SENRA Academic Publishers, British Columbia
Vol. 8, No. 2, pp. 2871-2900, June 2014
Online ISSN: 1920-3853; Print ISSN: 1715-9997

Canadian Journal of pure & applied sciences

EFFECT OF RIGHT BANK OUTFALL DRAIN (RBOD) ON BIODIVERSITY OF THE WETLANDS OF HALEJI WETLAND COMPLEX, SINDH

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ABSTRACT

In the present study, the effects of Right Bank Outfall Drain (RBOD) on the fauna of the wetlands were studied and inventories of the fauna and the flora were prepared. During the study period from 2007 – 2012, water samples taken from three sampling sites from the study areas viz., RBOD at Gharo, near Haleji Lake and near Keenjhar Lake were analyzed for physico-chemical parameters, pesticides and heavy metals. The mean salinity value of all sampling sites was recorded. RBOD at Gharo and RBOD near Keenjhar Lake showed high salinity value as per limit of World Health Organization standard. Water samples taken from RBOD near Keenjhar Lake showed pesticide OC compounds below the Maximum Acceptable Concentration (MAC). However, no serious adverse effects of environmental pollution were detected on the aquatic biodiversity except for some minor toxic effects due to the presence of heavy metals in water. Regarding biodiversity, two species of protozoans, 104 species of arthropods, 23 species of zooplanktons, 13 species of molluscs, 228 species of birds, 28 species of mammals, 31 species of reptiles, 2 species of amphibians and 59 species of fishes were recorded from the study areas. The biodiversity of RBOD is in decline mainly due to hunting, capturing, habitat destruction, cutting of trees, commercial fishing, anthropogenic activities and growing human population around the RBOD area.

Keywords: Right bank outfall drain, biodiversity of Sindh, environmental effects, threatened species.

INTRODUCTION

The province of Sindh forms the lower Indus basin and lies between 23^0 35' and 28^0 30' northern latitude and 66^0 42' and 71^0 10' east longitude (Khan *et al*., 2014). The different ecosystems of Sindh include wetlands, deserts, river, mangrove forests, agricultural and coastal areas. The River Indus act as a key source of water in Pakistan and majority of the population of Sindh depends on this River. There are many canals and barrages coming out of this River and giving lives to wetland birds all over the Sindh (Yahya, 2007). Sindh estuarine and coastal wetlands serve as nursery grounds for the lobsters, shrimps and fish. Each year during the migration season, over one million of water birds belonging to 108 species, visit Sindh wetlands (Khan, 2006). Thatta is an important district of Sindh Province due to its wetlands, Wildlife Protected Areas and Cultural Heritage Sites. Right Bank Outfall Drain at Gharo Creek, near Haleji Lake and near Keenjhar Lake all in Thatta district were selected for the present study (Figs. 1 and 2). In Sindh, after the Left Bank Outfall Drain project, the Right Bank Outfall Drain is the second biggest project.

Right Bank Outfall Drain

Presently, Pakistan is facing two big problems which are salinity and water logging and to resolve these issues many measures have been taken in Sindh. Right Bank Outfall Drain is a major measure which was carried out on the right bank of the Indus. Right Bank Outfall Drain is a long term project to drain out sewerage and water from towns and agricultural lands on the right bank of the River Indus. It carries effluents from the upper Sindh and adjacent areas of Balochistan and these are ultimately drained into the Arabian Sea. The RBOD is planned to take care of saline water and to dispose off directly into the Sea. But at present, since there is no outlet, the saline effluents flowing through main Nara Valley Drain are discharged as per force into Manchar Lake and Hammal Lake. This saline water contains agricultural waste like fertilizers, pesticides and domestic sewage, and these effluents have degraded and spoiled both the lakes. Currently, the Government has designed to outfall the poisonous effluent directly into the Sea through Gharo Creek.

The disposal of saline effluents into river near Sehwan causing risk for the peoples of Karachi, Hyderabad and small towns who draw their drinking water requirements direct from River Indus and Canal system of Keenjhar Lake. Presently, the effluent from the RBOD is disposed into Manchhar Lake. The principal features of the wetlands to be affected by the RBOD passing nearby, have been underlined below:

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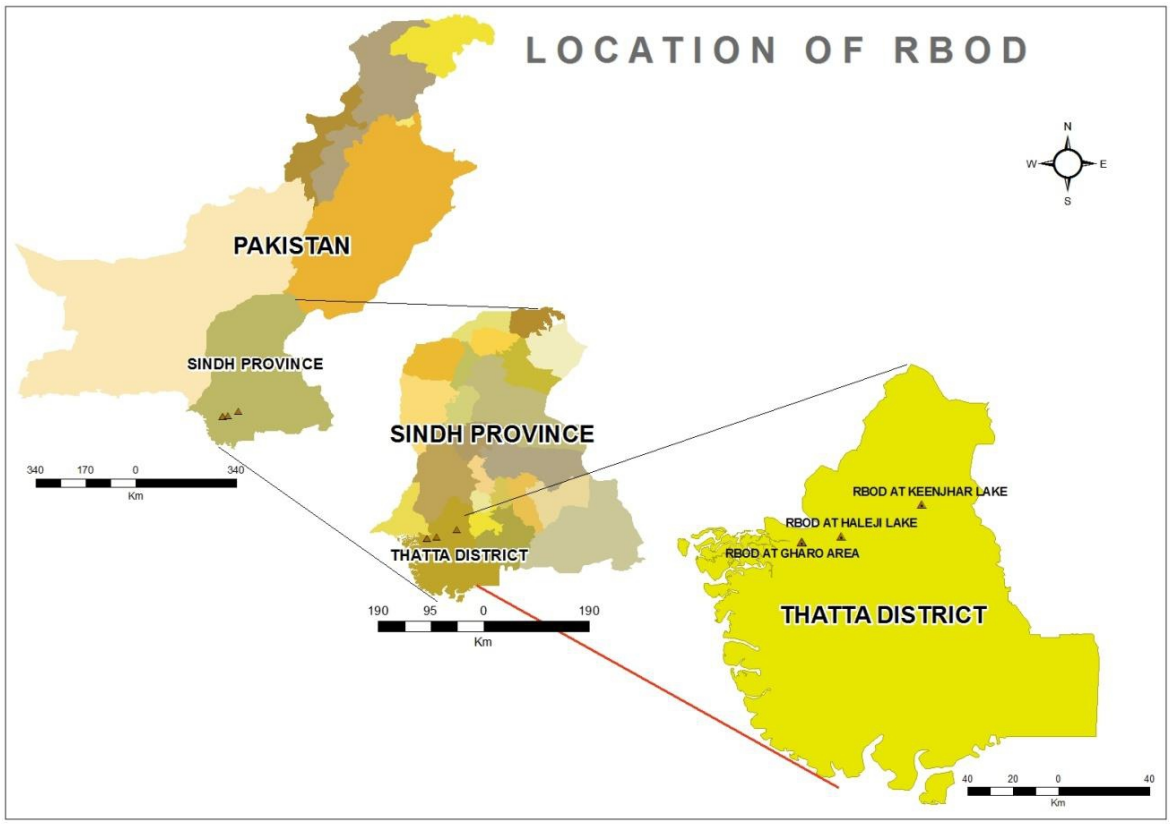

Fig. 1. Map showing study areas of RBOD.

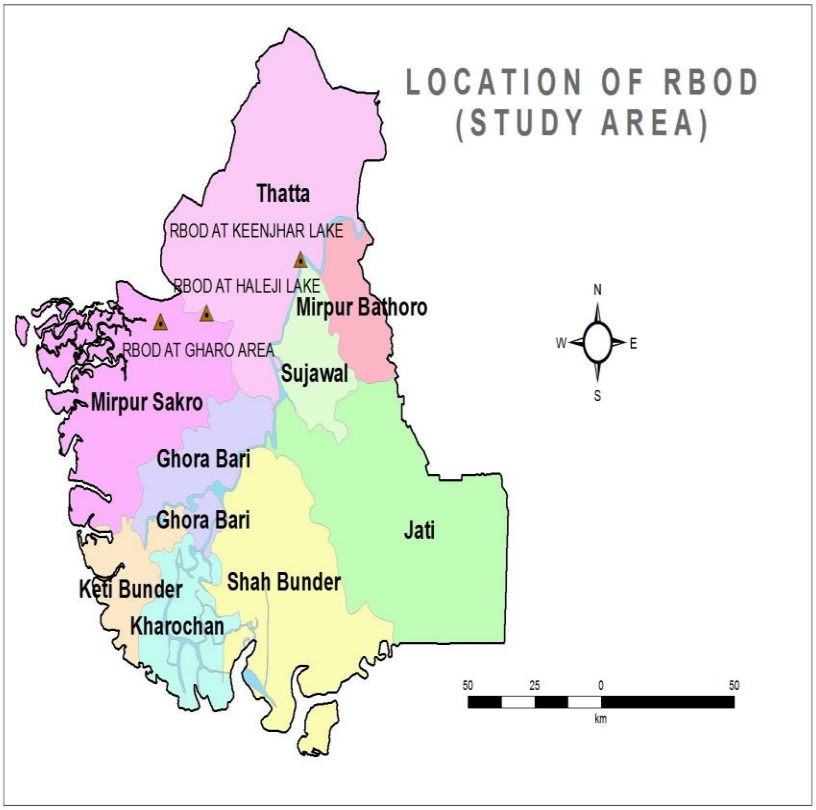

Fig. 2. Map of District Thatta showing the study areas.

1. Gharo Creek

Gharo Creek is located at 67° 11' E and 24° 47' N. It is about 5.5km long, 500m wide with a minimum depth of 7.5 meters and maximum depth of 17 meters. The total surface area of Gharo Creek is about 64,370ha (Fig. 3). It is placed towards the south east of Karachi. On the southern part of Gharo Creek are mangroves, as the western part is mostly reclaimed area for Port Qasim facility. The total length of Gharo Creek is about 30km and the total wastewater generation is about 30,000-35,000 gallons/day, which is discharged into the Sea without any treatment. In addition the bank of the creek is also used as a solid waste dumping site. Several pathogens, nutrients and chemicals that come along with the waste matter of Gharo city are not only detrimental to aquatic life, but also result in reduced biodiversity (Ahmed, 1995). The area near the city is also used for agricultural purpose. The agriculture runoff contains large amount of pesticides that ultimately find their way to the creek (Khan *et al*., 2004). Gharo Creek is a mangrove area, which provides nutrient requirements for species of shrimp and fish, and provides protection from storms and also provides excellent opportunities for research and development work.

2. Keenjhar Lake (Ramsar Site)

Keenjhar Lake is located on 68° 03' E, 24° 56' N, about 19 km North–East of Thatta town and 100 km away from

Fig. 3. View of RBOD at Gharo area.

Fig. 4. RBOD area near Keenjhar Lake.

Fig. 5. RBOD area near Haleji Lake.

Karachi. The Lake has an area of 13,468ha and the largest sweet water reservoir in Sindh and supplies water to the villages around the lake, and to Karachi city, Keti Bunder and Thatta. The maximum depth of the lake is 8m, it is also a Wildlife Sanctuary. The lake is associated with adjacent brackish seepage lagoons and marshes which are in a stony desert and made up of alternating layers of sandstone and limestone (Khan *et al*., 2012b).

RBOD near Keenjhar Lake

The RBOD flows approximately 3.5 kilometers away from the southern tip of Keenjhar Lake. After crossing Nai-Baran, the Drain is going through riverine area, keeping it on East of Keenjhar Lake between K.B. Feeder Link Canal and Indus River (Fig. 4). Keenjhar Lake is also a significant fish providing point.

3. Haleji Lake (Ramsar Site)

Haleji Lake (Wildlife Sanctuary) is located at 67°46' E and 24°47' N about 21km from Thatta and 88 km from Karachi. The lake is spread upto an area of 1,704ha with the level of water about 1-1.5m and maximum depth is 5-6m. Haleji Lake is a perennial fresh water lake associated with marshes and adjacent brackish seepage lagoons, set in a stony desert of limestone and sandstone bedrock (Khan *et al*., 2012b). In the late thirties, it used to be a shallow depression, which was converted into a freshwater reservoir by draining of saline water, building of embankments around the lake and filling its tip by Jam Branch Canal carrying water from Keenjhar Lake, which has remained the principal source of water. Haleji is well known for its Pelican and Cormorant Islands. It is also a breeding area of Herons and Egrets and many other birds. Presently it is infested with aquatic weeds and major portion is covered with aquatic grass.

RBOD near Haleji Lake

Presently, the RBOD flows along the edge of Haleji Lake with a discharge of 330 cusecs and a depth of 13 to 15 ft of water just 3 to 4 ft below ground level (Fig. 5). The RBOD drain has a common ground and flows very close to Haleji Lake the distance between RBOD and Haleji Lake hardly 50 to 100ft. The water level is 20-30 ft below the level of the lake area. Due to very short distance from RBOD, Haleji Lake may be affected by the seepage of its water to the drain. So as the ongoing construction work of RBOD may cause degradation in the area of Haleji Lake (Khan *et al*., 2012b).

4. Hadero Lake

Hadero Lake is located at 67° 52' E and 24° 49' N, about 10km northwest of Thatta town and 85 km away from Karachi, and having an area of 1,321ha. The lake is not deeper than 1.7m. The Lake is situated between the Haleji and Keenjhar Lakes. The substratum is made up of alternating layers of sandstone and limestone with rocky and sandy western and northern shores, bounded by stony desert. The lake is fed by the SLM drain, which links up through the Jam branch canal, and by a number of seasonal streams entering on the north shore. Its main source of water is the runoff from the surrounding catchment, there is no outlet. Hadero Lake is important for Ducks, Coots, Pelicans, Flamingoes and birds of prey. However, it has drastically dropped due to pollution and hunting. The RBOD stretching from Sehwan to Gharo Creek in the Arabian Sea is passing nearby in this lake for a distance of 2.3 canal miles. Presently the supply of drain water to Hadero Lake has been out off and the drain water now into the RBOD channel passing nearby with the result that the water level in the Hadero has gone down and the fauna has been affected (Gabol *et al.*, 2005). The

fishery is the main source of income of the residents who are living near the Lake.

MATERIALS AND METHODS

Study Areas

The following 20 important areas were selected for the present study (Table 1).

Table 1. Wildlife Habitats in RBOD study areas.

S. No.	Name of study area	Co-ordinates
1.	RBOD at Gharo	24 44 26.6 N 67 35 35.1 E 24 44 25.8 N 67 35 31.4 E 24 44.438 N 67 35.523 E 24 44.419 N 67 35.490 E 24 44.461 N 67 35.546 E
2.	RBOD near Haleji Lake	24 45 43.12 N 67 44 48.87E
3.	Haleji Lake Turning Point	24 44 22.38 N 67 44 40.65 E
4.	Main Haleji Lake	24 47 14.39 N 67 45 24.93 E 24 47.243 N 67 45.421 E
5.	Near Haleji Information Centre	24 47 12.2 N 67 47 24.0 E
6.	Near Haleji Rest House	24 49. 161 N 67 46. 171 E 24 47. 446 N 67 44. 940 E
7.	Haleji Seepage Lagoon/Villages	24 49 19.3 N 67 45 36.7 E
8.	Near Haleji Regulator	24 49 19.3 N 67 47 58.0 E
9.	10km from Makli towards Keenjhar Lake	24 44.600 N 67 47.728 E
10.	RBOD near Keenjhar Lake	24 53 25.50 N 68 03 54.86 E
11.	Keenjhar Information Centre	24 53 45.74 N 68 03 10.39 E 24 53 46.20 N 68 03 11.12 E
12.	Keenjhar Main Lake Area	24 54 990 N 68 04 387 E 24 58.378 N 68 05.566 E 24 54.657 N 68 06.501 E 25 06.628 N 68 07.636 E
13.	Keenjhar Reservoir Area	24 54.40 N 68 04.21 E
14.	Chiliya	24 50 190 N 68 00 081 E
15.	Jhimpir	25 02.163 N 68 05.740 E
16.	Moldi	24 58.06 N 68 01.38 E
17.	Chakro	24 01 69.6 N 68 02 06.0 E
18.	Sonehri	25 01.067 N 68 07.877 E
19.	Adam Bhambhro	24 51.102 N 67 59.761 E
20.	K.B. Feeder Canal	25 02 21.7 N 68 07 55.2 E

Methodology of Physico-Chemical Samples Collection and Analysis

During the study from 2007-2012, conductivity meter was used for the estimation of Conductivity, Total Dissolved Solids, Turbidity, Salinity, and pH was recorded by pH meter. Alkalinity, Carbon dioxide and Phosphates were examined by the process of Acid Base Titration (Titrimetric methods), Total Hardness, Calcium, Magnesium and Chloride were analyzed by using EDTA (Complexometric Titration), Basic Oxygen Demand was examined by Incubation Method-Redox Titration, while Sulphate was analyzed by Gravimetric method, Nitrate was analyzed by Brucine Colorimetric Method and Cadmium, Chromium, Lead and Nickle were analyzed by atomic absorption spectro-photometric method (WHO, 1982, 1993).

Methodology for Vertebrates

Mammals

The mammals were identified by Roberts (1997, 2005a, b).

Roadside Counts

In this method motor vehicles have been used along the road trails while the sighted number of individuals of the species being estimated is tallied and related to the number of kilometers travelled (Brower *et al*., 1990). Roadside counts methods have some advantaged, such as: traveling on a vehicle does not disturb the animals and there is a chance to observe the animals along the road / track from a few meters distance. Other advantages of this method are large areas can be covered in passage of short time and easily using only two persons and a vehicle (Khan *et al*., 2012b, c).

Tracks Counts

Track counts have been used for locating and recording the presence of animals.

Pellet Counts

This technique involves removing all pellet groups from plots and then estimating from subsequent observations on those plots the number of groups per hectare to compare animal use of the area between sampling periods.

Small Mammals

One effective way to survey small mammals is active searching. This method is equally applicable to both nocturnal and diurnal species in potential and suitable micro habitats along the canal banks, open plains, particularly in bushy areas and agriculture fields. Active searching is very effective for inventory of *Gerbillus, Meriones, Hystrix,* and *Hemiechinus* spp.

A mixture of different food grains mixed with fragrant seeds may be used as bait for the attraction of the small mammals. Wheat and rice are used as food grain while peanut butter, coriander, oats and onion are used for fragrance. This bait is found to be highly successful in the study area probably due to the overall food shortage and fragrance.

Traps and trapping procedure

Sherman traps are used to collect the live specimens. Fifty traps are set in a specific area on a line approximately 500 m long and approximately 10m apart. Each trap was marked by a colorful ribbon to locate the traps easily. The traps are set in the afternoon and checked early in the morning. The specimens are transferred into polythene bags and were identified in the field and released.

To investigate nocturnal species, night surveys are conducted in exposed areas of potential habitats on the ground. This methodology involves the use of a powerful torch light, sticks, long boots and gloves etc.

Birds

For field identification of birds, field guides such as Grewal *et al*. (2002), Grimmett *et al*. (1998) and Kazmierczak (2000) was used. Secondary data on the overall status of the birds recorded from RBOD were taken from Grimmett *et al*. (1998) and Roberts (1992). Each major habitat type in the study area was identified and surveys were made to record the species of birds found in each discreet habitat such as lakes, canals, ponds, marshes, forest, agriculture fields, vicinity of human habitation and fallow lands. The number of birds observed in each habitat type was also recorded with particular emphasis on the key species and relate the data to other components of the study area such as vegetation, water and soil, etc. The most commonly used field methods in birds surveying is the "Line Transects" method. It is based on recording birds continually along a predefined route within a predefined survey unit. It can be used in terrestrial, freshwater and marine systems to survey individual species, or group of species. It is to examine birds - habitat relationships and to derive relative and absolute measures of bird abundance.

Line Transects are suitable for extensive, open and uniform habitats and for large and conspicuous species. Double counting of birds becomes a minor issue as the observer is continually on the move. Line Transects are suited to situations where access is good and these are very useful for bird-habitat studies (Khan *et al*., 2010; Khan *et al*., 2012b,c).

In the present studies, each sample area was transversed examined by 2 observers separately; birds were searched on each side of the strip for 150m so that each study strip was 300m wide. To evaluate the numbers of water birds utilizing a site, whether from a stationary point or by moving through the area, we used binoculars or a telescope.

Reptiles and Amphibians

Various survey techniques have been employed for the observation of reptiles and amphibians (Khan *et al*., 2010; Khan *et al*., 2012a,b,c).

A. Direct Counting

One-hour Plot Searching

This consists of searching approximately 20ha (with a 250 meter radius of sampling points) for one hour exactly and recording the number of individuals of each species seen. Similarly, night survey was done with the help of search lights and torches.

Pitfall Traps

Reptiles and amphibians were also detected using a line or pitfall traps. Each pitfall line consists of 30meters of low, flexible nylon fencing pinned to the ground to divert the movements of small ground dwelling animals, mainly reptiles with six 3-liter meter bucket buried in the ground with its lips at ground level along and below the fence, so that the fence straddled each bucket. The use of pitfall lines are restricted to sites where the ground surface is soft enough to dig or sandy areas. Pitfall lines are set for one night only. Team members reach early in the morning before sunrise and record the total number of reptiles of each species found in the bucket.

Turning of Stones, Rocks and Rotten Trees Process

Nocturnal reptiles and amphibians take shelter or rest hiding themselves under the space of stones or rocks. Therefore, in the day time survey, stones or rocks or rotten fallen trees are turned to locate and record the presence of species (Auffenburg and Rahman, 1991).

Study of Basking Behavior

This method of sighting or locating Crocodiles is the most suitable, but it is applied mostly in the winter season. In winter, the temperature of the water of the water bodies becomes very low. Crocodiles come outside the lake for enjoying sunshine to keep themselves warm. Thus, the counting of crocodiles becomes very easy at a particular area during this season.

B. Indirect Counting

Presence of signs like fecal pellets, tracks, den or tunnels (egg laying excavation)

Evidences from the impression of a finger or foot prints, or tail, the presence of fecal pellets, tracks and existence of tunnels (egg laying excavation) help a lot for finding the existence and range of reptilian fauna.

Fish Collection Technique

The methods used for obtaining the representative sample of fish fauna are the gill netting and cast netting. A standard length of a 200m covering maximum of representative habitats, was used to obtain a representative sample (Khan *et al*., 2012b,c).

Gill Netting

Three nets were used for gill netting, each measuring 15m length with mesh size 2.5x2.5cm and 1.5x1.5cm. Usually the gill nets were used in the morning.

Cast Netting

Cast nets with identified circumference were casted in a stretch of 200m. Five cast nets were used on a line at different stations along the bank of the reservoir. Fish fauna were collected and identified and released after identification. The data collected through the two methods was pooled and called as the representative sampling of the study site.

Methodology for Surveys of Invertebrates

Protozoans

Sterilized screw capped glass bottles were used for the collection of samples from the selected study areas. Samples were quickly transferred and readily brought to the laboratory for analysis. The samples were kept at room temperature.

The protozoans were identified through shape, body structure, external features, locomotion and behavior (Edmondson, 1966; APHA 1992; Curds, 1982; Curds *et al.*, 1983).

Survey of Terrestrial Macroinvertebrates

Collection protocols, and standardizing procedures

Specimens belonging to diverse groups of Invertebrates were collected from the various localities of the selected study areas using a variety of collection protocols and techniques.

Sampling Methods for Flighted Terrestrial Macroinvertebrates

Traditional insect hand net

Insects were found upon the bushes, in grasses and on the bark of trees. With the help of traditional insect hand net the insects were collected.

Light trap

This method is used for nocturnal flying insects. The essential light trap comprised an electric bulb, a white sheet as a reflective surface and a funnel to collect insects; insects were collected close to the light source.

Sticky traps

This method is used for flying insects. Range of substrates (e.g. plates, dishes) coated in long-lasting glue. The efficacy of the traps was increased by the use of different colors, mostly depending on target species. Insects were removed from trap using solvents.

Yellow pan traps

This method is used for an extensive variety of insects. Simple method based on a yellow pan (mostly yellow color attracts insects) with vertical baffles the pan was then placed on the ground and added one or two drops of detergent to reduce water tension. Insects were attracted to container and just go down in the water. After the collecting period sieve the catch to remove the liquid and then transferred the contents to a long-term storage preservative such as ethanol.

Sampling Methods for ground dwelling Macro-invertebrates

Hand picking and use of forceps

Hand picking, through bare hands or with the help of long forceps, which has been adopted for the present studies, is by far the very productive method for capturing different groups of terrestrial invertebrates especially arachnids (spiders, solifugids) and myriopods etc.

Pitfall traps

This method is used for ground-dwelling invertebrates (e.g. ants, beetles, spiders). The ground-dwelling invertebrates were collected using pitfall traps. This is the most commonly employed sampling technique in biodiversity inventories. It is used for collecting invertebrates that move along the ground.

Shaking and beating

This method is used for leaf beetles, weevils and Lepidoptera larvae. This is the most widely used method for collecting invertebrates associated with plants. It was used to sample any part of the plant, including branches, leaves, flower heads and even dead wood. A sheet or beating tray is laid out under the plant which is then shaken and beaten and the dislodged invertebrates are collected quickly before they escaped.

Sweep nets

It is an inexpensive and usually used means of sampling invertebrates from vegetation. The net was swang a set number of times through ground vegetation (grass and shrubs), as pacing. To prevent invertebrates escaping the

mouth of the net was closed as soon as sweeping was completed.

Sampling Methods for Aquatic invertebrate fauna

For aquatic invertebrates, several sampling methods have been used which are as follows:

Plankton net and drag nets/dip nets

The target group is zooplankton and other aquatic invertebrates. The dip netting is the better way to discover macro-invertebrates like stoneflies, dragon flies, damsel flies, mayflies, water mites, water beetles, water striders, water boatman and water pennies, which are abundant in the water.

Random sampling

Zooplanktons are unequally distributed over wide space and time scales in the water bodies. As it was not possible to sample all of the zooplankton from the lakes and other reservoirs using a single collection method, random sampling was used as the probable procedure in which each and every species has the equal chance and probability to be caught during sampling. Every individual is chosen entirely by chance and the likelihood of a biased data collection is thus reduced.

Precautions in field

Sample labels were accurately completed, including sample ID, date, reservoir name, collecting location, sampler's name and placed into the sample container. All nets, pans and trays were rinsed properly after sampling at a given site, picked and examined free of organisms or debris. Remaining organisms were placed in the sample containers.

Preservation and storage of the specimens

All invertebrate specimens, including the zooplankton were preserved by the addition of grades of 70% ethyl alcohol and formaldehyde. These fluids suffice to preserve the samples indefinitely and in addition have the effect of sending all the plankton to the bottom of the jar. All zooplankton are delicate and simply get damaged,

Table 2. Water quality analysis of RBOD study areas during 2007- 2012.

Parameters	Average Pre-monsoon					Average Post-monsoon				
	2007	2008	2009	2011	2012	2007	2008	2009	2011	2012
Colour	A	A	A	A	A	A	A	A	A	A
Odour	O	O	O	O	O	O	O	O	O	O
Water Temperature (°C)	28	29	30	29	30	17.66	17.33	17	18	19
Air Temperature (°C)	31.33	32.33	33.33	32.33	33	20.66	20.33	20	21.33	22.66
Conductivity (µs/cm)	1940.66	1792	1755.33	1024.66	1934	3428.33	3005.66	3146.33	3457.66	3159
TDS (mg/l)	1086	1075.33	1009.33	995	1035	2057	2030.33	2010.33	1990.33	1990.33
pH	7.786	7.782	7.77	7.77	7.115	7.803	7.801	7.79	7.785	7.799
Turbidity (NTU)	1.58	1.61	1.21	0.82	1.03	2.95	2.71	2.54	2.09	1.38
Alkalinity (mg/l)	202.33	197.66	196.33	195	201.33	117.66	114.66	113	117.66	116.66
Total Hardness (mg/l)	589	566	543.66	537.66	577	555.66	533.33	510.66	493.33	557.66
Salinity (mg/l)	6.13	6.06	5.83	5.66	5.66	5.2	5.03	4.73	4.53	4.83
BOD (mg/l)	4.65	4.58	4.06	3.99	3.44	5.40	5.33	5.22	5.16	4.07
Carbon dioxide (mg/l)	1.33	1.33	1.33	1.66	1.33	1.33	1.66	1.66	1.33	1.33
Calcium (mg/l)	104.04	102.7	101.69	100.01	100.01	75.35	74.01	73.00	71.33	71.33
Magnesium (mg/l)	541.45	504.03	500.40	494.76	501.42	525.99	519.26	513.94	508.69	486.33
Sulphates (mg/l)	135.33	125	114.66	101	98.33	185.33	174	226.66	213	142.66
Chloride (mg/l)	692.66	683	671	661.66	656.66	666	656	640.66	632.66	642.66
Nitrates (mg/l)	0.210	0.205	0.202	0.198	0.170	0.192	0.189	0.185	0.179	0.150
Phosphates (mg/l)	0.87	0.90	0.85	0.80	0.87	0.61	0.56	0.54	0.506	0.57
Cadmium (mg/l)	0.007	0.006	0.005	0.003	0.002	0.009	0.007	0.008	0.006	0.010
Chromium (mg/l)	0.044	0.041	0.043	0.041	0.022	0.054	0.052	0.053	0.052	0.054
Lead (mg/l)	0.82	0.79	0.85	0.84	0.96	0.83	0.77	0.80	0.68	0.82
Nickel (mg/l)	0.72	0.55	0.51	0.59	0.89	0.79	0.69	0.66	0.69	0.84

therefore sample handling was gentle. It is advisable not to concentrate the sample too much. Zooplanktons were sub-sampled by adding water to bring the samples to a known volume (500 or 1000ml). The concentrated samples were then stored in appropriate bottles and plastic screw tapped jars. The place of origin, date, mesh-size of the net, length and depth of the haul were written permanent ink on quality paper and placed in the jar as the labels outer surface usually peel off after some time.

Counting and studying the zooplankton

The volume of the zooplankton was determined by the displacement method. First, the total volume of the concentrated sample in addition the preserving fluid was measured. Then the plankton was filtered off, by a filter paper in a funnel, and the volume of the filtrate is measured. The volume of the plankton was then obtained by the difference between the two volumes. A measure of the total catch was also prepared by weighing the filtered plankton. One ml of the concentrated sample may include so many organisms that it would be not easy to count them. Diluted 1ml sample to 100ml and then from it 1 ml was in use. Identification and counting the samples was completed under a dissecting microscope with dark-field illumination. Staining was not essential, although a drop of glycerin was put on each individual specimen isolated from the jar in order to avoid any damage to the samples.

RESULTS

Physico-chemical Parameters of RBOD

During 2007-2012, several standard physico-chemical parameters were analyzed to determine water quality, pollution, Temperature, Conductivity, Total Dissolved Solids, pH, Turbidity, Alkalinity, Total Hardness, Salinity, Basic Oxygen Demand, Carbondioxide, Calcium, Magnesium, Sulphate, Chloride, Nitrate, Phosphate, Cadmium, Chromium, Lead and Nickel were selected for the analysis of water quality. Parameters were analyzed seasonally. The water temperature in pre-monsoon was observed from 27 to 32°C, while in post monsoon, it varied from 16 to 20°C (Table 2).

Bioecological Studies

There are 2 protozoans species (Table 3), 104 species of arthropods (Table 4), 23 species of zooplanktons (Table 5), 13 species of molluscs (Table 6), 28 species of mammals (Table 7), 228 species of birds (Table 8), 31 species of reptiles (Table 9), 2 species of amphibians (Table 10), 59 species of fishes (Table 11) were recorded.

Species Status

Mammals

In the RBOD study area Palm Squirrel (*Funambulus pennantii*), Indian Desert Jird (*Meriones hurrianae*), Indian Gerbil (*Tatera indica*), Balochistan Gerbil (*Gerbillus nanus*), House Mouse (*Mus musculus*) and Roof Rat (*Rattus rattus*) were recorded as common species. While, Small Indian Civet (*Viverricula indica*) (Fig. 6), Desert Fox (*Vulpes vulpes*) (Fig. 7) were observed as rare species. The threatened species of mammals in the area include Fishing Cat (*Prionailurus viverrina*), and Smooth-coated Indian Otter (*Lutrogale perspicillata*).

Fig. 6. Small Indian Civet (*Viverricula indica*).

Fig. 7. Desert Fox (*Vulpes vulpes*).

Birds

Among birds, 262 species in all have been recorded. During the present study, 228 species of birds have been recorded (Table 8). The threatened bird species of the area are Pallas's Fishing Eagle (*Haliaeetus leucoryphus*) (Fig. 8), Ferruginous Duck (*Aythya nyroca*) (Fig. 9), Imperial Eagle (*Aquila heliaca*) (Fig. 10), Lesser White-fronted Goose (*Anser erythropus*) (Fig. 11), Egyptian Vulture (*Neophron percnopterus*) (Fig. 12), White-backed Vulture (*Gyps bengalensis*) (Fig. 13), Cotton Teal (*Nettapus coromandelianus*) (Fig. 14), White Stork (*Ciconia ciconia*) (Fig. 15), Marbled Teal (*Marmaronetta angustirostris*) (Fig. 16), White Ibis (*Threskiornis melanocephala*) (Fig. 17), Dalmatian Pelican (*Pelecanus crispus*) (Fig. 18), and Black-bellied Tern (*Sterna acuticauda*) (Fig. 19).

Fig. 8. Pallas's Fishing Eagle (*Haliaeetus leucoryphus*).

Fig. 9. Ferruginous Duck (*Aythya nyroca*).

Fig. 10. Imperial Eagle (*Aquila heliaca*).

Fig. 11. Lesser White-fronted Goose (*Anser erythropus*).

Fig. 12. Egyptian Vulture (*Neophron perenopterus*).

13. White-backed Vulture (*Gyps bengalensis*).

Fig. 14. Cotton Teal (*Nettapus coromandelianus*).

Fig. 15. White Stork (*Ciconia ciconia*).

Fig. 16. Marbled Teal (*Marmaronetta angustirostris*).

Fig. 17. White Ibis (*Threskiornis melanocephala*).

Fig. 18. Dalmatian Pelican (*Pelecanus crispus*).

Fig. 19. Black-bellied Tern (*Sterna acuticauda*).

Table 3. List of Protozoans recorded from RBOD study areas.

S. No.	Order	Family	Scientific Name
1.	Euglenoidina	Euglenaceae	*Euglena* sp.
2.	Volvocales	Volvocaceae	*Volvox* sp.

Table 4. List of Arthropods recorded from RBOD study areas.

S. No.	Order	Family	Scientific Name
1.	Hemiptera	Alcyrodidae	*Aleurolobus barodensis*
2.	Hemiptera	Alcyrodidae	*Neomaskellia* sp.
3.	Hemiptera	Pyrrhocoridae	*Dysdercus cingulatus*
4.	Hemiptera	Pentatomidae	*Bagrada picta*
5.	Hemiptera	Pentatomidae	*Scotinophara limosa*
6.	Hemiptera	Alydidae	*Leptocorisa acuta*
7.	Hemiptera	Aphididae	*Microsiphum granarium*
8.	Hemiptera	Aphididae	*Myzus persicae*
9.	Hemiptera	Diaspididae	*Aspidiotus* sp.
10.	Hemiptera	Pseudococcidae	*Pseudococcus saccharicola*
11.	Hemiptera	Pseudococcidae	*Icerya* sp.
12.	Hemiptera	Pseudococcidae	*Ripersia sacchari*
13.	Hemiptera	Diaspididae	*Aspidiotus* sp.
14.	Hemiptera	Lophopidae	*Pyrilla perpusilla*
15.	Hemiptera	Cicadellidae	*Nephotettix* sp.
16.	Hemiptera	Jassidae	*Idiocerus atkinsoni*
17.	Hemiptera	Lygaeidae	*Cavelarius excavatus*
18.	Hemiptera	Cicadellidae	*Nephotettix virescens*
19.	Hemiptera	Cicadellidae	*Amrasca devastans*
20.	Hemiptera	Cicadellidae	*Jacobiasca signata*
21.	Hemiptera	Cicadellidae	*Jacobiasca* sp.
22.	Hemiptera	Delphacidae	*Sogata distincta*
23.	Hemiptera	Delphacidae	*Sogatella furcifera*
24.	Hemiptera	Delphacidae	*Nilaparvata lugens*
25.	Hemiptera	Tingidae	*Urintius sentis*
26.	Hemiptera	Nepidae	*Nepa* sp.
27.	Hymenoptera	Apidae	*Apis* sp.
28.	Hymenoptera	Tenthridinidae	*Athalia proxima*
29.	Isoptera	Termitidae	*Odontotermes assmuthi*
30.	Isoptera	Termitidae	*Microtermes obesi*
31.	Thysanoptera	Thripidae	*Thrips oryzae*
32.	Thysanoptera	Thripidae	*Thrips tabaci*
33.	Thysanoptera	Thripidae	*Scirtothrips dorsalis*
34.	Lepidoptera	Arctiidae	*Amsacta lactinea*
35.	Lepidoptera	Noctuidae	*Sesamia inferens*
36.	Lepidoptera	Noctuidae	*Thysanoplusia orichalcea*
37.	Lepidoptera	Noctuidae	*Mythimna loreyi*
38.	Lepidoptera	Noctuidae	*Mythimna separata*
39.	Lepidoptera	Noctuidae	*Spodoptera exigua*
40.	Lepidoptera	Noctuidae	*Spodoptera litura*
41.	Lepidoptera	Noctuidae	*Agrotis ipsilon*
42.	Lepidoptera	Noctuidae	*Plusia* sp.
43.	Lepidoptera	Noctuidae	*Agrotis spinifera*
44.	Lepidoptera	Noctuidae	*Ochropleura berculea*

continued…

Table 4 continue

S. No.	Order	Family	Scientific Name
45.	Lepidoptera	Noctuidae	*Autogropha nigrisigna*
46.	Lepidoptera	Pyranstidae	*Leucinodes orbonalis*
47.	Lepidoptera	Plutellidae	*Plutella xylostella*
48.	Lepidoptera	Papilionidae	*Papilio demoleus*
49.	Lepidoptera	Pieridae	*Pieris brassicae*
50.	Lepidoptera	Pieridae	*Pieris rapae*
51.	Lepidoptera	Pyralidae	*Bissetia steniella*
52.	Lepidoptera	Pyralidae	*Chilo suppressalis*
53.	Lepidoptera	Pyralidae	*Chilo infuscatellus*
54.	Lepidoptera	Pyralidae	*Chilo partellus*
55.	Lepidoptera	Pyralidae	*Emmalocera depressella*
56.	Lepidoptera	Pyralidae	*Scirpophaga incertulas*
57.	Lepidoptera	Pyralidae	*Scirpophaga nivella*
58.	Lepidoptera	Pyralidae	*Scirpophaga innotata*
59.	Lepidoptera	Pyralidae	*Scirpophaga* sp.
60.	Orthoptera	Acrididae	*Oxya* sp.
61.	Orthoptera	Acrididae	*Acridella nasuta*
62.	Orthoptera	Acrididae	*Acrotylus insubricus*
63.	Orthoptera	Acrididae	*Hieroglyphus* sp.
64.	Orthoptera	Acrididae	*Chrotogonus* sp.
65.	Orthoptera	Acrididae	*Chrotogonus concavus*
66.	Orthoptera	Gryllidae	*Acheta domestica*
67.	Orthoptera	Gryllidae	*Gryllotalpa* sp.
68.	Orthoptera	Mantidae	*Mantis* sp.
69.	Coleoptera	Chrysomelidae	*Dicladispa armigera*
70.	Coleoptera	Chrysomelidae	*Raphidopalpa foveicollis*
71.	Coleoptera	Curculionidae	*Myllocerus* sp.
72.	Coleoptera	Curculionidae	*Cosmopolites sordidus*
73.	Coleoptera	Coccinellidae	*Epilachna dodecastigma*
74.	Coleoptera	Hispidae	*Hispa armigera*
75.	Coleoptera	Dynastidae	*Oryctes rhinoceros*
76.	Odonata	Gomphidae	*Gomphus* sp.
77.	Diptera	Anthomyiidae	*Atherigona indica*
78.	Diptera	Muscidae	*Musca domestica*
79.	Diptera	Culicidae	*Aedes aegypti*
80.	Diptera	Culicidae	*Culex fatigans*
81.	Diptera	Culicidae	*Culex pipiense*
82.	Diptera	Culicidae	*Culex tarsalis*
83.	Diptera	Culicidae	*Culex quinquefasciatus*
84.	Diptera	Culicidae	*Anopheles barbirostris*
85.	Diptera	Culicidae	*Anopheles barianensis*
86.	Diptera	Culicidae	*Anopheles claviger*
87.	Diptera	Culicidae	*Anopheles gigas simlensis*
88.	Diptera	Culicidae	*Anopheles nigerrimus*
89.	Diptera	Culicidae	*Anopheles culicifacies*
90.	Diptera	Culicidae	*Anopheles peditaeniatus*
91.	Diptera	Culicidae	*Anopheles maculatus*
92.	Diptera	Culicidae	*Anopheles moghulensis*
93.	Diptera	Culicidae	*Anopheles pallidus*

continued…

Table 4 continue

S. No.	Order	Family	Scientific Name
94.	Diptera	Culicidae	*Anopheles pulcherrimus*
95.	Diptera	Culicidae	*Anopheles willmori*
96.	Diptera	Culicidae	*Anopheles sergenti*
97.	Diptera	Culicidae	*Anopheles splendidus*
98.	Diptera	Culicidae	*Anopheles stephensi*
99.	Diptera	Trypetidae	*Bactocera cucurbitae*
100.	Diptera	Trypetidae	*Bactocera zonata*
101.	Araneae	Thomisidae	*Thomisus* sp.
102.	Araneae	Araneidae	*Cyclosa* sp.
103.	Decapoda	Penaeidae	*Penaeus merguiensis*
104.	Decapoda	Penaeidae	*Penaeus japonicus*

Table 5. List of Zooplankton recorded from RBOD study areas.

S. No.	Rotifera
1.	*Brachionus quadridentatus*
2.	*Brachionus falcatus*
3.	*Brachionus buda pestinensis*
4.	*Brachionus rubens*
5.	*Euchlanis* sp.
6.	*Keratella tropica*
7.	*Keratella volga*
8.	*Lecane* sp.
9.	*Mytilina* sp.
10.	*Platyias quadricornus*
Cladocera	
11.	*Alona rectangula*
12.	*Bosmina longirostris*
13.	*Bosminopsis deitersi*
14.	*Ceriodaphnia reticulata*
15.	*Chydorus parvuus*
16.	*Chydorus ovalis*
17.	*Daphnia* sp.
18.	*Macrocthrix rosea*
19.	*Moina* sp.
S. No.	
20.	*Sida* sp.
21.	*Simocephalus vetulus*
Copepoda	
22.	*Cyclopoid* sp.
23.	*Calonoid* sp.

Table 6. List of Molluscs recorded from RBOD study areas.

S. No.	Class	Species
1.	Gastropoda	*Bellamya naticoides*
2.		*Bellamya dissimilis*
3.		*Bellamya bengalensis*
4.	Gastropoda	*Thiara tuberculata*
5.		*Gyraulus euphraticus*
6.		*Lymnaea acuminata*
7.		*Indoplanorbis exusta*
8.		*Physa acuta*
9.	Bivalvia	*Lamellidense marginalis*
10.		*Lamellidense corrianus*
11.		*Parreysia caerula*
12.		*Parreysia pachysoma*
13.		*Parreysia wynegungaensis*

Reptiles

In the present study, 31 species of reptiles were recorded (Table 9).

Amphibians

Among amphibians, Skittering Frog (*Euphlyctis cyanophlyctis*) and Indus Toad (*Duttaphrynus stomaticus*) are common (Table 10).

Fishes

There are 59 fish species were recorded. *Catla catla, Aorichthys aor, Bagarius bagarius, Gudusia chapra, Wallago attu, Channa marulia, Xenentodon cancila, Labeo rohita, Heteropneustes fossilis, Cirrhinus mrigala, Notopterus notopterus, Hypophthalmichthys molitrix, Aristchthys nobilis* and *Ctenpharyngodon idella* are some important fishes of the study area (Table 11).

Flora

As regards the flora, 262 species of plants were recorded. *Typha angustata, Phragmites karka* and *Hydrilla verticillata* were found common aquatic floral species in the area. *Salvinia molesta* and *Eichhornia crasspes* were recorded as exotic species, whereas *Tamarix* spp. was found abundant.

Table 7. List of Mammals recorded from RBOD study areas.

S. No.	Order	Family	Scientific Name	Common Name	Status	Previously recorded	Presently Recorded
1.	Rodentia	Hystricidae	*Hystrix indica*	Indian Crested Porcupine	LC	+	+
2.	Rodentia	Sciuridae	*Funambulus pennantii*	Palm Squirrel	C	+	+
3.	Rodentia	Muridae	*Mus saxicola*	Grey Spiny Mouse	LC	+	+
4.	Rodentia	Muridae	*Rattus rattus*	Roof Rat / House Rat	C	+	+
5.	Rodentia	Muridae	*Mus musculus*	House Mouse	C	+	+
6.	Rodentia	Muridae	*Mus booduga*	Little Indian Field Mouse	LC	+	+
7.	Rodentia	Muridae	*Nesokia indica*	Short-tailed Mole Rat	LC	+	+
8.	Rodentia	Muridae	*Meriones hurrianae*	Indian Desert Jird	C	+	+
9.	Rodentia	Muridae	*Tatera indica*	Indian Gerbil	C	+	+
10.	Rodentia	Muridae	*Gerbillus nanus*	Balochistan Gerbil	C	+	+
11.	Insectivora	Erinaceidae	*Paraechinus micropus*	Indian Hedgehog	LC	+	+
12.	Insectivora	Erinaceidae	*Hemiechinus collaris*	Long-eared Desert Hedgehog	LC	+	+
13.	Insectivora	Soricidae	*Suncus murinus*	House Shrew	LC	+	+
14.	Chiroptera	Vespertilionidae	*Pipistrellus kuhlii*	Kuhl's Bat	S	+	+
15.	Chiroptera	Megadermatidae	*Hipposideros fulvus*	Leaf-nosed Bat	LC	+	+
16.	Chiroptera	Rhinopomatidae	*Rhinopoma microphyllum*	Large Mouse-tailed Bat	LC	+	+
17.	Chiroptera	Pteropidae	*Rousettus aegypticus*	Egyptian Bat	LC	--	+
18.	Lagomorpha	Leporidae	*Lepus nigricollis*	Desert Hare / Indian Hare	LC	+	+
19.	Artiodactyla	Suidae	*Sus scrofa*	Indian Wild Boar	LC	+	--
20.	Pholidota	Manidae	*Manis crassicaudata*	Indian Pangolin	Rr	+	--
21.	Carnivora	Mustelidae	*Lutrogale perspicillata*	Smooth-coated Otter	Rr	+	+
22.	Carnivora	Canidae	*Vulpes vulpes*	Desert Fox/Red Fox	Rr	+	+
23.	Carnivora	Canidae	*Canis aureus*	Asiatic Jackal	LC	+	+
24.	Carnivora	Canidae	*Vulpes bengalensis*	Indian Fox	S	+	+
25.	Carnivora	Herpestidae	*Herpestes javanicus*	Small Mongoose	LC	+	+
26.	Carnivora	Herpestidae	*Herpestes edwardsi*	Grey Mongoose	LC	+	+
27.	Carnivora	Felidae	*Felis sylvestris*	Indian Desert Cat	S	+	+
28.	Carnivora	Felidae	*Felis chaus*	Jungle Cat	S	+	+
29.	Carnivora	Felidae	*Prionailurus viverrina*	Fishing Cat	Rr	+	+
30.	Carnivora	Viverridae	*Viverricula indica*	Small Indian Civet	Rr	+	+

Legends: C = Common; LC = Less Common; S = Scarce; Rr = Rare; + = Present; -- = Absent

Table 8. List of Birds recorded from RBOD study areas.

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	
						Previous	Present
1.	Podicipediformes	Podicipedidae	*Podiceps cristatus*	Great Crested Grebe	WV	+	--
2.	Podicipediformes	Podicipedidae	*Tachybaptes ruficollis*	Little Grebe	R	+	+
3.	Pelecaniformes	Phalacrocoracidae	*Phalacrocorax carbo*	Large Cormorant	R	+	+
4.	Pelecaniformes	Phalacrocoracidae	*Phalacrocorax fuscicollis*	Indian Shag	R	+	--
5.	Pelecaniformes	Phalacrocoracidae	*Phalacrocorax niger*	Little Cormorant	R	+	+
6.	Pelecaniformes	Phalacrocoracidae	*Anhinga melanogaster*	Darter	O	+	--
7.	Pelecaniformes	Pelecanidae	*Pelecanus crispus*	Dalmatian Pelican	WV	+	+
8.	Pelecaniformes	Pelecanidae	*Pelecanus onocrotalus*	White Pelican	WV	+	+
9.	Ciconiformes	Ardeidae	*Ardea cinerea*	Grey Heron	R	+	+
10.	Ciconiformes	Ardeidae	*Ardea purpurea*	Purple Heron	R	+	+
11.	Ciconiformes	Ardeidae	*Buturoides striatus*	Little Green Heron	R	--	+
12.	Ciconiformes	Ardeidae	*Ardeola grayii*	Indian Pond Heron	R	+	+
13.	Ciconiformes	Ardeidae	*Egretta alba*	Large Egret	R	+	+
14.	Ciconiformes	Ardeidae	*Bubulcus ibis*	Cattle Egret	R	+	+
15.	Ciconiformes	Ardeidae	*Egretta intermedia*	Intermediate Egret	R	+	+
16.	Ciconiformes	Ardeidae	*Egretta garzetta*	Little Egret	R	+	+
17.	Ciconiformes	Ardeidae	*Egretta gularis*	Indian Reef Heron	O	+	+
18.	Ciconiformes	Ardeidae	*Nycticorax nycticorax*	Night Heron	R	+	+
19.	Ciconiformes	Ardeidae	*Ixobrychus cinnamomeus*	Chestnut Bittern	SV	+	+
20.	Ciconiformes	Ardeidae	*Ixobrychus sinensis*	Yellow Bittern	SV	+	+
21.	Ciconiformes	Ardeidae	*Dupetor flavicollis*	Black Bittern	SV	+	+
22.	Ciconiformes	Ciconiidae	*Anastomus oscitans*	Openbill Stork	O	+	--
23.	Ciconiformes	Ciconiidae	*Ciconia ciconia*	White Stork	O	+	--
24.	Ciconiformes	Threskiornithidae	*Threskiornis melanocephala*	White Ibis	R	+	+
25.	Ciconiformes	Threskiornithidae	*Plegadis falcinellus*	Glossy Ibis	R	+	+
26.	Ciconiformes	Threskiornithidae	*Platalea leucorodia*	Spoonbill	WV	+	+
27.	Ciconiformes	Phoenicopteridae	*Phoenicopterus roseus*	Greater Flamingo	O	+	+
28.	Anseriformes	Anatidae	*Anser albifrons*	White-fronted Goose	WV	--	--

continued..

Table 8 continue…

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	
						Previous	Present
29.	Anseriformes	Anatidae	*Dendrocygna javanica*	Lesser Whistling Teal	SV	+	--
30.	Anseriformes	Anatidae	*Dendrocygna bicolor*	Large Whistling Teal	O	+	--
31.	Anseriformes	Anatidae	*Cygnus columbianus*	Bewick's Swan	O	--	--
32.	Anseriformes	Anatidae	*Tadorna ferruginea*	Ruddy Shelduck	WV	+	+
33.	Anseriformes	Anatidae	*Tadorna tadorna*	Common Shelduck	O	+	+
34.	Anseriformes	Anatidae	*Anser erythropus*	LesserWhite-fronted Goose	WV	+	--
35.	Anseriformes	Anatidae	*Marmaronetta angustirostris*	Marbled Teal	WV	+	+
36.	Anseriformes	Anatidae	*Anas acuta*	Pintail	WV	+	+
37.	Anseriformes	Anatidae	*Anas creca*	Common Teal	WV	+	+
38.	Anseriformes	Anatidae	*Anas querquedula*	Garganey	PM	+	+
39.	Anseriformes	Anatidae	*Anas poecilorhyncha*	Spotbill Duck	R	+	--
40.	Anseriformes	Anatidae	*Anas platyrhynchos*	Mallard	WV	+	+
41.	Anseriformes	Anatidae	*Anas strepera*	Gadwall	WV	+	+
42.	Anseriformes	Anatidae	*Anas penelope*	Wigeon	WV	+	+
43.	Anseriformes	Anatidae	*Anas clypeata*	Shoveller	WV	+	+
44.	Anseriformes	Anatidae	*Aythya ferina*	Common Pochard	WV	+	+
45.	Anseriformes	Anatidae	*Aythya nyroca*	Ferruginous Duck	WV	+	+
46.	Anseriformes	Anatidae	*Aythya marila*	Scaup Duck	O	+	--
47.	Anseriformes	Anatidae	*Aythya fuligula*	Tufted Duck	WV	+	+
48.	Anseriformes	Anatidae	*Netta rufina*	Red-crested Pochard	O	+	--
49.	Anseriformes	Anatidae	*Nettapus coromandelianus*	Cotton Teal	R	+	--
50.	Falconiformes	Accipitridae	*Elanus caeruleus*	Black-winged Kite	R	+	+
51.	Falconiformes	Accipitridae	*Milvus migruns*	Black Kite	R	+	+
52.	Falconiformes	Accipitridae	*Haliastur indus*	Brahminy Kite	O	+	+
53.	Falconiformes	Accipitridae	*Haliaeetus albicilla*	White-tailed Sea Eagle	O	+	--
54.	Falconiformes	Accipitridae	*Neophron percnopterus*	Egyptian Vulture	R	--	+
55.	Falconiformes	Accipitridae	*Haliaeetus leucoryphus*	Pallas's Fishing Eagle	R	+	+
56.	Falconiformes	Accipitridae	*Gyps bengalensis*	White-backed Vulture	R	+	--
57.	Falconiformes	Accipitridae	*Gyps fulvus*	Griffon Vulture	WV	+	+
58.	Falconiformes	Accipitridae	*Aegypius monachus*	Cinereous Vulture	WV	+	+
59.	Falconiformes	Accipitridae	*Circaetus gallicus*	Short-toed Eagle	O	+	+

continued..

Table 8 continue…

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	
						Previous	Present
60.	Falconiformes	Accipitridae	*Circus aeruginosus*	Marsh Harrier	WV	+	+
61.	Falconiformes	Accipitridae	*Circus macrourus*	Pallid Harrier	WV	+	+
62.	Falconiformes	Accipitridae	*Accipitier badius*	Shikra	R	+	+
63.	Falconiformes	Accipitridae	*Butastur teesa*	White-eyed Buzzard	R	+	+
64.	Falconiformes	Accipitridae	*Buteo vulpinus*	Desert Buzzard	WV	+	+
65.	Falconiformes	Accipitridae	*Buteo rufinus*	Long-legged Buzzard	WV	+	+
66.	Falconiformes	Accipitridae	*Aquila clanga*	Greater Spotted Eagle	WV	+	+
67.	Falconiformes	Accipitridae	*Aquila rapax*	Tawny Eagle	R	+	+
68.	Falconiformes	Accipitridae	*Aquila heliaca*	Imperial Eagle	WV	+	+
69.	Falconiformes	Accipitridae	*Aquila nipalensis*	Steppe Eagle	WV	+	+
70.	Falconiformes	Accipitridae	*Hieraaetus pennatus*	Booted Eagle	WV	+	--
71.	Falconiformes	Accipitridae	*Hieraaetus fasciatus*	Bonelli's Eagle	R	+	--
72.	Falconiformes	Pandionidae	*Pandion haliaetus*	Osprey	WV	+	+
73.	Falconiformes	Falconidae	*Falco tinnunculus*	Kestrel	R	+	+
74.	Falconiformes	Falconidae	*Falco chiquera*	Red-headed Merlin	R	+	+
75.	Falconiformes	Falconidae	*Falco columbarius*	Merlin	WV	--	+
76.	Galliformes	Phasianidae	*Francolinus francolinus*	Black Partridge	R	+	+
77.	Galliformes	Phasianidae	*Francolinus pondicerianus*	Grey Partridge	R	+	+
78.	Galliformes	Phasianidae	*Conturnix coturnix*	Common Quail	PM	+	+
79.	Gruiformes	Rallidae	*Rallus aquaticus*	Water Rail	WV	+	+
80.	Gruiformes	Rallidae	*Porzana porzana*	Spotted Crake	WV	+	+
81.	Gruiformes	Rallidae	*Amaurornis phoenicurus*	White-breasted Water Hen	R	+	+
82.	Gruiformes	Rallidae	*Gallinula chloropus*	Indian Moorhen	R	+	+
83.	Gruiformes	Rallidae	*Porphyrio porphyrio*	Purple Moorhen	R	+	+
84.	Gruiformes	Rallidae	*Fulica atra*	Coot	WV	+	+
85.	Gruiformes	Rallidae	*Gallicrex cinerea*	Watercock	WV	+	+
86.	Gruiformes	Gruidae	*Grus grus*	Common Crane	PM	+	--
87.	Gruiformes	Gruidae	*Anthropoides virgo*	Demoiselle Crane	PM	+	--
88.	Charadriiformes	Jacanidae	*Hydrophasianus chirurgus*	Pheasant-tailed Jacana	R	+	+
89.	Charadriiformes	Jacanidae	*Metopidius indicus*	Bronze-winged Jacana	O	+	--
90.	Charadriiformes	Haematopodidae	*Haematopus ostralegus*	Oystercatcher	WV	--	+

continued..

Table 8 continue…

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	
						Previous	Present
91.	Charadriiformes	Charadriidae	*Vanellus leucurus*	White-tailed Lapwing	WV	+	+
92.	Charadriiformes	Charadriidae	*Vanellus indicus*	Red-wattled Lapwing	R	+	+
93.	Charadriiformes	Charadriidae	*Vanellus vanellus*	Green Plover	O	+	+
94.	Charadriiformes	Charadriidae	*Vanellus malabaricus*	Yellow-wattled Lapwing	SV	+	+
95.	Charadriiformes	Charadriidae	*Pluvialis squatarola*	Black-bellied Plover	WV	+	--
96.	Charadriiformes	Charadriidae	*Pluvialis dominica*	Eastern Golden Plover	WV	+	--
97.	Charadriiformes	Charadriidae	*Charadrius dubius*	Little Ringed Plover	WV	+	+
98.	Charadriiformes	Charadriidae	*Charadrius alexandrines*	Kentish Plover	WV	+	+
99.	Charadriiformes	Recurvirostridae	*Himantopus himantopus*	Black-winged Stilt	R	+	+
100.	Charadriiformes	Recurvirostridae	*Recurvirostra avosetta*	Avocet	O	+	+
101.	Charadriiformes	Burhinidae	*Glareola pratincola*	Collared Pratincole	SV	+	+
102.	Charadriiformes	Burhinidae	*Glareola lacteal*	Small Indian Pratincole	SV	+	+
103.	Charadriiformes	Scolopacidae	*Numenius phaeopus*	Whimbrel	PM	+	+
104.	Charadriiformes	Scolopacidae	*Numenius arquata*	Curlew	PM	+	+
105.	Charadriiformes	Scolopacidae	*Limosa limosa*	Black-tailed Godwit	WV	+	+
106.	Charadriiformes	Scolopacidae	*Limosa lapponica*	Bartailed Godwit	WV	--	+
107.	Charadriiformes	Scolopacidae	*Tringa erythropus*	Spotted Red Shank	WV	+	+
108.	Charadriiformes	Scolopacidae	*Tringa totanus*	Common Red Shank	WV	+	+
109.	Charadriiformes	Scolopacidae	*Tringa stagnatilis*	Marsh Sandpiper	WV	+	+
110.	Charadriiformes	Scolopacidae	*Tringa nebularia*	Green Shank	WV	+	+
111.	Charadriiformes	Scolopacidae	*Tringa ochropus*	Green Sandpiper	WV	+	+
112.	Charadriiformes	Scolopacidae	*Tringa glareola*	Wood Sandpiper	WV	+	+
113.	Charadriiformes	Scolopacidae	*Tringa terek*	Terek Sandpiper	WV	+	+
114.	Charadriiformes	Scolopacidae	*Tringa hypoleucos*	Common Sandpiper	WV	+	+
115.	Charadriiformes	Scolopacidae	*Capella gallinago*	Common Snipe	WV	+	+
116.	Charadriiformes	Scolopacidae	*Calidris minutus*	Little Stint	WV	+	+
117.	Charadriiformes	Scolopacidae	*Calidris temminckii*	Temminck's Stint	WV	+	+
118.	Charadriiformes	Scolopacidae	*Calidris alpinus*	Dunlin	WV	+	+
119.	Charadriiformes	Scolopacidae	*Philomachus pugnax*	Ruff	PM	+	+
120.	Charadriiformes	Glareolidae	*Cursorius coromandelicus*	Indian Courser	R	--	+
121.	Charadriiformes	Laridae	*Larus argentatus*	Herring Gull	WV	+	+

continued..

Table 8 continue…

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	
						Previous	Present
122.	Charadriiformes	Laridae	*Larus fuscus*	LesserBlack-backed Gull	WV	--	+
123.	Charadriiformes	Laridae	*Larus ichthyaetus*	GreatBlack-headed Gull	WV	+	+
124.	Charadriiformes	Laridae	*Larus brunnicephalus*	Brown-headed Gull	WV	+	+
125.	Charadriiformes	Laridae	*Larus ridibundus*	Black-headed Gull	WV	+	+
126.	Charadriiformes	Laridae	*Larus genei*	Slender-billed Gull	WV	+	+
127.	Charadriiformes	Laridae	*Larus canus*	Mew Gull	O	+	--
128.	Charadriiformes	Sternidae	*Chlidonias hybrida*	Whiskered Tern	R	+	+
129.	Charadriiformes	Sternidae	*Chlidonias leucopterus*	White-winged Black Tern	PM	+	+
130.	Charadriiformes	Sternidae	*Gelochelidon nilotica*	Gull-billed Tern	R	+	+
131.	Charadriiformes	Sternidae	*Hydroprogne caspia*	Caspian Tern	R	+	+
132.	Charadriiformes	Sternidae	*Sterna aurantia*	River Tern	WV	+	+
133.	Charadriiformes	Sternidae	*Sterna hirundo*	Common Tern	SV	--	+
134.	Charadriiformes	Sternidae	*Sterna repressa*	White Cheecked Tern	SV	--	+
135.	Charadriiformes	Sternidae	*Sterna acuticauda*	Black-bellied Tern	R	+	+
136.	Charadriiformes	Sternidae	*Sterna albifrons*	Little Tern	PM	+	+
137.	Charadriiformes	Sternidae	*Sterna bergii*	Large Crested Tern	O	+	--
138.	Charadriiformes	Sternidae	*Sterna sandvicensis*	Sandwich Tern	M	--	+
139.	Charadriiformes	Rhynchopidae	*Rynchops albicollis*	Indian Skimmer	PM	+	--
140.	Columbiformes	Pteroclididae	*Pterocles exustus*	Chestnut-bellied Sandgrouse	O	+	+
141.	Columbiformes	Pteroclididae	*Pterocles senegallus*	Spotted Sandgrouse	WV	--	+
142.	Columbiformes	Pteroclididae	*Pterocles orientalis*	Black-bellied Sandgrouse	WV	--	+
143.	Columbiformes	Pteroclididae	*Pterocles alehata*	Pintailed Sandgrouse	R	--	+
144.	Columbiformes	Columbidae	*Treron phoenicoptera*	Yellow Footed Green Pigeon	WV	+	+
145.	Columbiformes	Columbidae	*Columba livia*	Blue Rock Pigeon	R	+	+
146.	Columbiformes	Columbidae	*Columba eversmanni*	Yellow-eyed or Eastern Rock Pigeon	O	+	+
147.	Columbiformes	Columbidae	*Treron bicincta*	Orange-breasted Green Pigeon	O	--	+
148.	Columbiformes	Columbidae	*Streptopelia decaocto*	Ring Dove	R	+	+
149.	Columbiformes	Columbidae	*Streptopelia tranquebarica*	Red Turtle Dove	SV	+	+

continued..

Table 8 continue…

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	
						Previous	Present
150.	Columbiformes	Columbidae	*Streptopelia senegalensis*	Little Brown Dove	R	+	+
151.	Psittaciformes	Psittacidae	*Psittacula krameri*	Rose Ringed Parakeet	R	+	+
152.	Cuculiformes	Cuculidae	*Clamator jacobinus*	Pied-crested Cuckoo	SV	+	+
153.	Cuculiformes	Cuculidae	*Eudynamys scolopacea*	Koel	R	+	+
154.	Cuculiformes	Cuculidae	*Centropus sinensis*	Greater Coucal	R	+	+
155.	Strigiformes	Tytonidae	*Tyto alba*	Indian Barn Owl	R	--	+
156.	Strigiformes	Strigidae	*Otus brucei*	Striated Scops Owl	WV	--	+
157.	Strigiformes	Strigidae	*Otus scops*	Eastern Scops Owl	WV	--	+
158.	Strigiformes	Strigidae	*Otus bakkamoena*	Collared Scops Owl	O	+	+
159.	Strigiformes	Strigidae	*Bubo bubo*	Eagle Owl	O	+	+
160.	Strigiformes	Strigidae	*Athene brama*	Spotted Owlet	R	+	+
161.	Strigiformes	Strigidae	*Asio otus*	Long-eared Owl	WV	--	+
162.	Strigiformes	Strigidae	*Asio flammeus*	Short-eared Owl	WV	--	+
163.	Caprimulgiformes	Caprimulgidae	*Caprimulgus asiaticus*	Indian Little Nightjar	R	+	+
164.	Caprimulgiformes	Caprimulgidae	*Caprimulgus europaeus*	European Nightjar	SV	+	+
165.	Caprimulgiformes	Caprimulgidae	*Caprimulgus mahrattensis*	Syke's Nightjar	R	+	+
166.	Apodiformes	Apodidae	*Apus affinis*	House Swift	R	+	+
167.	Coraciformes	Alcedinidae	*Ceryle rudis*	Pied Kingfisher	R	+	+
168.	Coraciformes	Alcedinidae	*Alcedo atthis*	Common Kingfisher	R	+	+
169.	Coraciformes	Alcedinidae	*Halcyon smyrnensis*	White-breasted Kingfisher	R	+	+
170.	Coraciformes	Meropidae	*Merops superciliosus*	Blue-cheeked Bee-eater	SBV	+	+
171.	Coraciformes	Meropidae	*Merops orientalis*	Green Bee-eater	R	+	+
172.	Coraciformes	Meropidae	*Merops apiaster*	European Bee-eater	R	--	+
173.	Coraciformes	Coraciidae	*Coracias garrulus*	European Roller	R	+	--
174.	Coraciformes	Coraciidae	*Coracias bengalensis*	Indian Roller	R	+	+
175.	Coraciformes	Upupidae	*Upupa epops*	Hoopoe	WV	+	+
176.	Piciformes	Picidae	*Dinopium bengalensis*	Lesser Golden-backed Woodpecker	R	+	+
177.	Piciformes	Picidae	*Picoides mahrattensis*	Yellow-fronted Pied Woodpecker	R	+	+
178.	Piciformes	Picidae	*Jynx torquilla*	Wryneck	PM	+	+
179.	Passeriformes	Alaudidae	*Mirafra erythroptera*	Indian/Red-winged Bush Lark	O	+	+

continued..

Table 8 continue…

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	
						Previous	Present
180.	Passeriformes	Alaudidae	*Eremopterix grisea*	Ashy-crowned Finch Lark	R	+	+
181.	Passeriformes	Alaudidae	*Eremopterix nigriceps*	Black-crowned Finch Lark	R	+	+
182.	Passeriformes	Alaudidae	*Ammomanes deserti*	Desert Finch Lark	R	+	+
183.	Passeriformes	Alaudidae	*Calandrella rufescens*	Lesser Short-toed Lark	WV	--	+
184.	Passeriformes	Alaudidae	*Calandrella raytal*	Indus Sand Lark	R	--	+
185.	Passeriformes	Alaudidae	*Galerida cristata*	Crested Lark	R	+	+
186.	Passeriformes	Alaudidae	*Alauda gulgula*	Oriental Sky Lark	R	+	+
187.	Passeriformes	Hirundinidae	*Riparia riparia*	Collared Sand Martin	WV	--	+
188.	Passeriformes	Hirundinidae	*Riparia paludicola*	Grey-throated Sand Martin	WV	+	+
189.	Passeriformes	Hirundinidae	*Hirundo smithi*	Wire-tailed Swallow	SV	+	+
190.	Passeriformes	Hirundinidae	*Hirundo rustica*	Barn Swallow	WV	+	+
191.	Passeriformes	Hirundinidae	*Hirundo daurica*	Red-rumped Swallow	WV	+	+
192.	Passeriformes	Motacillidae	*Anthus novaeseelandiae*	Paddyfield Pipit	R	+	+
193.	Passeriformes	Motacillidae	*Anthus campestris*	Tawny Pipit	WV	+	--
194.	Passeriformes	Motacillidae	*Anthus trivialis*	Tree Pipit	PM	+	+
195.	Passeriformes	Motacillidae	*Anthus spinoletta*	Water Pipit	WV	--	+
196.	Passeriformes	Motacillidae	*Motacilla flava*	Yellow Wagtail	PM	+	+
197.	Passeriformes	Motacillidae	*Motacilla citreola*	Yellow-headed Wagtail	WV	+	+
198.	Passeriformes	Motacillidae	*Motacilla alba*	Pied Wagtail	WV	+	+
199.	Passeriformes	Motacillidae	*Motacilla maderaspatensis*	White-browed Pied Wagtail	R	+	+
200.	Passeriformes	Laniidae	*Lanius isabellinus*	Isabelline Shrike	WV	+	+
201.	Passeriformes	Laniidae	*Lanius excubitor*	Grey Shrike	R/SBV	+	+
202.	Passeriformes	Laniidae	*Lanius vittatus*	Bay-backed Shrike	R	+	+
203.	Passeriformes	Laniidae	*Lanius schach*	Rufous-backed Shrike	R	+	+
204.	Passeriformes	Dicruridae	*Dicrurus adsimilis*	Black Drongo/ King Crow	R	+	+
205.	Passeriformes	Sturnidae	*Sturnus roseus*	Rosy Pastor	PM	+	+
206.	Passeriformes	Sturnidae	*Acridotheres ginginianus*	Bank Myna	R	+	+
207.	Passeriformes	Sturnidae	*Sturnus vulgaris*	Common Starling	O	+	+
208.	Passeriformes	Sturnidae	*Acridotheres tristis*	Indian Myna	R	+	+
209.	Passeriformes	Corvidae	*Dendrocitta vagabunda*	Tree Pie	R	+	+

continued..

Table 8 continue…

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	
						Previous	Present
210.	Passeriformes	Corvidae	*Corvus splendens*	House Crow	R	+	+
211.	Passeriformes	Corvidae	*Corvus corax*	Common Raven	R/WV	+	+
212.	Passeriformes	Campephagidae	*Tephrodornis pondicerianus*	Common Wood Shrike	R	+	+
213.	Passeriformes	Campephagidae	*Pericrocotus cinnamomeus*	Wandering Minivet	O	+	--
214.	Passeriformes	Pyconotidae	*Pycnonotus leucogenys*	White-cheeked Bulbul	R	+	+
215.	Passeriformes	Pyconotidae	*Pycnonotus cafer*	Red-vented Bulbul	R	+	+
216.	Passeriformes	Timaliidae	*Turdoides caudatus*	Common Babbler	R	+	+
217.	Passeriformes	Timaliidae	*Turdoides earlei*	Striated Babbler	R	+	+
218.	Passeriformes	Timaliidae	*Turdoides striatus*	Jungle Babbler	R	+	+
219.	Passeriformes	Nectariniidae	*Nectarinia asiatica*	Purple Sunbird	R	+	+
220.	Passeriformes	Muscicapidae	*Muscicapa striata*	Spotted Flycatcher	PM	+	+
221.	Passeriformes	Muscicapidae	*Ficedula parva*	Red-throated Flycatcher	PM	+	+
222.	Passeriformes	Monarchidae	*Hypothymus azurea*	Black-naped Flycatcher	WV	+	--
223.	Passeriformes	Sylviidae	*Orthotomus sutorius*	Tailor Bird	R	+	+
224.	Passeriformes	Sylviidae	*Acrocephalus agricola*	Paddy-field Warbler	WV	+	+
225.	Passeriformes	Sylviidae	*Acrocephalus stentoreus*	Clamorous Great Reed Warbler	WV	+	+
226.	Passeriformes	Sylviidae	*Cettia cetti*	Cetti's Warbler	WV	+	+
227.	Passeriformes	Sylviidae	*Acrocephalus dumetorum*	Blyth's Reed Warbler	PM	+	+
228.	Passeriformes	Sylviidae	*Prinia inornata*	Plain Prinia	R	+	+
229.	Passeriformes	Sylviidae	*Prinia buchanani*	Rufous-fronted Long-tailed Warbler	R	+	+
230.	Passeriformes	Sylviidae	*Prinia gracilis*	Streaked Wren Warbler	R	+	+
231.	Passeriformes	Sylviidae	*Prinia flaviventris*	Yellow Bellied Long-tailed Warbler	R	+	+
232.	Passeriformes	Sylviidae	*Prinia burnesii*	Long-tailed Grass Warbler	R	+	+
233.	Passeriformes	Sylviidae	*Hippolais caligata*	Syke's Tree Warbler	WV	+	+
234.	Passeriformes	Sylviidae	*Sylvia hortensis*	Orphean Warbler	WV	+	+
235.	Passeriformes	Sylviidae	*Sylvia curruca*	LesserWhite-throat	WV	+	+
236.	Passeriformes	Sylviidae	*Sylvia communis*	CommonWhite-throat	PM	+	+

continued..

Table 8 continue…

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	
						Previous	Present
237.	Passeriformes	Sylviidae	*Sylvia nana*	Desert Warbler	WV	+	+
238.	Passeriformes	Sylviidae	*Phylloscopus collybita*	Brown Leaf Warbler	WV	+	+
239.	Passeriformes	Sylviidae	*Phylloscopus sindianus*	Sind Chiffchaff	WV	--	+
240.	Passeriformes	Sylviidae	*Phylloscopus neglectus*	Plain Leaf Warbler	WV	+	+
241.	Passeriformes	Sylviidae	*Phylloscopus nitidus*	Bright Green Leaf Warbler	WV	+	+
242.	Passeriformes	Turdidae	*Erythropygia galacototes*	Rufous chat/ Rufous-tailed Scrub Robin	PM	+	+
243.	Passeriformes	Turdidae	*Luscinia svecicus*	Bluethroat	WV	+	+
244.	Passeriformes	Turdidae	*Phoenicurus ochruros*	Black Redstart	WV	+	+
245.	Passeriformes	Turdidae	*Saxicola caprata*	Pied Bush Chat	R	+	+
246.	Passeriformes	Turdidae	*Oenanthe deserti*	Desert Wheatear	WV	+	+
247.	Passeriformes	Turdidae	*Oenanthe picata*	Pied Chat	WV	+	+
248.	Passeriformes	Turdidae	*Oenanthe alboniger*	Hume's Wheatear	R	+	+
249.	Passeriformes	Turdidae	*Saxicoloides fulicata*	Indian Robin	R	+	+
250.	Passeriformes	Rhipiduridae	*Rhipidura aureola*	White-browed Fantail Flycatcher	R	+	+
251.	Passeriformes	Passeridae	*Passer domesticus*	House Sparrow	R	+	+
252.	Passeriformes	Passeridae	*Passer hispaniolensis*	Spanish Sparrow	PM	+	+
253.	Passeriformes	Passeridae	*Passer pyrrhonotus*	Sindh Jungle Sparrow	R	+	+
254.	Passeriformes	Passeridae	*Pectronia xanthocollis*	Yellow-throated Sparrow	SV	+	+
255.	Passeriformes	Ploceidae	*Ploceus philippinus*	Baya	R	+	+
256.	Passeriformes	Ploceidae	*Ploceus manyar*	Streaked Weaver	SV	+	+
257.	Passeriformes	Estrildidae	*Lonchura malabarica*	White-throated Munia/Indian Silver Bill	R	+	+
258.	Passeriformes	Fringillidae	*Fringilla montifringilla*	Brambling	O	+	--
259.	Passeriformes	Fringillidae	*Bucanetes githaginea*	Trumpeter Finch	R	+	--
260.	Passeriformes	Emberizidae	*Emberiza buchanani*	Grey-necked Bunting	PM	+	--
261.	Passeriformes	Emberizidae	*Emberiza melanocephala*	Black-headed Bunting	WV	+	+
262.	Passeriformes	Emberizidae	*Emberiza striolata*	Striped Bunting	R	+	--

Legends: R = Resident; WV = Winter Visitor; SV = Summer Visitor; SBV = Summer Breeding Visitors; YRV = Year Round Visitors; O = Vagrant; PM = Passage Migrant; S = Scarce; + - Present; -- - Absent.

Table 9. List of Reptiles recorded from RBOD study areas.

S. No.	Order	Family	Scientific Name	Common Name	Status
1.	Squamata	Elapidae	*Bungarus caeruleus*	Indian Krait	LC
2.	Squamata	Elapidae	*Naja naja*	Indian Cobra / Spectacled Cobra	LC
3.	Squamata	Colubridae	*Oligodon taeniolatus*	Streaked Kukri Snake	LC
4.	Squamata	Colubridae	*Platyceps rhodorachis*	Cliff Racer	LC
5.	Squamata	Colubridae	*Platyceps ventromaculatus*	Glossy-bellied Racer / Plain's Racer	C
6.	Squamata	Colubridae	*Psammophis condanarus*	Indian Sand Snake / Oriental Sand Snake	LC
7.	Squamata	Colubridae	*Psammophis leithii*	Ribbon Snake	LC
8.	Squamata	Colubridae	*Ptyas mucosus*	Dhaman / Rope Snake	C
9.	Squamata	Colubridae	*Spalerosophis diadema*	Royal Snake	LC
10.	Squamata	Colubridae	*Xenochrophis piscator*	Checkered-keel Back	LC
11.	Squamata	Viperidae	*Echis carinatus*	Saw-scaled Viper	LC
12.	Squamata	Viperidae	*Daboia russelii*	Russel's Viper	LC
13.	Squamata	Boidae	*Eryx johnii*	Common Sand Boa	LC
14.	Squamata	Boidae	*Eryx conicus*	Sand Boa	LC
15.	Squamata	Lacertidae	*Acanthodactylus cantoris*	Indian Fringe-toed Lizard	C
16.	Squamata	Varanidae	*Varanus griseus*	Desert Monitor Lizard	LC
17.	Squamata	Varanidae	*Varanus bengalensis*	Indian Monitor Lizard	LC
18.	Squamata	Uromastycidae	*Saara hardwickii*	Indian Spiny-tailed Lizard	LC
19.	Squamata	Agamidae	*Trapelus megalonyx*	Afghan Ground Agama	LC
20.	Squamata	Agamidae	*Trapelus agilis*	Brilliant Agama / Agile Agama	LC
21.	Squamata	Agamidae	*Calotes versicolor*	Indian Garden Lizard/Common Tree Lizard	C
22.	Squamata	Eublepharidae	*Eublepharis macularius*	Fat-tailed Gecko / Pakistani Leopard Gecko	LC
23.	Squamata	Geckonidae	*Cyrtopodion kachhensis*	Warty Rock Gecko / Kutch Gecko	LC
24.	Squamata	Geckonidae	*Cyrtopodion scaber*	Keeled Rock Gecko	LC
25.	Squamata	Geckonidae	*Crossobamon orientalis*	Sindh Sand Gecko	LC
26.	Squamata	Geckonidae	*Hemidactylus flavivirdis*	Yellow-bellied House Gecko	LC
27.	Squamata	Geckonidae	*Hemidactylus brookii*	Spotted Indian House Gecko/Brook's Gecko	LC
28.	Squamata	Geckonidae	*Hemidactylus leschenaultii*	Bark Gecko / Marbled Tree Gecko	LC
29.	Chelonia	Trionychidae	*Lissemys punctata*	Indian Flap-shell Turtle	C
30.	Testudines	Emydidae	*Geoclemys hamiltonii*	Spotted Pond Turtle	C
31.	Crocodilia	Crocodylidae	*Crocodylus palustris*	Marsh Crocodile	LC

Legends: C= Common; LC= Less Common

Table 10. List of Amphibians recorded from RBOD study areas.

S. No.	Order	Family	Scientific Name	Common Name	Status
1.	Anura	Ranidae	*Euphlyctis cyanophlyctis*	Skittering Frog	Common
2.	Anura	Bufonidae	*Duttaphrynus stomaticus*	Indus Toad	Common

Table 11. List of Fish fauna recorded from RBOD study areas.

S. No.	Order	Family	Scientific Name
1.	Cypriniformes	Cyprinidae	*Salmostoma bacaila*
2.	Cypriniformes	Cyprinidae	*Securicula gora*
3.	Cypriniformes	Cyprinidae	*Barilius vagra*
4.	Cypriniformes	Cyprinidae	*Amblypharyngodon mola*
5.	Cypriniformes	Cyprinidae	*Chela cachius*
6.	Cypriniformes	Cyprinidae	*Aspidoparia morar*
7.	Cypriniformes	Cyprinidae	*Esomus danricus*
8.	Cypriniformes	Cyprinidae	*Barbodes sarana*
9.	Cypriniformes	Cyprinidae	*Rasbora daniconius*
10.	Cypriniformes	Cyprinidae	*Catla catla*
11.	Cypriniformes	Cyprinidae	*Cirrhinus reba*

continued..

Table 11 continue…

S. No.	Order	Family	Scientific Name
12.	Cypriniformes	Cyprinidae	*Cirrhinus mrigala*
13.	Cypriniformes	Cyprinidae	*Labeo dero*
14.	Cypriniformes	Cyprinidae	*Labeo calbasu*
15.	Cypriniformes	Cyprinidae	*Labeo fimbriatus*
16.	Cypriniformes	Cyprinidae	*Labeo gonius*
17.	Cypriniformes	Cyprinidae	*Labeo dyocheilus*
18.	Cypriniformes	Cyprinidae	*Labeo rohita*
19.	Cypriniformes	Cyprinidae	*Osteobrama cotio*
20.	Cypriniformes	Cyprinidae	*Puntius ticto*
21.	Cypriniformes	Cyprinidae	*Puntius chola*
22.	Cypriniformes	Cyprinidae	*Puntius sophore*
23.	Cypriniformes	Cyprinidae	*Ctenpharyngodon idella*
24.	Cypriniformes	Cyprinidae	*Cyprinus carpio*
25.	Cypriniformes	Cyprinidae	*Hypophthalmichthys molitrix*
26.	Cypriniformes	Cyprinidae	*Aristchthys nobilis*
27.	Clupeiformes	Clupeidae	*Gudusia chapra*
28.	Osteoglossiformes	Notopteridae	*Notopterus notopterus*
29.	Osteoglossiformes	Notopteridae	*Notopterus chitala*
30.	Siluriformes	Bagridae	*Aorichthys aor*
31.	Siluriformes	Bagridae	*Rita rita*
32.	Siluriformes	Bagridae	*Mystus gulio*
33.	Siluriformes	Bagridae	*Mystus vittatus*
34.	Siluriformes	Bagridae	*Mystus bleekeri*
35.	Siluriformes	Bagridae	*Mystus cavasius*
36.	Siluriformes	Sisoridae	*Bagarius bagarius*
37.	Siluriformes	Sisoridae	*Gagata cenia*
38.	Siluriformes	Sisoridae	*Nangra nangra*
39.	Siluriformes	Siluridae	*Ompok bimaculatus*
40.	Siluriformes	Siluridae	*Wallago attu*
41.	Siluriformes	Heteropneustidae	*Heteropneustes fossilis*
42.	Siluriformes	Schilbeidae	*Ailia coila*
43.	Siluriformes	Schilbeidae	*Clupisoma garua*
44.	Siluriformes	Schilbeidae	*Clupisoma naziri*
45.	Siluriformes	Schilbeidae	*Eutropiichthys vacha*
46.	Beloniformes	Belonidae	*Xenentodon cancila*
47.	Channiformes	Channidae	*Channa marulia*
48.	Channiformes	Channidae	*Channa punctata*
49.	Channiformes	Channidae	*Channa striata*
50.	Perciformes	Chandidae	*Chanda nama*
51.	Perciformes	Chandidae	*Parambassis baculis*
52.	Perciformes	Chandidae	*Parambassis ranga*
53.	Perciformes	Badidae	*Badis badis*
54.	Perciformes	Mugilidae	*Sicamugil cascasia*
55.	Perciformes	Gobidae	*Glossogobium giuris*
56.	Perciformes	Belontidae	*Colisa fasciata*
57.	Perciformes	Belontidae	*Colisa lalia*
58.	Perciformes	Cichlidae	*Oreochromis mossambicus*
59.	Synbranchiformes	Mastcembelidae	*Mastacembelus armatus*

DISCUSSION

The water samples of the year 2010 were uncollectable due to flooding in the area as water become diluted. The present study reveals that RBOD is continuously receiving the discharges containing polluted water through three sources viz., municipal wastewater, industrial wastewater and agricultural runoff. The continuous accumulation causes a potential threat to aquatic life. The poisonous metals such as Mercury, Lead, Zinc, Copper, Cadmium and Chromium etc. in the industrial wastes and storm water drainage in the urban areas prove fatal for most living organisms. These toxic materials through water currents in the under surface

water have reached and have polluted most freshwater resources (Abbas, 2011).

In the present work, water samples taken from the RBOD near Keenjhar Lake showed pesticide OC compounds below the Maximum Acceptable Concentration (MAC). The data show 0.001mg/l DDT of OC groups analyzed presently in the ground water of RBOD near Keenjhar Lake. The concentration of these compounds and their continuous accumulation in the benthic deposit and their entry in food chain need to be addressed immediately.

The environmental impacts of OC group DDT pesticide residues and their effect on human health is an important matter of concern. The effect of DDT on estrogen behavior in human suggested the implication of these compounds in breast cancer (Carvalhado *et al*., 1998). Pesticides that are soluble in both water and fats are generally taken up more quickly by animals and man as the traces of these pesticides with their metabolites and breakdown products are universally present in abiotic and biotic environment (Tiel, 1972). In addition, the proportion of pesticides that is absorbed by the gut depends on the movement of the gut and the rate of way of food stuff through it.

In another study, pesticide residues of deltamethrin, aldrin, dieldrin, DDT and DDE in muscles, fat and liver of three Labeo species of fishes were found in Keenjhar and Haleji Lakes (Saqib *et al*., 2005).

The increased use of pesticides in a franzy to increase production of crops is also complicating the problem. The increased usage of even the most persistent and toxic chemicals like DDT is also continued (Nasir *et al*., 1987). The quantity of OC compounds and their metabolites were found in a higher amount in Sindh lakes as reported by Siddiqui (1998). He also noted dieldrin and other OC compounds from muscles and fat bodies of waterbirds on different lakes of Sindh. Detection of pesticide residues deltamethrin, aldrin, dieldrin, DDT, cypermethrin, DDE and melathion of the water samples of Gharo Creek showed no considerable concentration of pesticides (Khan, 2004).

The quantity of OC and OP compounds were estimated above the Maximum Acceptable Concentration in Haleji Lake and below the MAC in Keenjhar Lake as reported by Abbas (2011). During our study, no adverse effects of environmental pollution were found on the aquatic biodiversity except for some minor toxic effects due to the presence of heavy metals in water. All the physico-chemical parameter values were observed as per limit of World Health Organization standard. The depletion of Dissolved Oxygen indicated organic pollution harmful for aquatic biodiversity (Khan *et al*., 2012).

The salinity values near Gharo and near Keenjhar were observed high as per limit of World Health Organization standard, but having no adverse effect on aquatic biodiversity. Higher value of salinity presented during summer may be due to evaporation and comparatively low value was recorded during winter and rainy season. The rain water, however, causes dilution, aeration and additional biological activity as the BOD and COD pressure is decreased and solubility level of air in water is increased (Abbas, 2011). The desalination of the RBOD drainage water through treatment plants is not costly because of post-purification benefits for agriculture and adjacent affected wetlands.

It is also marked from these studies that dissolved oxygen content, salinity and pH do not affect the growth of copepods. The population of copepods shows growth pattern which only corresponds with the variation of temperature.

In January and December, beside the other factors, deficiency of nutrient salts due to accumulation is responsible for the decline of population of plankton (Welch, 1952). In summer temperature, increase in predation and downward migration are the factors responsible for the low population. The adults die out soon after breeding, and summer period is the peak of breeding. All these factors probably acting simultaneously are responsible for the extremely low population during May and June (Baqai and Rehana, 1973). During all the study period in pre-monsoon and post- monsoon the populations of copepods have a maximum.

Environmental Problems in RBOD

The RBOD is presently passing across the southern tip of Hadero Lake. For the present alignment there is a risk of pollution of Hadero Lake. The RBOD drain flows very close to Haleji Lake, the distance between RBOD and Haleji Lake is hardly 50 to 100ft. The water level is 20-30ft below the level of the lake area. Since the water level in Haleji Lake would be higher, (average depth 17ft) than that of the Drain. There is a possibility of the lake water spilling over the embankment and flowing into the drain in wet years of excessive rainfall. Due to very short distance from RBOD, Haleji Lake may be affected by the seepage of its water to the drain. Necessary measures have to be adopted to ensure environmental sustainability, safety of Haleji Lake from saline water intrusion and safety of RBOD from spilling of lake waters into RBOD and consequent flooding.

A very undesirable situation is prevailing for the last many years of discharging about 20 to 25 cusecs of untreated industrial wastewater from Kotri and Nooriabad Industrial Area into K.B Feeder, a channel which provides drinking water to Karachi. The logic in favour is the higher dilution rate and those 20 to 25 cusecs after all, is

an insignificant volume compared to K.B. Feeder discharge of 10,000 cusecs. Environmentally, this is an unacceptable practice. With the completion of RBOD, the industrial wastewater will be discharged into the drain whose alignment lies between the K.B Feeder and Kotri Industrial Area. This is very significant positive environmental impact as far as saving of K.B Feeder is concerned.

The largest part of the marginal area of the drain is presently surrounded with water lilies like Lotus, Phragmites and Typha along with Mesquites elsewhere. The open water area is dominated by submerged aquatic vegetation filling the whole water profile from bottom to surface. As a result the open area is reducing which is the habitat of many waterbirds. Some agriculture lands close to the marginal area which may in the long run affect the water quality of the water body. Runoff from agricultural fields containing chemical fertilizers triggers pollution. There are some social impacts such as washing of clothes and grazing of cattle. These social impacts may affect and contaminate the water but not to a great extent. Water is available in deep or shallow pools in the drain beds. The drain beds have risen due to sedimentation. At the RBOD area near Keenjhar Lake water is found in stagnant condition and it has resulted in the deterioration of water quality. In the study area, about 20% residents of towns and big villages are having water supply system, whereas remaining residents getting water from hand pumps, canal and river for drinking and domestic use. The villages which are near to the river are having fresh ground water, whereas the water logged area of Thatta ground water is brackish. In Thatta area from Chillya to Gharo residents living near to proposed drain are getting water from K.G. Canal and distributaries and also children and adults doing fishing practice and take bath from this drain water. This polluted water is not suitable for health and may cause diseases. The main health issue that relates to stagnant water (drainage near Keenjhar Lake) is Malaria. Due to using this polluted water, the general health of the majority of respondents was extremely poor. In every village, at least such diseases were described as common. These are Malaria, Common Fever, Diarrhea, Gynecological problems, Eye infection, Typhoid, Skin diseases and Cough.

All the stakeholders and residents are having negative remarks about the RBOD project, because of lack of information and awareness. They are under the impression that the drain will carry the industrial effluent, which will destroy agriculture land, crop and livestock and also would harm human health. The drain will divide their land in two parts. Approach roads from main Highway to RBOD passing through their land/village will destroy the crop lands during the construction phase. A large number of families at least 5,000 will be affected from the construction phase of RBOD. Any big project like RBOD is required for proper planning and compensation requirements for the people to whom it affected. If acceptable compensation and alternative source of property is provided, then it will be become very easy to make this project successful as well as acceptable for the concerned families.

Currently, all the polluted and contaminated water from MNVD is partly flowing into the Manchar Lake and partly being used for irrigation by the local cultivators. The quality of water is marginally suitable for irrigation with potential hazard for the soil, which is harmful to the environment and ecology of the lake, but after the flow of RBOD, it will directly dispose off into the Sea via Gharo and it will be very much beneficial for the environment. It is hoped that the construction of RBOD will save Manchar Lake and surrounding areas and carry the saline drainage water to the Arabian Sea. The discharge of K.G drain into Gharo Creek for the last three decades did not have any significant negative impact on the ecology of Gharo Creek as compared with the discharge of untreated sewage flowing through Malir River into Ghizri Creek and Lyari into Keamari which has significantly impacted the ecology and marine life of these two outfall areas.

Therefore, the construction of RBOD from Sehwan to Sea via Gharo Creek carrying the saline water from northern area drainage units will go a long way off in saving River Indus from permanent damage and is by far one of the very important mitigation measures to protect Manchar Lake and River Indus. River Indus is the life line of Pakistan and Sindh and no cost will be too great to save it from permanent damage and pollution.

Further studies are needed to collect more data for preparing a conservation plan for the management of Right Bank Outfall Drain. There is a need to increase public awareness regarding the importance and implement a monitoring program to provide protection of biodiversity and to enhance public co-operation in the conservation and management of the Drain and the threatened species.

CONCLUSION

On the basis of the present study, it is concluded that the environmentally RBOD project is a step in the right direction to save Manchar Lake and River Indus downstream of Sehwan from salinization and also take care of saline water and channel it into the Sea. The environmental issues likely to cause negative impacts, during construction and post construction era, can be handled with proper mitigation measures. The present study being the first study of its kind, will serve as a

baseline data for the future researchers on the biodiversity and environment of the area.

ACKNOWLEDGMENTS

The authors are deeply thankful to Free Software Foundation for using of some bird photos and also thank Mr. Abdur Razzaq Khan for his field surveys support.

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Received: Oct 12, 2013; Revised: Jan 16, 2014;
Accepted: Jan 25, 2014