

Research Paper

Importance of sewage treatment ponds for water-birds in semi-arid zone of Gujarat, India

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Abstract

Khodiyar sewage pond located in Anand district of Gujarat state in India was visited during each winter from 1988 to 2004 and every month from June 2002 to June 2004 to understand utilization of pond by waterbirds. The birds were observed by using binoculars (10X50) and a spotting scope (20X80). Species richness, Shannon Wiener Index (H') and Evenness (E) were calculated for each month. Monthly data was divided into three seasons viz. monsoon, winter and summer. Physicochemical parameters such depth, temperature, pH and dissolved Oxygen (DO) were measured. Total 66 species of waterbirds belonging to 17 families and 11 orders were recorded. There was no significant difference in the Shannon-Wiener Index and evenness between the three seasons. Total density ($F_{2, 20} 27.57, P < 0.0001$) and species richness ($F_{2, 20} 39.61, P < 0.0001$) of water birds of different seasons differed significantly due to influx of migratory birds during winter. Species richness and density of water birds were not significantly correlated with the physicochemical parameters of the pond. The Khodiyar pond was found to be important for waterbirds conservation.

Keywords: Anand, Gujarat, Khodiyar Sewage Pond, Water birds, Utilization

Introduction

With the global loss of natural wetlands the waterbirds have become increasingly dependent on alternative and artificial aquatic habitats^[1]. Sewage/wastewater treatment ponds are among such a man made wetlands found to be useful for waterbirds^[2,3,4,5]. Unlimited food sources are considered to be one of the factors attracting the birds at wastewater treatment ponds. For example, the waste water treatment pond of Victoria in Australia is reported to have high density of zooplankton and supports filter-feeding waterfowls at the end of treatment series^[5]. Such ponds also serve as important staging sites for migratory bird species^[6,7,8,9]. There is a significant increase in sewage treatment wetlands across the globe^[1]. With the disappearance in the natural wetlands, availability of sewage ponds/wastewater treatment ponds can become good habitat for waterbirds conservation.

However utilization of wastewater treatment ponds by birds is always remained a topic of debate. Many scientists believe these artificial ponds to be an attractive nuisance by exposing birds to pathogens or harmful pollutants and their use by waterbirds poses health risks for both birds and humans^[1]. To

overcome the health risks of sewage ponds utilization, their association with birds should be understood in detail and documented. In Gujarat there are few sewage ponds supporting large number of waterbirds such as Kumbharwada in Bhavnagar, Aji-I in Rajkot, and Porbandar Bird Sanctuary in Porbandar. However, the detail information on long term utilization of sewage treatment ponds by waterbirds and factors attracting them to such ponds is lacking. Hence, the present study was designed to determine (i) the annual and seasonal patterns in bird communities at sewage pond (ii) identify different factors supporting the bird fauna at such pond and (iii) discuss the consequent effects of utilization of pond by birds.

Study Area

Khodiyar wetland, also known as Lambhvel pond ($22^{\circ} 35' 01.64''\text{N}$; $72^{\circ} 57' 00.08''\text{E}$) is located about 5km north to Anand city in semi-arid Central Gujarat state of India. This wetland was constructed in 1980 and is spread in about 70 to 100 acres area. There are mainly three seasons viz., summer (March-June), Monsoon (July-October) and Winter (November-February). The temperature varies from about $45\text{-}47^{\circ}\text{C}$ during summer to $12\text{-}14^{\circ}\text{C}$ during winter. The pond receives rain water during southwest monsoon and organic waste water from Vallabh Vidya Nagar and Anand Towns throughout the year. The wetland is divided into two unequal halves by a railway track, however both the halves are connected by narrow channels. The left part of the pond is consists of two patches of water body (Figure 1). *Eichhornia crassipes* is the dominant aquatic plant covering the major surface of water. Other plants of the pond are *Typha angustata*, *Ipomea sp.*, *Lemna* etc. The pond is surrounded by *Acacia nilotica* and *Prosopis juliflora* etc. at its periphery.

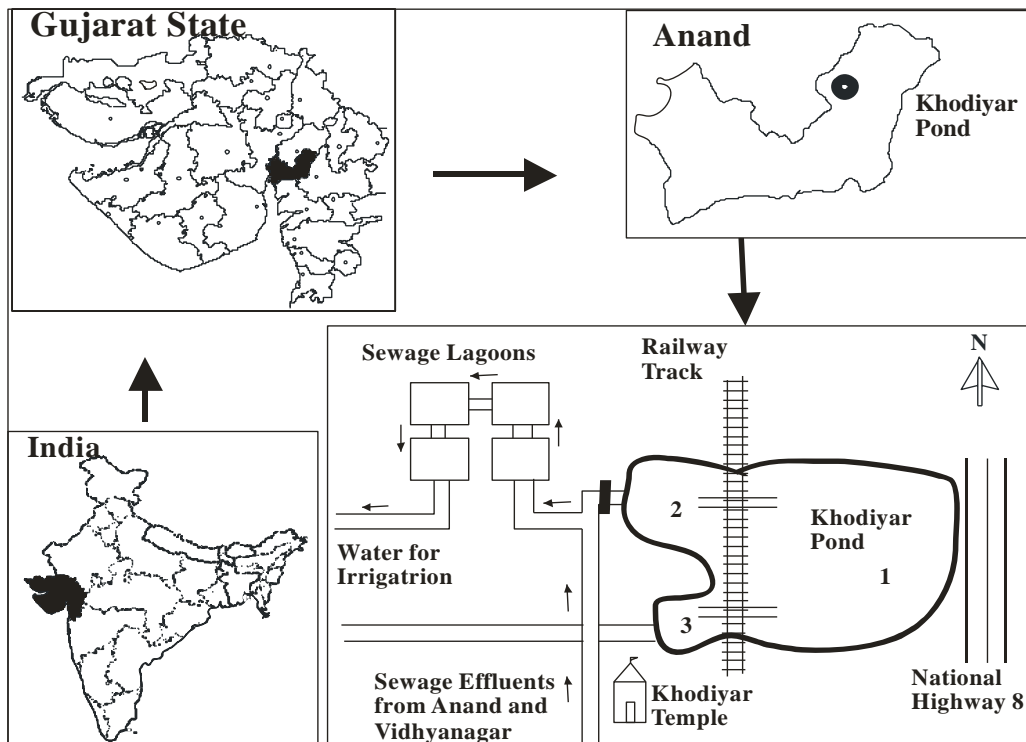


Figure 1: Location of Khodiyar Sewage Pond

Materials and Methods

Khodiyar pond was visited during winter from 1988 to 2004 to understand long term utilization of pond by birds and study annual variation. The pond was visited every month from June 2002 to June 2004 to understand seasonal variation in the abundance of waterbirds at the pond. Water birds were observed by

using binoculars (10X50) and a spotting scope (20X80) and identified by field guides on birds of Indian subcontinent^[10,11]. Population of each species was estimated by either Actual Count (when the birds were countable) or Block Count Methods as described by Howes and Bakewell^[12]. Birds were counted on all the three parts of pond (part 1, 2 and 3) from the site of appropriate light condition. Data was collected on tabulated forms and then transferred to software programmes for comparative analysis. Species richness, species diversity indices-Shannon Wiener Index (H') and Evenness (E) were calculated for annual and monthly visits. Total numbers of residential and migratory species were noted. To understand the utilization of pond, all the birds were categorized into four groups viz. (1) Ducks, (2) Waders (3) Wading birds and (4) Waterfowls. To understand the composition of bird community feeding at pond, they were divided into (i) Divers: feeding from within the water and (ii) Surface Feeders: obtaining food from surface water or superficial layers of mud by straining. Total number of birds of all the species was considered as total density of that period. Numbers of species nesting within the pond as well as in 1-2kms periphery of the pond were noted throughout the study period.

Physicochemical parameters such depth, water spread area, temperature, pH and dissolved Oxygen (DO) were measured for nine months from July 2003 to June 2004 at four different sites of ponds monthly. Depth of water was measured by using calibrated rode and total water spread was estimated by visual observation referring total open area as 100%. For this, the observations were made on all the sites of pond and an average value was referred for each month. Temperature and pH were measured by thermometer and pH meter respectively. DO was measured by Winkler's method^[13]. Mean value of all hydrological parameters for each season was considered and correlated with the density of birds of that particular period.

Statistical analysis

Data for four months were pooled for each season according to the Indian climate viz., summer, monsoon and winter. Mean and Standard Error of Mean (SEM) of species richness, total density were calculated for three seasons and One-way ANOVA was performed followed by Bonferroni test using GraphPad Prism version 3.0 for Windows (GraphPad Software, San Diego California USA). Total densities of surface feeders and divers were compared for each season by performing unpaired t-test. P values were significant, moderately significant and highly significant, if found to be less than 0.05, 0.001 and 0.0001 respectively. Mean values of physicochemical parameters of water were correlated with the total density of birds during the respective seasons by performing Pearson correlation two tailed test. As the number of birds was too high for correlation tests, their densities were converted into the \log_{10} values.

Results and Discussion

Total 66 species of waterbirds belonging to 17 families and 11 orders were observed during the study period. Initially after the construction of pond, the number of birds remained low till 1997 but then a peak in their number was observed in the following years (Figure 2).

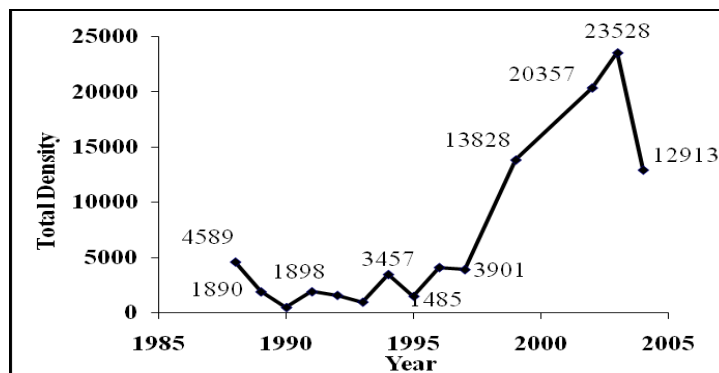


Figure 2: Annual variation in Species Richness and total number of birds at Khodiyar Pond

Total density ($F_{2, 20} 27.57, P < 0.0001$) and species richness ($F_{2, 20} 39.61, P < 0.0001$) of water birds differed significantly between different seasons. Total density was maximum during winter (2959 ± 980.4) followed by monsoon ($15,460 \pm 1724$) and summer (3503 ± 1303) (Figure 3). Species richness was maximum during winter (30.0 ± 1.946) followed by monsoon (43.14 ± 1.550) and summer (22 ± 0.9661) (Figure 4). The values of Evenness during monsoon, winter and summer seasons were 0.6166 ± 0.04954 ; 0.5117 ± 0.02852 and 0.6273 ± 0.0518 respectively. Shannon-Weiner Index (H') values for monsoon, winter and summer seasons were 2.680 ± 0.1594 ; 1.919 ± 0.1165 and 2.096 ± 0.1499 respectively. There was no significant difference in diversity index (H') ($F_{2, 22} 0.4467, P > 0.05$) and evenness ($F_{2, 22} 2.011, P > 0.05$) between the three seasons. Seasonal variations in total density and species richness can be attributed to the influx of ducks, waders and waterfowls (*i.e.* Migratory waterbirds) during winter season (Figure 5). Density of ducks ($F_{2, 22} 22.87, P < 0.0001$), waders ($F_{2, 22} 09.511, P < 0.05$) and waterfowls differed significantly between different seasons ($F_{2, 22} 04.407, P < 0.05$). However the density of wading birds did not differ significantly between different seasons (Figure 6). Most of wading birds were residential and utilized the pond throughout the year. 61% of total waterbirds species comprised of surface feeders and only 29% were divers. The divers included mainly the cormorants, grebes, pochards and kingfishers, however their numbers remained too low compared to surface feeders during each season ($P_{\text{monsoon}} < 0.001, t = 3.216, df = 16$; $P_{\text{winter}} < 0.0001, t = 8.914, df = 12$; $P_{\text{summer}} < 0.05, t = 3.001, df = 10$). Pond supported >20,000 waterfowls twice during the study period. 1% geographic population (Asia) of Ruff (*Philomachus pugnax*) and Glossy Ibis (*Plegadis falcinellus*) was reported for several months. Hence, the pond was reported fulfilling two Ramsar criteria during the present study period.

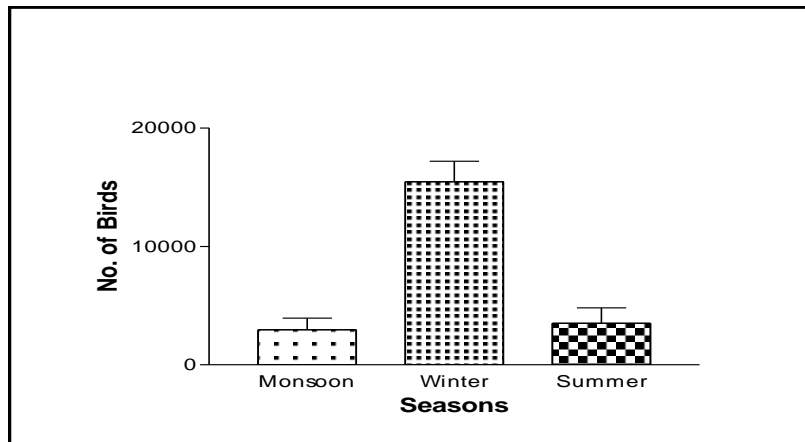


Figure 3: Total Water bird density at Khodiyar Pond during different seasons

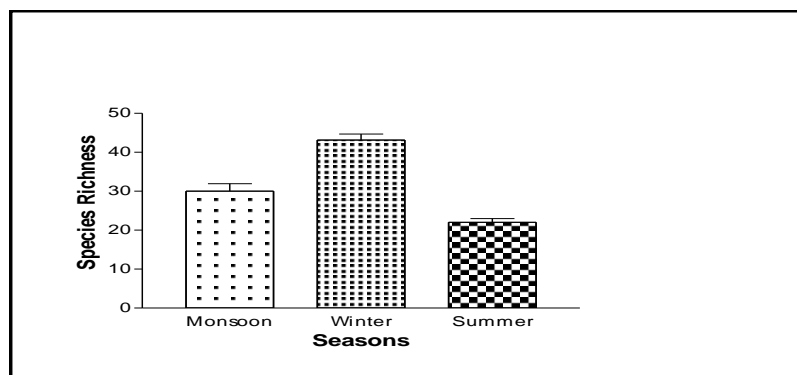


Figure 4: Total Water bird Species Richness at Khodiyar Pond during different seasons

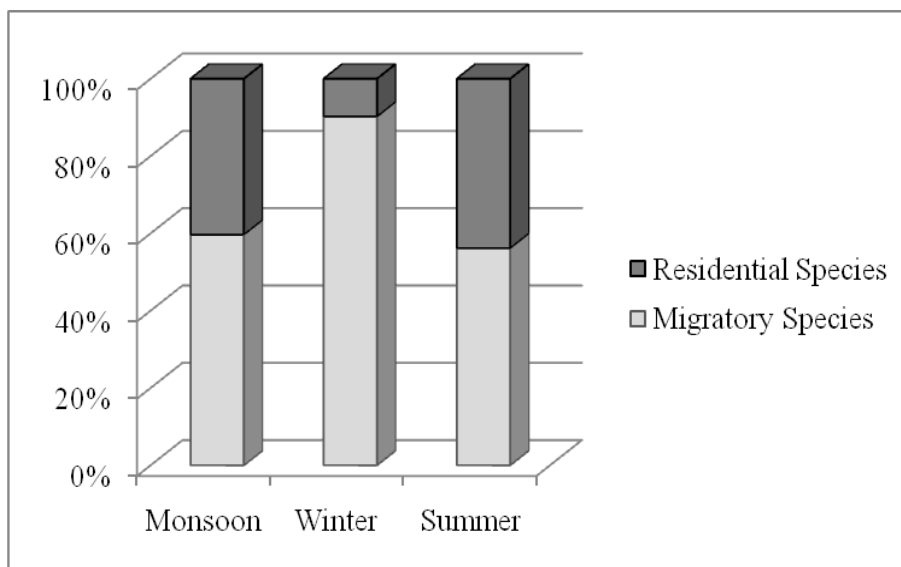


Figure 5: Proportion of Migratory and Residential species inhabiting Khodiyar pond during different seasons. (R=Residential Species; M= Migratory species of water birds at Khodiyar Pond)

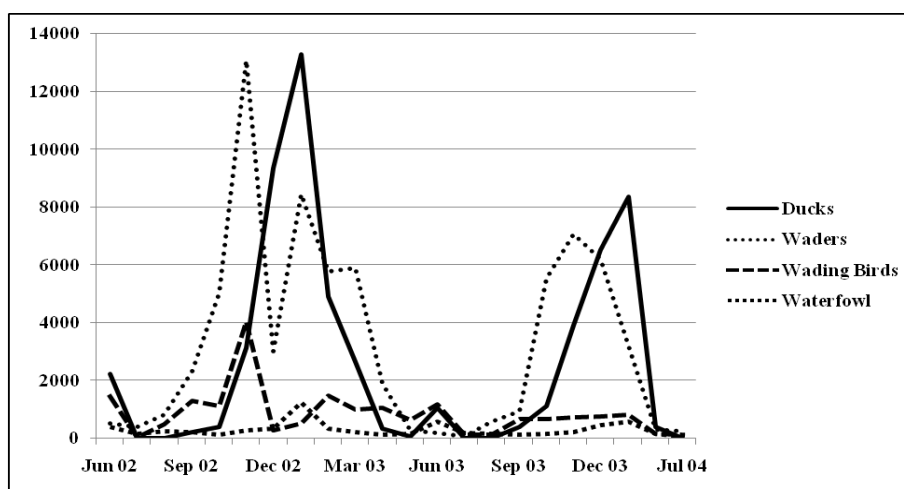


Figure 6: Seasonal Variations in the densities of Ducks, Waders, Wading birds and waterfowls at Khodiyar pond

Depth of pond varied from minimum 30.00 ± 12.29 cm to maximum 48.50 ± 11.53 cm during the study period. As the domestic effluents were discharged regularly this pond was never dry and too shallow to limit the birds. Though there were seasonal variations in the species richness and total density of birds these parameters were non-significantly correlated with the water depth ($P_{\text{Species Richness}}=0.0969$; $r^2=0.344$; $dF=9$; $P_{\text{Total Density}}=0.1625$; $r^2=0.2583$; $dF=9$) (Figure 7). pH value remained more or less constant during the study period (Figure 8) and varied from minimum 7.35 ± 0.028 to maximum 7.72 ± 0.025 . D. O. of water varied between minimum 2.075 ± 0.047 mg/L to maximum 3.8 ± 0.070 mg/L.

There was no significant seasonal difference in pH and D. O. of water, however the temperature differed significantly between three seasons, from minimum 17.0 ± 0.40 during winter to maximum 29.0 ± 0.50 during summer months (Figure 7). Species richness ($P_{\text{pH}}=0.8428$; $r^2=0.00601$; $dF=9$; $P_{\text{Temperature}}=0.786$; $r^2=0.0112$; $dF=9$; $P_{\text{D.O.}}=0.5702$; $r^2=0.0482$; $dF=9$) and density ($P_{\text{pH}}=0.6375$; $r^2=0.03348$; $dF=9$; $P_{\text{Temperature}}=0.9623$; $r^2=0.00034$; $dF=9$; $P_{\text{D.O.}}=0.9393$; $r^2=0.00089$; $dF=9$) of waterbirds were not significantly correlated with the chemical parameters of water.

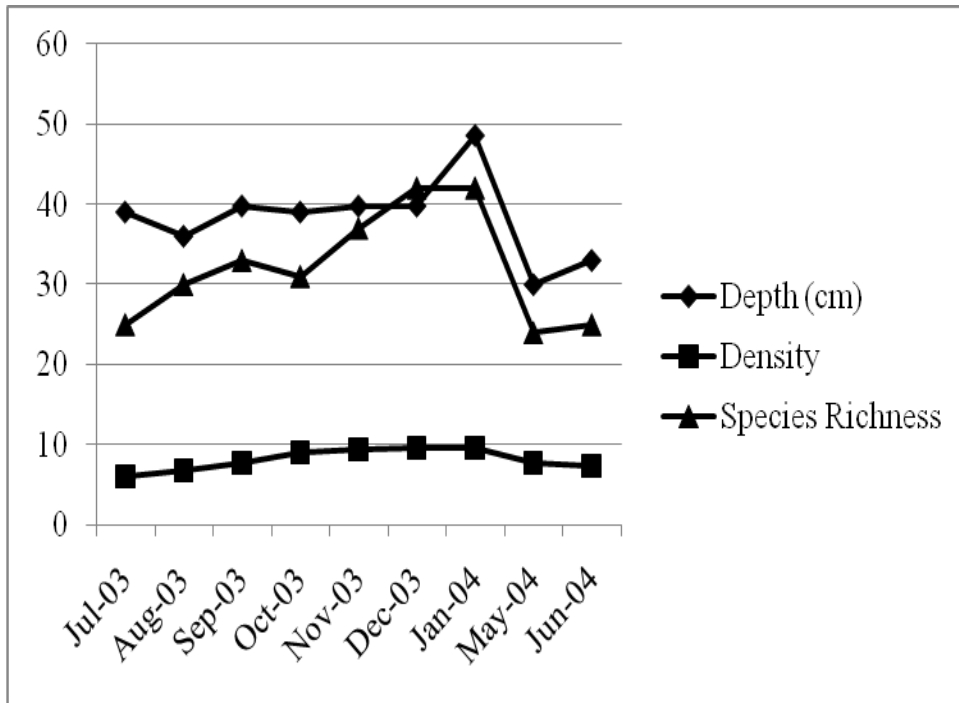


Figure 7: Depth of Pond, Species Richness and Total density of water birds at Khodiyar pond

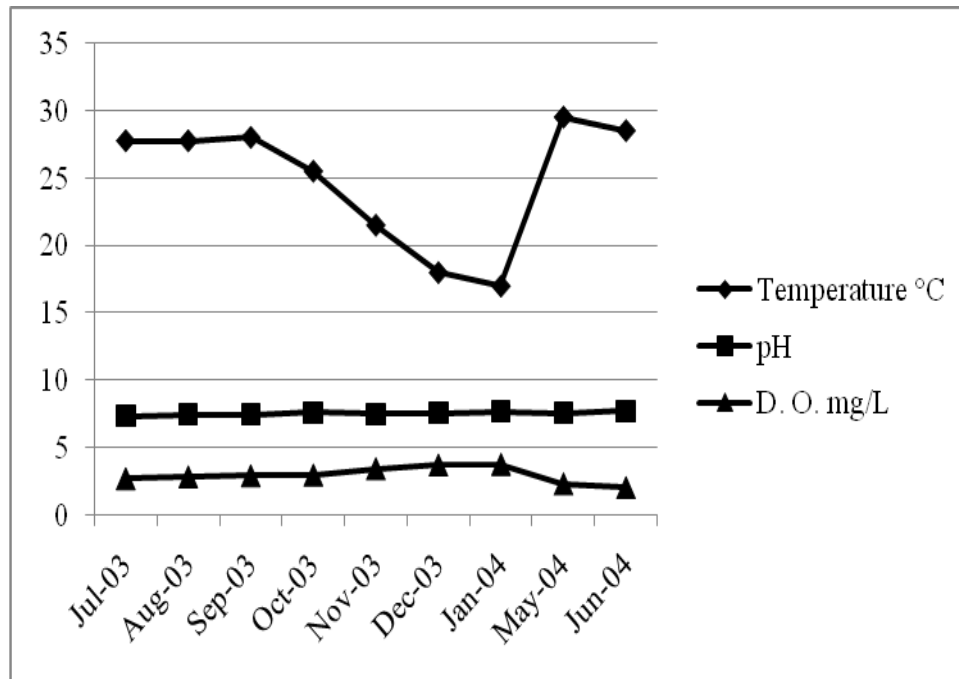


Figure 8: Variations in physicochemical parameters at Khodiyar pond

Waterbirds utilized the pond for feeding, roosting and nesting. Total nine and twelve species of birds were found nesting within and around the Khodiyar pond respectively (Table 1). The birds nesting within the pond used the vegetation such as *Eichornea*, *Typha* etc. for making nests.

Table 1: The species breeding within and around the Khodiyar pond

S. No.	Name of Species	Birds Breeding within the pond	Birds Breeding around the pond
1	Comb Duck <i>Sarkidiornis melanotus</i>	-	+
2	Lesser Whistling Teal <i>Dendrocygna javanica</i>	-	+
3	Night Heron <i>Nycticorax nycticorax</i>	-	+
4	Purple Heron <i>Ardea purpurea</i>	+	-
5	Pond Heron <i>Ardeola grayii</i>	+	-
6	Cattle Egret <i>Bubulcus ibis</i>	-	+
7	Large Egret <i>Ardea alba</i>	-	+
8	Smaller Egret <i>Egretta intermedia</i>	-	+
9	Little Egret <i>Egretta garzetta</i>	-	+
10	White Ibis <i>Threskiornis aethiopica</i>	-	+
11	Indian Black Ibis <i>Pseudibis papillosa</i>	-	+
12	Sarus Crane <i>Grus antigone</i>	+	-
13	Whitebreasted Waterhen <i>Amaurornis phoenicurus</i>	+	-
14	Indian Moorhen <i>Gallinula chloropus</i>	+	-
15	Indian Purple Moorhen <i>Porphyrio porphyrio</i>	+	-
16	Pheasant-tailed Jacana <i>Hydrophasianus chirurgus</i>	+	-
17	Bronzewinged Jacana <i>Metopidius indicus</i>	+	-
18	Redwattled Lapwing <i>Vanellus indicus</i>	+	-
19	Blackwinged Stilt <i>Himantopus himantopus</i>	-	+
20	Whitebreasted Kingfisher <i>Halcyon smyrnensis</i>	-	+
21	Wiretailed Swallow <i>Hirundo smithii filifera</i>	-	+

Present study supports the importance of sewage ponds for waterbirds. The birds used this pond for feeding, roosting and nesting. Shannon-Weiner Index and Evenness did not differ significantly between the three seasons. This suggests that the relative abundance and diversity of waterbird remained high and more or less constant throughout the study period. Seasonal variations in species richness and total density of waterbirds were attributed to influx of migratory ducks, waders and waterbirds during winter. There was no significant variation in the number of wading birds during different season, which suggest that they inhabited the pond throughout the pond. Hence, these results highlight the importance of sewage pond/waste treatment ponds for supporting the residential and migratory species.

Being located in the semi-arid zone, this part of the state faces the challenge of water scarcity. Most of the inland fresh water wetlands become either dried or too shallow during the summer season. Hence, very few wetlands remain available with sufficient water and fulfill the needs of waterbirds during summer. Moreover, seasonal differences in physicochemical parameters due to drying, become too high which affect the phytoplankton (primary productivity), food availability and ultimately the birds inhabiting them [14,15,16,17]. In such condition sewage ponds become very important habitat for large numbers of birds, even during the summer season due to the constant input of water along with the organic contents. Quality of water was important in determining the type of waterbirds at the pond. The pond supported large number of surface feeders and very few divers. The water of the pond remained was slightly alkaline, turbid and too shallow due to high organic contents to support the divers. Temperature was low during winter and high during summer, however never too extreme to limit the birds. D.O. was inversely related to

temperature. The results of present study support the previous findings of hydro-chemical parameters ^[18]. All the water parameters were found suitable to support the waterbirds throughout the study period.

Use of wastewater by waterbirds poses health risks for both birds and humans and may create microbial, chemical and mechanical hazards and these risks must be better understood ^[1]. Water from Khodiyar pond was drained twice during the annual study period, by the local people in response to the bloom in mosquito population, which made the pond too shallow and affected the bird population. Initially, after the construction of pond, the water surface remained fully covered by aquatic vegetation. Later on the vegetations were grazed by domestic buffalos. Hence, the pond was never fully covered by vegetation. This could be one reason for the difference in the total densities of waterbirds between the annual and monthly surveys. As loss of natural wetlands poses the challenge of conserving waterbirds, the sewage ponds provide good alternative habitat for supporting bird population. No other major health issues/decease was reported at this pond during the study period. However, specific studies on possible health hazards due to sewage pond should be conducted so the issues related to the health of birds and human can be overcome. Construction of sewage ponds with suitable design required for management of suitable catchment period, depth of water etc. to support the waterbird population without creating health hazards.

Conclusion

The present study provides evidence of sewage pond playing important role in supporting residential and migratory waterbird species in the semi-arid zone of Gujarat. Most of the inland wetlands in semi-arid zone become dry or too shallow and hence physicochemical parameters of such ponds change. This affects the phytoplankton density and ultimately the food chain of the ponds. Hence such inland wetlands become less suitable for waterbirds during summer season. Constant flow of water and organic contents in sewage treatment pond throughout the year make it significant for the waterbirds to be utilized for the whole year even during summer when other natural wetlands get dried up. All the species of waterbirds were evenly distributed and the increase in their density and species richness was attributed to the influx of migratory birds. Khodiyar pond is important feeding and nesting site for large number of waterbird species. Hence, this sewage pond plays key role in conservation of waterbirds. However, detail research on the health related issued should be done to avoid any hazardous condition.

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