [56]. The population of planktons in Patna Lake were found to be more in the rainy as well as winter season and less in the summer season because the rainy and winter seasons are more productive in comparison to the summer season which is probably due to the water temperature and other optimum conditions required for higher productivity of aquatic life.

The present studies on bird community structure of Vennaru River in Vaduvur birds Sanctuary. A list of birds recorded from Vaduvur Lake with common and scientific names, Order, Family, Ecological group, Food habit and their occurrence in various years is given in the table (Table 1). The study reveals the occurrence of 26 species of birds in Vaduvur bird sanctuary. It was interesting to note that the Species the order Passeriformes dominated among the avian diversity.

Families such as Anatidae, Ardeidea, Scolopacidae, and Podicipedidae, as well as Charadriidae, were found to be prominent, each with five species of birds. Similar investigations in and around Nanded urban [29] found 151 species of birds belonging to 44 groups and 16 orders. The current investigation backs up the findings of the following researchers.

A total of 168 bird species from 53 Families and 15 Orders have been reported from the Godavari River Basin in Nanded District [28]. Majalgaon Reservoir in Beed District has documented 84 bird species from 15 orders and 30 families [35]. The biggest number of bird species may be attributed to birds' inclination for refuge (nesting), food in the form of grains, insects, and fruit plants. Because there is less human interference than in other locations such as lakes and rivers. However, in some regions, we observed birds suffering as a result of tree cutting, agricultural development, pesticide spraying, noise pollution, and other human intervention.

Spot-billed during the study period, a pelican, a globally near threatened (IUCN 2007) and resident species with local migrations in India, was discovered three times in the lake. On 24th a total of 60 Spot-billed Pelicans were counted in June 2009 in the Vaduvur Bird Sanctuary in Tamil Nadu, India. This lake's importance is highlighted by the fact that it has been recorded. Similarly, a maximum of 218 painted storks, another near-threatened [57] resident species with local significance, were recorded.

In the same year, movements were also detected. Despite the fact that a few pairs of Spot-billed pelicans were reported to breed in this lake during 1998-1999, no breeding activity of this species were observed throughout the study period. Local wildlife enthusiasts reported that the usage of firecrackers by devotees during festival season in temples adjacent to the lake forced the pelican to abandon its nesting activities during the aforementioned period. Another near threatened bird (IUCN 2007) was the Oriental white Ibis, which was frequently observed in this lake. Regardless of the year, the diversity of birds peaked in March, when nearly all birds were accompanied by chicks (Fig 1).

As the majority of the birds finish their mating season and leave the lake before the month of May, and the lake totally dries out between late April and early June; the number of bird species decreased after March. The neighbouring paddy fields provide a decent feeding site for the majority of aquatic birds, which primarily eat on insects, molluscs, and other small animals.

CONCLUSION

Some of the samples have total dissolved solids, pH, alkalinity, total hardness, magnesium, calcium and dissolved oxygen values exceeding the permissible limits as prescribed by Indian standards. We noticed parameters such as electrical conductivity, chloride, nitrate and biological oxygen demand values are within permissible limits. Biodiversity and Ecosystem have a complicated relationship as the Ecosystem's structure is in extricably linked to species diversity and distribution. The results of the present study of physic chemical parameters the lake water showed a seasonal pattern. This area has a very large natural ecosystem Migratory birds used lake water. Therefore, careful monitoring of water quality parameters may be necessitated throughout the year. The Present study had provided of Vaduvur bird sanctuary which influence the and microbe the diversity of microbes. Total 26 bird species observed during study period of January 2021 to December 2022. In the study of avian faunal diversity of Vennaru river. Indicate abundance of most of the common species e.g. Little Egret, Spot Billed Duck, Common Coot, Red Wattled Lapwing, Blue Rock Pigeon, Blossom Headed parakeet, Common Koel, Common Kingfisher, Common Myna, Red-Vented Bulbul and House Sparrow also found (NT) near threatened bird species Oriental White/Black Head Ibis and River Tern by IUCN status and other was LC-least concern.

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