

## Physico, chemical and biological parameters for Yesavankullam wetland of Thoothukudi District

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### Abstract

Wetlands are defined as 'lands transitional between terrestrial and aquatic eco-systems. Wetlands are also important as resting sites for migratory birds. The physical and chemical parameters of one of the major habitats for birds- the wetlands are known to influence congregation of migratory and resident species of bird's aquatic vegetation is a valuable source of food, especially for waterfowl. In the study area of wetland three time sampling was carried out the geographical nature of the pond, usage of water in water bodies, during the period January 2017 to January 2018, 3 seasons (South-west monsoon, North-east monsoon, Post-monsoon) were analyzed 16 parameters (Air temperature, water temperature, pH, Alkalinity, Do, Hardness, Conductivity, Total Dissolved Solids, nitrogen, phosphors, Major ions (Ca<sup>2+</sup>, Mg<sup>2+</sup>, Na<sup>+</sup>, Cl<sup>-</sup>, k, HCO<sub>3</sub><sup>-</sup>)). In this work we have selected five sites. Totally 66 birds were identified in this wetland. The check list of birds in this wetland as well as physico-chemical factors are discussed.

**Keywords:** Wetland, water quality parameters, birds, conservation

### Introduction

Water is essential to maintain physical and biological processes, food for growth, shelter from potential predators and undisturbed space for meeting social and other life functions, including nesting, foraging, loafing, and moulting (Rajpar and Zakaria 2011) <sup>[1]</sup>. Wetlands are often considered as 'hot spots' of biodiversity within a region or a landscape (Gopal and Sah, 1993) <sup>[2]</sup> and are unique communities that involve a diversity of plants and animals, many of which are adapted to shallow and often dynamic water regimes (Weller, 1999) <sup>[3]</sup>. Wetlands are important bird habitats, and birds use them for nesting, breeding, roosting, and rearing young ones and for feeding, resting, shelter, and social interaction (Stewart, 2001) <sup>[4]</sup>. With the intensification of human activities causing environmental changes, wetlands are subjected to heavy pressure and threats (Turner *et al.*, 2000) <sup>[5]</sup>. The value of the world's wetlands is increasingly receiving due attention as they contribute to a healthy environment in many ways. They retain water during dry periods, thus keeping the water table high and relatively stable. (Gopal 1994) <sup>[6]</sup>. Wetland habitats and resources are currently being threatened by anthropogenic and biogeophysical factors such as population pressure and rapid urbanization, mining and pollution, logging and overgrazing, desertification and drought as well as invasion by alien flora and fauna species (Deshkar, 2010) <sup>[7]</sup>. Aquatic vegetation is a valuable source of food, especially for waterfowl. In the winter, migratory waterfowl search the sediment for nutritious seeds, roots and tubers (Raju 1993) <sup>[8]</sup>. Avian community is an important component of an ecosystem. Birds are playing a major role in the environment as pollinators. Birds might live on this earth even if there were no human beings, but human beings cannot live without bird. Birds are an integral part of the whole system of life on this earth (Ali, 2005) <sup>[9]</sup>. Wetland

supports congregation of large number of migratory and resident species of birds as it has high nutritional value as well as productivity (Paracuellos 2006) <sup>[10]</sup>. The bird assemblages are affected by various factors like the food availability, the size of the wetland and the abiotic changes in the wetlands (Jaksic 2004; Lagos *et al.* 2008) <sup>[11, 12]</sup>.

In a wetland ecosystem these biotic factors are mostly dependent on the seasons and hydrology (Hussain 1995) <sup>[13]</sup>. Ultimately these changes alter the corresponding food web structures at the primary and secondary production levels (Wrona *et al.* 2006) <sup>[14]</sup>. Thus, the physical and chemical properties of freshwater body are characteristics of the climatic, geochemical, geomorphological as well as pollution conditions prevailing in the drainage basin and the underlying aquifer. These characteristics with natural or manmade changes determine the quality of water (Anonymous 2003) <sup>[15]</sup>. Thus, wetlands are highly complex ecosystems due to various interactions between the components like water, soil, biosphere and atmosphere (Bodegom *et al.* 2004) <sup>[16]</sup>. The global diversity of birds is considerably decreasing due to anthropogenic activities and climate change (Chen *et al.*, 2011) <sup>[17]</sup>. Consequently, declines in wetland-dependent species have been some of the greatest recorded (Sievers *et al.* 2018) <sup>[18]</sup>, and wetland birds in particular are sensitive indicators of wetland conditions. This study intended to assess water quality parameters to examine their relationship with bird numbers. An objective of the study is to find out the water quality parameters of the wetlands and to identify the conservation problems faced by wetland birds.

### Materials and Methods

#### Description of the Study Area

The pond Yesavankulam is situated 3 kilometers from the study centre and 5 kilometers from Srivaikundam Taluk

Headquarters. It is a well-located pond that has water spread over an area of two hectares. It has an approximate depth of ten feet. This pond is used for 207-hectare land. This pond receives rainwater and Tamiraparani River water through a canal. Water is used for various purposes like drinking, bathing, bathing the domestic animals and cleaning.



Fig 1: Study area Yesavankulam

**Water quality analysis**

Physico-chemical characteristics of the water of the study area were studied at seasonal intervals in 2017-2018, by choosing five different sampling sites (Site1– site 5) representing different sites of the wetland. Physicochemical analysis of water was conducted to determine the water quality of the study area. Physico-chemical parameters were determined employing methods described in APHA, (1998) [19]. Water quality data collected from 5 study areas during 3 seasons (South-west monsoon, North-east monsoon, Post-monsoon).

Bird surveys were carried out at seasonal intervals in the morning. In this wetland, birds were identified by using binoculars and by taking photographs. The Birds were diagrammatically

represented by using a pencil. These diagrams and the photos were taken to the laboratory and verified with standard textbooks, which are available in the department. Bird surveys were carried out at seasonal intervals (South-west monsoon, North-east monsoon, Post-monsoon) at yesavankulam in the year 2018. Direct count of the birds was carried out by using the binoculars. The methodology was followed as described by Bibby *et al.* (2000) [20]. The birds were sighted using a binocular (8X40) and only confirmed species were included in the checklist. For the spot identification standard field guide Grimmett *et al.*, (2008) [21], for nomenclature Manakadan and Pittie (2001) and for classification Kazmierczak and Perlo (2000) [22] were followed.

**Results and Discussion**

Seasonal variation of water temperature showed that the water temperature was always lower than the air temperature in all the seasons (south-west monsoon, north-east, and post-monsoon periods). During the north-east monsoon season, minimum water temperature was observed in site 3 (26.9°C) and maximum water temperature was observed in site 5 (30.2°C). Result was recorded and shown in Tables 1, 2, and 3. Temperature is one of the most important parameters in the aquatic environment. Air Temperature level showed moderate to high levels of variation between each season, with an average level of 28.2°C, 27.8°C and 29.6°C, respectively, during the south-west monsoon, north-east monsoon season, during 2017 and post-monsoon season during 2018. The water pH level showed slight fluctuation between each season with the average levels of 8.1, 8.9 and 8.0 respectively, for each season (south-west monsoon, north-east monsoon and post-monsoon). The pH of a water body indicates the degree of deterioration of water quality (Avvannavar and Shrihari, 2008). During this study period, pH varied from 7.1 to 8.9. This work clearly showed that the salinity was higher in site 5 (140 mg/l) and lower in site 2 (95 mg/l).

Table 1: Water quality parameters in the sampling sites during post-monsoon period

Sl. No.	Air Temp °C	Water Temp °C	pH	Alkalinity mg/l	DO mg/l	Hardness mg/l	Conductivity ho/cm	TDS mg/l	Nitrogen mg/l	Phosphors mg/l	H <sub>2</sub> CO <sub>3</sub>	Cl	Ca	Mg	Na	K
1.	29.4	28.2	7.8	98.8	4.6	92.1	236	151.5	1.960	0.0608	12.7	11.4	11.6	0.5	0.5790	0.0357
2.	29.8	27.6	7.7	106.8	8.4	80.8	236	145.8	1.195	0.0718	12.1	11.1	11.5	0.8	0.5911	0.0432
3.	29.8	27.6	7.8	101.2	4.8	78.6	220	150.2	1.788	0.0601	12.4	11.6	11.8	0.7	0.6401	0.0495
4.	30.1	28.2	7.1	83.6	4.8	76.8	205	130.6	1.788	0.0742	21.8	11.5	11.4	0.4	0.7122	0.0566
5.	30.8	28.2	7.9	78.6	7.8	73.9	214	142.3	1.748	0.0585	21.9	11.2	11.4	0.6	0.6899	0.0678

Table 2: Water quality parameters in the sampling sites during south-west monsoon period

Sl. No.	Air Temp °C	Water Temp °C	pH	Alkalinity mg/l	DO mg/l	Hardness mg/l	Conductivity ho/cm	TDS mg/l	Nitrogen mg/l	Phosphors mg/l	H <sub>2</sub> CO <sub>3</sub>	Cl	Ca	Mg	Na	K
1.	29.1	27.1	7.7	30.3	8.9	34.7	162	149.8	1.873	0.0567	12.5	11.4	11.2	1.10	0.5862	0.0562
2.	29.7	27.6	6.8	107.0	7.9	82.0	215	140.7	1.293	0.0699	12.3	10.9	11.5	1.33	0.5321	0.0433
3.	29.9	27.9	7.7	81.1	4.7	76.2	204	131.3	1.402	0.0688	11.6	10.9	11.1	0.82	0.5388	0.0267
4.	30.5	27.5	8.0	82.8	4.2	75.1	210	137.5	1.855	0.0762	11.2	11.0	11.5	0.61	0.4831	0.0315
5.	30.6	28.6	8.0	79.5	5.5	75.0	210	135.0	1.738	0.0582	11.5	11.3	11.5	0.90	0.5632	0.0348

**Table 3:** Water quality parameters in the sampling sites during post-monsoon period

Sl. No.	Air Temp °C	Water Temp °C	pH	Alkalinity mg/l	DO mg/l	Hardness mg/l	Conductivity ho/cm	TDS mg/l	Nitrogen mg/l	Phosphors mg/l	H <sub>2</sub> CO <sub>3</sub>	Cl	Ca	Mg	Na	K
1.	30.1	27.9	7.7	29.1	9.8	35.8	162	107.8	1.501	0.0911	12.1	11.6	11.7	0.9	0.5702	0.0378
2.	30.6	28.6	8.0	94.2	5.9	92.4	221	148.6	1.988	0.0589	12.7	11.4	11.6	0.6	0.6235	0.0362
3.	29.9	26.9	7.3	110.0	9.2	81.3	219	141.9	1.201	0.0821	11.6	11.2	11.8	0.9	0.5630	0.0347
4.	30.2	28.7	7.6	85.0	5.3	76.0	208	138.9	1.840	0.0831	11.5	11.3	11.8	0.8	0.6333	0.0423
5.	31.9	30.2	8.9	81.2	8.5	74.6	225	146.9	1.130	0.0680	11.4	11.3	12.1	1.2	0.7444	0.0382

Alkalinity ranged from 29 mg/l to 119 mg/l in the present study. During the study period, a dissolved oxygen level was observed in the ranges of 8.9 mg/l, 9.9 mg/l and 8.6 mg/l respectively, during each successive season. Dissolved oxygen concentrations often indicate excessive productivity resulting from nutrient enrichment (Walling and Webb, 1992) [23]. Low dissolved oxygen concentrations in rivers can be linked to both natural conditions and human activities (Mann *et al.*, 2007) [24]. Hardness level showed higher variation between each season with in the ranges of 140.1 mg/l, 144.8 mg/l, 96.8 mg/l respectively for the post-monsoon, north-east monsoon, and south-west monsoon seasons. The maximum value of hardness was at all sites 5 (144 mg/l) and the minimum was in site 1 (35.8 mg/l) during the north-east monsoon season. Electrical conductivity varied from 283 mho/cm to 360 mho /cm; the values were found to be increased from site 1 to site 5, during the north-east monsoon, when compared with the other two seasons. Electrical conductivity values showed higher fluctuations during each season. The conductivity is related to the nature and concentrations of ionized substances present in water and to the temperature of the water (Haggard *et al.*, 2005) [25]. The TDS values tend to be diluted by surface runoff and for most rivers, there is an inverse correlation between the charge rate and TDS. High nitrogen levels are not good for aquatic life (Wang *et al.*, 2002) [26]. The present study results were recorded within the prescribed level, except during October 2017 and February 2018.

Phosphorus level showed higher variation between each season within the average ranges of mg/l 1.204 mg/l, 0.098 mg/l, and 0.078 mg/l, during the study period. High levels of both phosphate and nitrogen can lead to eutrophication, which increases algae growth and ultimately reduces dissolved oxygen levels in the water (Murdoch *et al.*, 2001) [27]. The chloride level was uniformly altered during each season due to seasonal changes. In the present investigation,

the magnesium content up to 5.60 mg/l was observed with higher concentration during the winter season and lower concentration in the monsoon season. Sodium and potassium levels maximum during post monsoon season when compared with the other two seasons. Under low potassium concentration, the growth rate and photosynthesis of algae, especially blue-green algae become poor and respiratioare ns increased (Jain, 2011) [28]. It has been reported that the grazing Fields, agricultural croplands, waste discharges, and other anthropogenic activities are known causes of nutrient enrichment and threats to wetland deterioration (Togue *et al.*, 2012) [29].

**Avian Fauna**

We observe 66 species of birds in these wetlands. By the count was reduce due to activity of people by hunting. Forest Department and people should take steps to stop the activity and give shelter to the birds. A total of 1500 birds belonging to 66 species and 35 families were recorded from the Yesavankullam of Thoothukudi District. The recorded 1500 number of the bird population will not remain as such. In my work, 86 species (Table.4) are expected to decrease in the coming years because the Thoothukudi District wetlands are facing grave threats to their existence. The main threats are encroachment, garbage dumping, urbanization, land filling, and unscientific fishing etc. Secondly, there has been no clear demarcation between the wetland area and the housing area. Thirdly, invasive plants like hypomia and hyacinth are the major threats to the wetland birds. Birds are good bio-indicators and useful models for studying a variety of environmental problems (Urfi *et al.*, 2005) [30]. Diving birds prefer deep water level and some birds need depths more than 1m (Halse *et al.*, 1993) [31]. Indian Pond Heron *Ardeola grayii* was the most common species that occurred in wetlands surveyed, followed by Little Egret *Egretta garzetta* (85%) and Little Cormorant *Phalacro coraxniger* (81%).

**Table 4:** Yesavankullam wetlands birds

Sl.No.	Common Name	Biological Name	Status	Family
1.	Little Grebe	<i>Tachybaptus ruficollis</i>	RC	Podicipedidae
2.	Spot Billed Pelican	<i>Pelecanus Philippensis</i>	R VC	Pelecanidae
3.	Little Cormorant	<i>Phalacrocorax niger</i>	R VC	Phalacrocoracidae
4.	Great Cormorant	<i>Phalacrocorax carbo</i>	R VC	Phalacrocoracidae
5.	Indian Shag	<i>Phalacrocorax Fuscicollis</i>	R Ra	Phalacrocoracidae
6.	Darter	<i>Anhinga melanogaster</i>	RRa	Anhingiae
7.	Grey Heron	<i>Ardea Cinerea</i>	R VC	Ardeidae
8.	Purple Heron	<i>Ardea Purpurea</i>	R O	Ardeidae
9.	Indian Pond-Heron	<i>Ardeola grayii</i>	R VC	Ardeidae

10.	Eastern Cattle Egret	<i>Bubulcus ibis</i>	R O	Ardeidae
11.	Great Egret	<i>Egretta alba</i>	R VC	Ardeidae
12.	Intermediate Egret	<i>Egretta Intermedia</i>	R O	Ardeidae
13.	Little Egret	<i>Egretta garzetta</i>	R VC	Ardeidae
14.	Black Crowned Night Heron	<i>Nycticorax nycticorax</i>	R O	Ardeidae
15.	Little Green Heron	<i>Butorides Striatus</i>	R VC	Ardeidae
16.	Black Bittern	<i>Dupetor flavicollis</i>	R O	Ardeidae
17.	Painted stork	<i>Mycteria Leucocephala</i>	R VC	Ciconiidae
18.	Asian open Bill stork	<i>Anastomus Oscitans</i>	R C	Ciconiidae
19.	Black headed ibis	<i>Threskiornis melanocephalus</i>	R O	Threskiornithidae
20.	Glossy Ibis	<i>Plegadis Falcinellus</i>	SM Ra	Threskiornithidae
21.	Indian Black Ibis	<i>Pseudibis papillosa</i>	VVRa	Threskiornithidae
22.	Eurasian Spoonbill	<i>Platalea leucorodia</i>	R/SM/ Ra	Threskiornithidae
24.	Bar-headed goose	<i>Anser indicus</i>	WM RA	Anatidae
25.	Lesser whistling Duck	<i>Dendrocygna Javanica</i>	R VRa	Anatidae
26.	Northern Pintail	<i>Anas acuta</i>	WM VC	Anatidae
27.	Cotton Teal	<i>Nettapus coromandelianus</i>	R VRa	Anatidae
28.	Indian Spot Billed Duck	<i>Anas poecilorhyncha</i>	R VC	Anatidae
29.	Eurasian Wigeon	<i>Anas Penelope</i>	WM Ra	Anatidae
30.	Garganey	<i>Anas querquedula</i>	WM C	Anatidae
31.	Nothern shoveller	<i>Anas clypeata</i>	WM C	Anatidae
32.	Common Teal	<i>Anas crecca</i>	WM C	Anatidae
33.	Comb Duck	<i>Sarkidiornis melanotos</i>	Localy Ex	Anatidae
34.	White Breasted Waterhen	<i>Amaurornis phoenicurus</i>	R VC	Rallidae
35.	Common Moorhen	<i>Gallinula chloropus</i>	R VC	Rallidae
36.	Purple Moorhen	<i>Porphyrio porphyrio</i>	R/SM/ Ra	Rallidae
37.	Eurasian Coot	<i>Fulica atra</i>	R/SM/Ra	Rallidae
38.	Pheasant-tailed Jacana	<i>Hydrophasianus chirurgus</i>	SM/O	Jacanidae
39.	Bronze winged jacana	<i>Metopidius indicus</i>	VRa	jacanidae
40.	Black-Winged Stilt	<i>Himantopus Himantopus</i>	WMC	Recurvirostridae
41.	Yellow Watted Lapwing	<i>Vanellus malabaricus</i>	R C	Charadriidae
42.	Red Watted Lapwing	<i>Vanellus indicus</i>	R C	Charadriidae
43.	Little ringed Plover	<i>Charadrius dubius</i>	R/SM VC	Charadriidae
44.	Black tailed Godwit	<i>Limosa limosa</i>	WM C	Scolopacidae
45.	Common Snipe	<i>Gallinago Gallinago</i>	WM C	Scolopacidae
46.	Marsh sandpiper	<i>Tringa stagnatilis</i>	WM C	Scolopacidae
47.	Common sandpiper	<i>Actitis hypoleucos</i>	WM C	Scolopacidae
48.	Wood Sandpiper	<i>Tringa glareola</i>	WM C	Scolopacidae
49.	Pied Crested Cuckoo	<i>Clamator coromandus</i>	RC	Cuculidae
50.	Small Green Billed Malkoha	<i>Phaenicophaeu viridirostris</i>	RC	Cuculidae
51.	Asian Koel	<i>Eudynamys scolopacea</i>	RC	Cuculidae
52.	Small blue Kingfisher	<i>Alcedo atthis</i>	R O	Alcedinidae
53.	Lesser-Pied Kingfisher	<i>Ceryle rudis</i>	R O	Alcedinidae
54.	White Breased King Fisher	<i>Halcyon smyrnensis</i>	R O	Alcedinidae
55.	Blue tailed Bee eater	<i>Merops philippinus</i>	R O	Meropidae
56.	Small Bee eater	<i>Merops orientalis</i>	R O	Meropidae
57.	Indian Roller	<i>Coracias benghalensis</i>	RC	Coraciidae
58.	Common Hoopoe	<i>Upupa epops</i>	RO	Upupidea
59.	Common Swallow	<i>Hirundo rustica</i>	RC	Hirundinidae
60.	Wire-tailed Swallow	<i>Hirundo smithii</i>	RC	Hirundinidae
61.	Large Pied Wagtail	<i>Motacilla maderaspatensis</i>	RC	Motacillidae
62.	Yellow Wagtail	<i>Motacilla flava</i>	WM	Motacillidae
63.	Grey Wagtail	<i>Motacilla cinerea</i>	WM	Motacillidae
64.	Bay Backed Shrike	<i>Lanius vittatus</i>	WM	Danidae
65.	Oriental Magpie Robin	<i>Copsychus saularis</i>	RC	Turdidae
66.	Eurasian Golden Oriole	<i>Oriolus oriolus</i>	RC	Orioleidae

During the dry season, when all tanks fed by the Tamiraparani Riverine wetlands go dry, birds congregate at

this wetland in huge numbers. Birds in this wetland are threatened by poaching, and more recently, we need to think

of various innovative measures that prevent loss of heronry and wetlands to rapid urbanization happening in the region, along with improved monitoring and documentation (Santhalakshmi and Sakthika, 2019) [32]. Activities of water birds are considered as indicator of quality of the wetland ecosystem and form the terminal links in many aquatic food chains, and as a result they reflect changes originating in several different ecosystem components (Custer TW1977) [33]. The present study suggests the importance of the small village ponds as they prove to be the important feeding grounds for the migratory and the resident species of the birds. Both groups, ducks and waders, judiciously use the pond either in terms of density or in terms of diversity. Moreover, various abiotic parameters play an important role in making up the density as well as diversity of the water birds, hence indicating that a single abiotic factor is unfeasible.

### Conclusion

In conclusion, in the present study, the physico-chemical and biological characteristics of pond water were assessed to assess the relative density and abundance of native and migratory avian species. Wetlands in breeding, migratory, or wintering areas are all important to sustain bird populations. As the wetland habitats in these areas are drained or altered, the ability of these areas to sustain bird populations decreases. Each species of wetland-dependent bird has a unique and complex set of needs for wetland habitats that makes it difficult to generalize about how loss or degradation of wetlands affects bird populations. It seems reasonable to expect, however, that as the number of wetlands in a region declines, so too will the numbers of wetland-dependent birds.

### References

1. Rajpar MN, Zakaria M. Effects of water level fluctuation on water bird's distribution and aquatic vegetation composition at natural wetland reserve, Peninsular Malaysia. *International Scholarly Research Network Ecology*, 2011, 1.
2. Gopal B, Sah M. Conservation and management of rivers in India: case study of the River Yamuna. *Environmental Conservation*, 1993;20:243–254.
3. Weller MW. *Wetland Birds: Habitat Resources and Conservation Implications*. Cambridge University Press, 1999, 271.
4. Stewart RE Jr. Technical Aspects of Wetlands: Wetlands as Bird Habitats. National Water Summary on Wetland Resources, United States Geological Survey Water Supply Paper 2425, 2001. Assessed from <http://water.usgs.gov/nwsum/WSP2425/birdhabitat.html> on 12-3-2009.
5. Turner RK, van den Bergh JCJM, Soderqvist T, Barendregt A, van der Straaten J, Maltby E, van Ierland EC. Ecological-economic analysis of wetlands: scientific integration for management and policy. *Ecological Economics*, 2000;35(1):7–23.
6. Gopal B. Conservation of inland waters in India: an overview. *Verhandlungen der Internationalen Vereinigung für Theoretische und Angewandte Limnologie*, 1994;25:2492–2497.
7. Deshkar S, Rathod J, Padate G. Avifaunal diversity and water quality analysis of an inland wetland. *Journal of Wetlands Ecology*, 2010;4:1–32.
8. Raju PLN, Chakraborti AK, Deshpande CV. Estimation of suspended sediment load upper lake, Bhopal using remote sensing techniques, 1993, 25–27.
9. Ali Z. Ecology, distribution and conservation of migratory birds at Uchalli Wetlands Complex, Punjab, Pakistan. Ph.D. Thesis. University of the Punjab. Pakistan, 2005, 265–269.
10. Paracuellos M, Telleria JL. Factors affecting the distribution of a water bird community: the role of habitat configuration and bird abundance. *Waterbirds*, 2004;27:446–453.
11. Jaksic F. El Niño effects on avian ecology: lesson learned from the southeastern Pacific. *Ornitologia Neotropical*, 2004;15:61–72.
12. Lagos NA, Paolini P, Jaramillo E, Lovengreen C, Duarte C, Contreras H. Environmental processes, water quality degradation, and decline of waterbird populations in the Rio cruces wetland, Chile. *Wetlands*, 2008;28:938–950.
13. Hussain S. Management for migratory waterfowl. In: Gopal B, editor. *Handbook of wetland Management*. WWF-India, New Delhi, India, 1995.
14. Wrona F, Prowse T, Reist J, Hobbie J, Levesque L, Warwick F. Climate Change Effects on Aquatic Biota, Ecosystem Structure and Function. *Ambio*, 2006;35:359–369.
15. Anonymous. Soroti District Development Programme, (SDDP), Kampala, 1994, 42–47.
16. Bodegom V, Bakker PC, van der Gon HD. Identifying key issues in environmental wetland research using scaling and uncertainty analysis. *Regional Environmental Change*, 2004;4:100–106.
17. Chen LD, Qi X, Zhang XY. Effect of agricultural land use changes on soil nutrient use efficiency in an agricultural area, Beijing, China. *Chinese Geographical Science*, 2011;21(4):392–402.
18. Sievers M, Hale R, Parris KM, Swearer SE. Impacts of human-induced environmental change in wetlands on aquatic animals. *Biological Reviews*, 2018;93:529–554.
19. APHA. Standard methods for the examination of water and wastewater. American Public Health Association, 18th edition, Washington DC., USA, 1998.
20. Bibby C, Jones M, Marsden S. Expedition Field Techniques: Bird Surveys. Expedition Centre, Royal Geographical Society, London, 1998, 201–209.
21. Grimmett R, Inskipp C, Inskipp T. *Pocket Guide to the birds of the Indian sub-continent*. Oxford University Press, New Delhi, 2008, 384.
22. Kazmierczak K. *A field Guide to the Birds of India, Sri Lanka, Pakistan, Nepal, Bhutan, Bangladesh and the Maldives*. On Book Service, New Delhi, 2000.
23. Walling DE, Webb BW. Water quality: I. Physical characteristics. In: Calow P, Petts GE, editors. *The rivers handbook*. Blackwell Scientific, Oxford, UK, 1992;(1):48–72.
24. Mann ME, Emanuel KA. Atlantic hurricane trends linked to climate change. *Eos, Transactions American Geophysical Union*, 2006;87:233–244.

25. Haggard BE, Stanley EH, Storm DE. Nutrient retention in a point-source-enriched stream. *Journal of the North American Benthological Society*,2005;24:29–47.
26. Wang W, Wang A, Chen L, Liu Y, Sun R. Effects of pH on Survival, Phosphorus Concentration, Adenylate Energy Charge and Na<sup>+</sup>-K<sup>+</sup> ATPase Activities of *Penaeus chinensis* Osbeck Juveniles. *Aquatic Toxicology*,2002;60:75–83.
27. Murdoch T, Cheo M, Laughlin K. Stream keeper's Field Guide: Watershed Inventory and Stream Monitoring Methods. Adopt-A-Stream Foundation, Everett, WA, 2001, 297.
28. Jain MK, Dadhich LK, Kalpana S. Water quality assessment of Kishanpura dam, Baran, Rajasthan, India. *Nature Environment and Pollution Technology*,2011;10(3):405–408.
29. Togue FK, Kuate GLO, Oben LM. *Journal of Materials and Environmental Science*,2017;8(6):1910–1920.
30. Urfi AJ, Sen M, Kalam A, Meganathan T. Counting Birds in India: methodologies and Trends. *Current Science*, 2005, 89(12).
31. Halse SA, Williams MR, Jaensch RP, Lane JAK. Wetland characteristics and water bird use of wetlands in southwestern Australia. *Wildlife Research*,1993;20:103–126.
32. Santhalakshmi AS, Sakthika T. Check list of Birds in Tamiraparani riverine wetlands - Thoothukudi District, Tamilnadu. *Journal of Emerging Technologies and Innovative Research*, 2019, 6(2). [www.jetir.org](http://www.jetir.org) (ISSN-2349-5162)
33. Custer TW, Osborne RG. Wading birds as biological indicators. Long Survey, U.S. Department of Interior, Fish and Wildlife Service, Washington DC, 1977.