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EFFECTS OF ENVIRONMENTAL POLLUTANTS ON AQUATIC VERTEBRATE BIODIVERSITY AND INVENTORY OF HUB DAM: RAMSAR SITE

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ABSTRACT

In the present study, the effects of environmental pollution on aquatic vertebrate biodiversity were studied and inventory of vertebrate fauna of Hub Dam was prepared. The water samples taken from four sampling sites from the study areas viz. Main Dam, Spill way, Hub Canal and shallow water area were analyzed for physico-chemical parameters viz temperature in air, temperature in water, color, pH, TDS, COD, BOD, alkalinity, salinity, conductivity, hardness, Phosphate, Nitrate, Bicarbonates, Sulphate, Chloride, Carbon dioxide, Dissolved Oxygen, Turbidity and Fluoride, Cations (Ca^+, Na^+, Mg^+, K^+) and some selected heavy metals (Cr, Fe, Ni, Cu, Zn, As, Cd, Pb, and Hg). The seasonal and yearly variations in selected physico chemical parameters and trace metals were determined with respect to the amount of annual rainfall and contamination factors involved. During the study, no adverse effects of environmental pollution were found on the aquatic biodiversity except for some minor toxic effects due to trace metals in water. All the physico – chemical parameters' values were observed as per limits of World Health Organization standard. Microbial analysis was carried out and water samples of Hub Dam did not meet the microbiological standard set by WHO. After suitable treatment the water may be supplied for domestic use. As many as 16 species of mammals, 160 species of birds, 23 species of reptiles, 03 species of amphibians, 29 species of fishes, and 25 species of plants were recorded from the Hub Dam area. There are no serious effects of pollution on the vertebrate biodiversity of the wetland. The population of the waterbirds has declined significantly in recent years mainly due to disturbances and commercial fishing activities in the reservoir area.

Keywords: Hub dam, environmental pollution, vertebrate biodiversity.

INTRODUCTION

Hub dam (25° 15‘N 67° 07′E) constructed across Hub River in 1981, at a distance of 56 km North of Karachi falls in the provinces of Sindh and Balochistan (Fig. 1). Main Dam is 15,640 m long whereas 5,400 m lies in Balochistan and 10,240 m in Sindh.

Hub Dam (Fig. 3) has also been declared as a Wildlife Sanctuary in Sindh and was established in 1972 for the preservation of waterbirds and the fish Mahsheer. It falls under Category IV of IUCN as Habitat / Species Management Area under the IUCN Protected Area Category System.

The dam is situated in an area of semi arid and desert with sedimentary rocks. The hills which run around on three sides are yellow with many shades of brown and grey. There are a few small islands in the midst of the reservoir. The Hub River rises in Kirthar Range of eastern Balochistan and enters the Arabian Sea just west of Karachi. The water level in the reservoir fluctuates widely according to rainfall in the water catchment area which extends over 3410 sq.miles.The topography of the upper catchment is sub – mountainous to hilly and plain. The area is generally barren with sparse vegetation at certain locations. The catchment of the Hub reservoir is wholly rain fed. The dam is relatively shallow with maximum depth of 9.6 m. The water has relatively high concentration of dissolved salts of sulphates, sodium and chloride and dissolved oxygen which results into much greater primary and secondary production (Sohail Siddiqi, pers. comm.).

The Hub Dam Canal system consists of the Main Canal, Karachi Water Supply Canal, Lasbella Canal and the Bund Murad Minor (Fig. 2). The water supply canal is 14 miles long lined with concrete tiles to supply 100 MGD to Karachi Water and Sewerage Board.

The Lasbela branch canal, 20 miles long lined with concrete tiles to supply water for irrigation of 21,000 acres of land and 15 MGD water for industries in Lasbela district.

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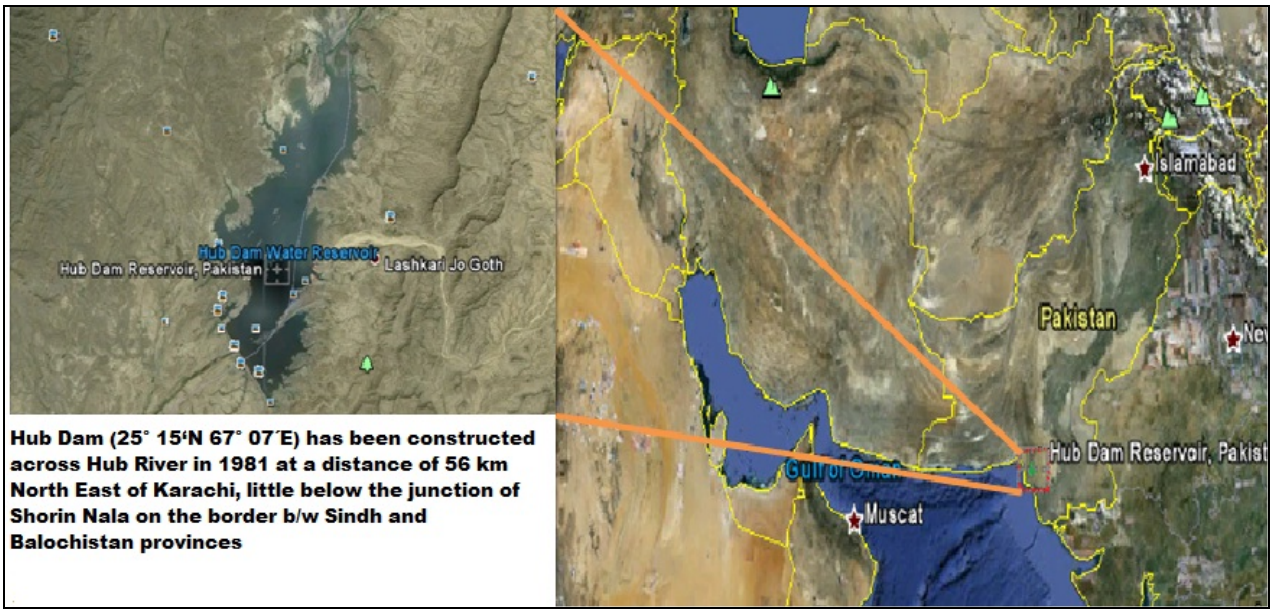

Fig.1. Map of Pakistan showing the location of Hub Dam.

Table 1. List of Ramsar Sites in Pakistan.

S. No.	Name	Location	Area
01	Astola (Haft Talar) Island	Balochistan	5,000ha
02	Chashma Barrage	Punjab	34,099 ha
03	Deh Akro	Sindh	20243 ha
04	Drigh Lake	Sindh	164 ha
05	Haleji Lake	Sindh	1,704 ha
06	Hub Dam	Sindh, Balochistan	27,000 ha
07	Indus Delta	Sindh	472,800 ha
08	Indus Dolphin Reserve	Sindh	125,000 ha
09	Jiwani Coastal Wetland	Balochistan	4,600 ha
10	Jabho Lagoon	Sindh	706 ha
11	Keenjhar Lake	Sindh	13,468 ha
12	Miani Hor	Balochistan	55,000 ha
13	Nurri Lagoon	Sindh	2,540 ha
14	Ormara Turtle Beaches	Balochistan	2,400 ha
15	Rann of Kutch	Sindh	566,375 ha
16	Tanda Dam	Khyber Pakhtoonkhah	405 ha
17	Taunsa Barrage	Punjab	6,756 ha
18	Thanedar Wala,	Khyber Pakhtoonkhah	40,47 ha
19	Uchhali Complex (including Khabbaki, Uchhali and Jahlar lakes),	Punjab	1,243 ha

The climate of the area tends to be very arid and average annual rainfall is less than 200 mm. The temperature often exceeds 36°C during the summer.

The water level in the dam depends on the amount of rainfall in the water catchment area. The maximum depth is 45 m and the average drawdown 19m. There has been no ample rain for the last five years and the water level in the reservoir has decreased significantly, posing a problem for the drinking water supply to Karachi West.

This site is an important staging and wintering area for waterbirds including Grebes, Pelicans, Flamingos, Anatids, Coots and Cranes. It regularly supported over 45,000 water birds (in the past, but does not anymore) including Black-necked Grebe (*Podiceps nigricollis)*, Little Cormorant (*Phalacrocorax niger*), Tufted Duck (*Aythya fuligula),*Common Pochard (*Aythya ferina)*, Dalmatian Pelican (*Pelecanus crispus*), White Pelican (*Pelecanus onocrotalus*), Coot (*Fulica atra*), and Little Tern (*Sterna albifrons*). The site is a breeding site for

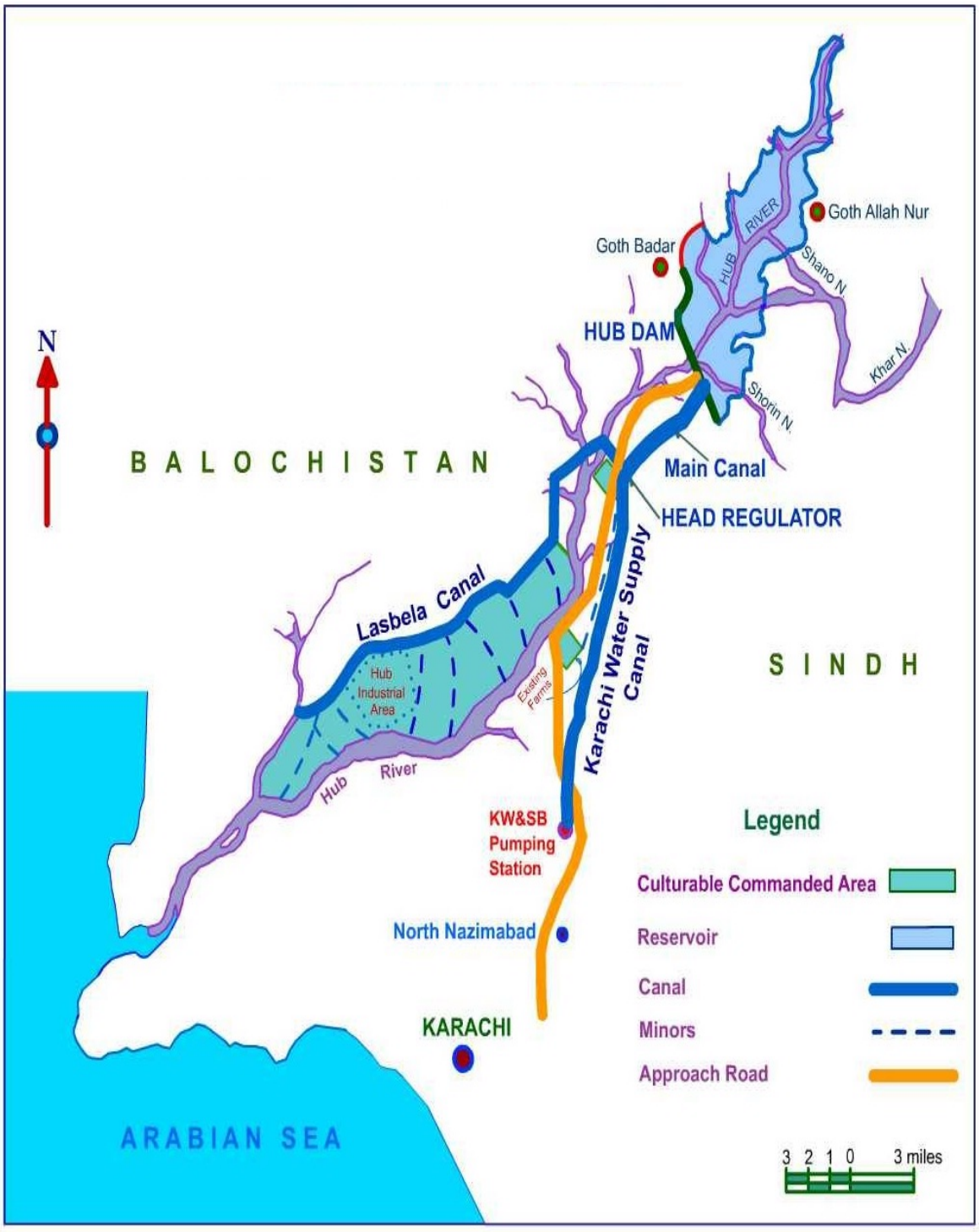

Fig. 2. Map showing location of Hub Dam.

Little Tern (*Sterna albifrons*) and Painted Snipe (*Rostratula benghalensis*). Marsh Crocodile or Mugger (*Crocodylus palustris*) is now found in the Hub Reservoir. The reservoir is an important spawning ground for a large number of fishes including some exotic fishes such as *Labeo rohita, Cyprinus carpio* and *Tilapia mossambica*, while the Mahsheer (*Tor putitora*) is the most important fish of this reservoir.

During 1986, the Fisheries Directorate, WAPDA started development of fisheries at Hub Dam according to National Fisheries Management Program to meet the

Fig. 3. View of Hub Dam.

protein demand of the growing population of the country. In order to develop and promote fisheries in Hub reservoir, a medium sized hatchery and a rearing farm were established in 1990 located in front of WAPDA colony on the right bank of Hub Dam Canal, 500 meter downstream of the Dam. (Muhammad Aslam, pers. comm.).

Commercial fishing was allowed in the Dam in 1988. Since 1989, hatchery and rearing farm were utilized to produce fish seeds of the following species:

Rohu *(Labeo rohita)*
Mori *(Cirrihinus mrigala)*
Gulfam (*Cyprinus carpio*)
Silver carp (*Hypophthalmichthys molitrix*)
Grass carp *(Ctenopharyngodon idella)*

An area of 27,192ha on the eastern shore and south of dam in the Sindh province has been declared as a Wildlife Sanctuary but the greater part of the reservoir in Balochistan province remains unprotected.

There are social impacts due to the presence of the many villages around such as Haji Muhammad Bux Goth, Usman Qalandria Goth, Dado Bandeejah Goth, Robo Goth, and Safar Goth. Raho Khaskeli Goth is the largest one having a population of almost 3000 people.

The objective of the present study was to identify the environmental factors and their effec on the aquatic vertebrate biodiversity and to prepare the inventory of vertebrate biodiversity of Hub Dam with a view to make recommendations for its conservation and management.

MATERIALS AND METHODS

The reservoir and adjoining areas were regularly visited during summer and winter seasons from 2007 to 2010. Quarterly surveys of three weeks duration were undertaken each year in the area for the collection of data with regard to the occurrence, distribution and habitats of the biodiversity of the area i.e birds, mammals, reptiles, fishes, amphibians and plants.

The avifauna of Hub Dam consists of resident as well as migratory species. Water bird census was undertaken in January and the data for the annual Waterbird Census were collected.

On the basis of baseline study, sites such as Spill way area, Main Hub dam, Main Sampling Point, Agriculture Land, Khar Centre, Usman Qalandria Goth, Hub Canal, Roho Khaskheli Goth, Robo Goth, Safar Goth, Rest House, Plantation Area and Bund Murad were selected for data collection with respect to mammals, resident and migratory birds, reptiles, amphibians, fishes and plants (Fig. 4, Table 2).

A. PARAMETERS FOR WATER QUALITY ANALYSIS

(i) Preparation of water samples and sampling sites

For the study of physico–chemical parameters, composition of trace metal and microbial analysis, four different sites viz. Main Dam, Spill way, Hub Canal, and shallow water were selected. Rainfall data were collected from Metrology department.

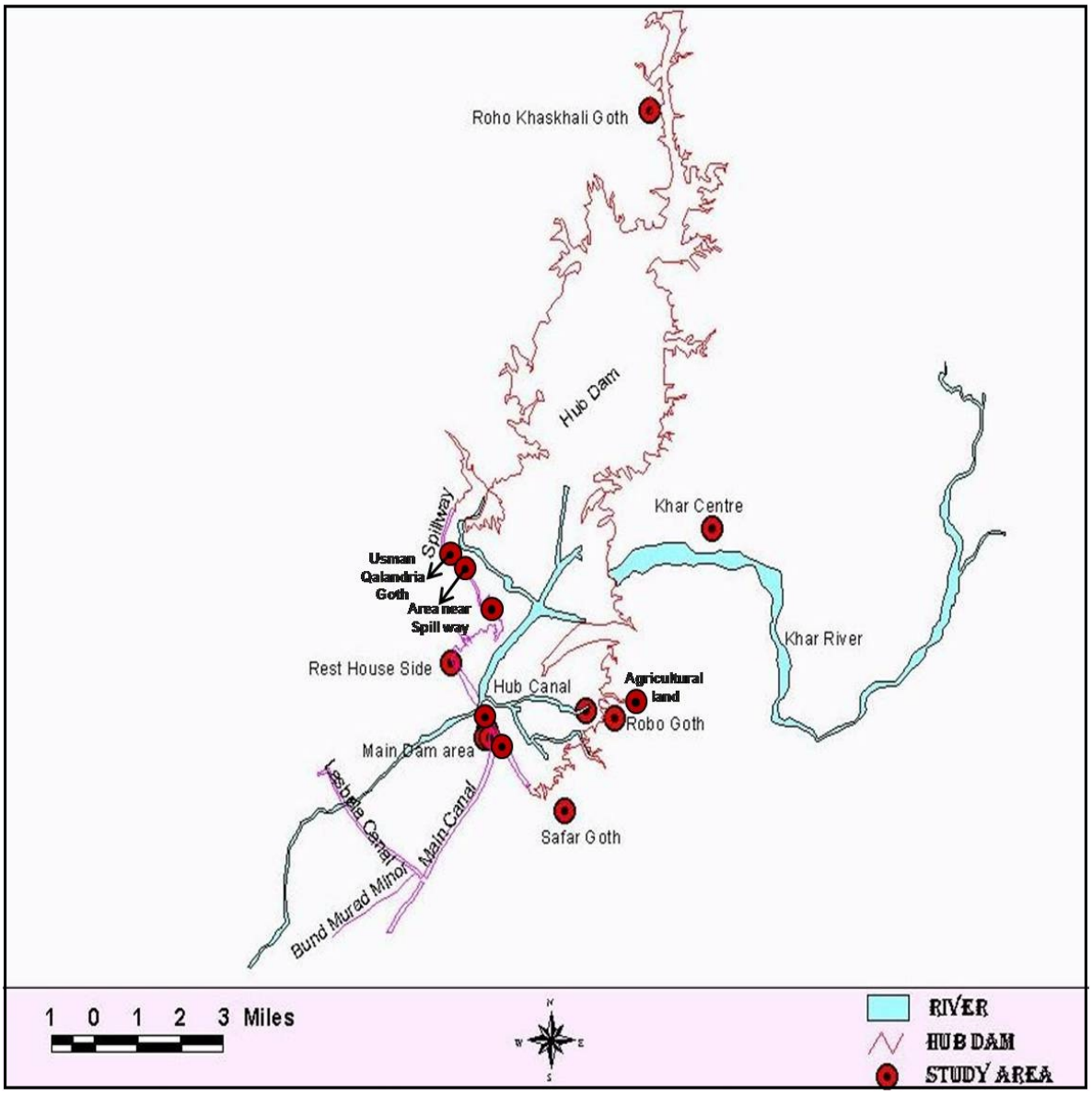

Fig. 4. Map showing the study areas.

During the study period 2007 – 2010, most of the samples were collected in 1000 ml polyethylene screw – cap bottles in order to obtain the water of the required depth. Bottles were cleaned sequentially, tap water rinse, 24 hour soak in 1% HNO_3 and several distilled water rinse. Dried at 100ºC for 1 hour, cooled at room temperature, capped and labeled. After collecting the samples, 10 ml HNO_3 (1 ml acid / 100 ml) was added to the samples which were useful for the estimation of concentration of trace metals.

(ii) Digestion of the samples

A very crucial step to analyze the samples was the transformation of a sample into an analytic solution. For this purpose a complete digestion of the samples was required. Decomposition procedures were dry ashing and wet oxidation (Gorsuch, 1976; Santa *et al*., 1986). In present investigation nitric acid based digestion method was carried out.

(iii) Methodology

For the preparation of reagents, Analytical Grade (AR) chemicals were used. For the determination of water quality parameters, standard analytical methods were carried out.

(a) Physico Chemical Analysis of Samples

Temperature measured at the spot by using Mercury Thermometer, pH was recorded with Orion 420 pH meter. Alkalinity was measured by titration method with 0.02 M hydrochloric acid (Electrometric method No.15 WHO,

Table 2. Study areas of Hub Dam.

S. No.	Study Area	Co-ordinates	Habitat
01	Area near Spill Way (Balochistan)	N 25° 17′ 23.2 E 67° 05′ 55.6	Rocky slopes with sparse vegetation, reservoir area
02	Main Dam area	N 25º 14 ′ 35.5 E 67º 06′ 45.8	Wetland
03	Main sampling point (on dam)	N 25º 14′ 42.9 E 67º 06′ 40.1	Wetland
04	Agriculture land / Shallow water area towards Khar Centre	N 25º 14′ 55.3 E 67º 08′ 56.3	Agriculture land, Rocky area and marshes
05	Khar Centre	N 25º 18′ 03.2 E 67º 11′ 40.9	Hilly, Rocky area and Agricultural plain area
06	Usman Qalandria Goth	N 25° 17′ 38.5 E 67° 05′ 94.2	Rocky area, Agricultural land and Plain area
07	Hub Canal	N 25º 14′ 26.6 E 67º 06′ 48.6	Rocky and Plain area
08	Roho Khaskheli Goth	N 25º 17′ 48.4 E 67º 10′ 12.2	Rocky and Flat Plain area
09	Robo Goth	N 25º 14′ 48.1 E 67º 09′ 32.5	Rocky and Plain area
10	Safar Goth	N 25º 13′ 15.6 E67º 08′ 31.2	Rocky area, Agricultural land and Plain area
11	Rest House Side	N 25º 15′ 40.1 E 67º 05′ 54.8	Wetland and Rocky area
12	Plantation Area	N 25° 16 ′ 32.3 E 67° 06′ 39.1	Forest / Wetland and Rocky area
13	Bund Murad	N 26° 05′ 77.4 E 69° 09′ 39.0	Wetland and Rocky area

1982). Conductivity was measured by light and dark bottles method (Welch, 1952). The turbidity of water was estimated with the help of Secchi disk while free Carbon Dioxide was measured as describe by APHA (1998). By gravimetric methods Sulphate and TDS were determined, Chloride by argentometric method, Nitrate was measured by employing a specific ion analyzer Orion -710, Calcium and Magnesium were determined by EDTA titration method, Sodium and Potassium were measured by flame photometer. The Chemical Oxygen Demand (COD) was measured by Method No. 16.4 (WHO, 1982), BOD, Fluoride, Bicarbonate, Salinity and Colour were measured by using standard method APHA (1998). Phosphate was measured using pectrophoto-metric method (Jones *et al*., 1983), Hardness were analyzed by titration with 0.01m EDTA (Ethylene Diamine Tetra Acetic Acid, Method No. 103 WHO, 1982). Dissolved Oxygen was analyzed by standard procedure mentioned in APHA (1998).

(b) Chemical Analysis of Trace Metals

To give aqueous phase the acidified water samples were treated with reagent and trace metal analyzed by Flame Atomic Absorption (Mastoi *et al.*, 1997). Digested liquid wastes were used to analyze Cr by Graphite Furnace method, Fe by Flame Atomic Absorption Spectrophotometer, Ni by Graphite Furnace method, Cu and Zn by Flame Atomic Absorption Spectrophotometer, As by Hydrate Generation method, Cd and Pb by Graphite Furnace method, Na and K by Flame Photometer method, Ca and Mg by titration method and Hg by Hydrate Generation method. The instrument (Perkin Elmer Model No. A analysts 700) was using different techniques such as Flame atomic absorption spectrometer, Graphite and hydrates system to analyze the chemicals. Determination for each metal was taken out in triplicate for getting representative results.

(c) Microbial Analysis of the samples

For microbial analysis, samples were collected in Brown Nelson Bottles and immediately transferred to lab. Microbial characteristic of the water samples were determined such as HPC, Total Coliforms and Faecal Coliforms by using multiple fermentation technique and membrane filter techniques described by standard method APHA (1998).

B. Survey Techniques and Counting Methods for the Biodiversity

Following direct and indirect observation methods have been applied during the surveys.

Large Mammals

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

1. 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 method has some advantages such as: travelling on vehicle does not disturb the animals and there is a chance to observe the animals along the road / track from a few meters distance. Another advantage of this method is that large areas can be covered in short time using only two persons and a vehicle, but in this method there are chances of some species being overlooked.

2. Track Counts

A track count is another method used for locating and observing the presence of nocturnal and secretive animals.

3. 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 area between sampling periods.

Small Mammals

One effective way to survey small mammals is active searching, particularly during the day time. This method is equally applicable to both nocturnal and diurnal species in potential and suitable microhabitats along the banks, open plains, particularly in bushy areas and agriculture fields. Active searching is very effective for inventory of Gerbils, Jirds, Porcupine, and Hedgehogs. 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, gloves etc.

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, corriander, oats and onion are used for fragrance. This bait is found to be highly successful in the study area probably due to the overall shortage of food and fragrance.

Traps and trapping procedure

Sherman traps are used to collect the live specimens. Fifty traps are set at specific areas on a line approximately 500 m long and approximately 10 m apart. Each trap is 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, identified in the field and released.

Birds

Birds are identified using spottingscopes and binoculars and making use of the field identification guides such as Grimmett (1998) and Snobe *et al.* (1993). Each major habitat type in the study area was identified and surveyed to record the species of birds found in each discreet habitat such as 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 to relate the data to other components of the study area such as vegetation, water and soil etc.

The most commonly used field method in birds surveying is the “Line Transect method”. It is based on recording birds continually along a predefined route within a predefined survey unit.

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*., 2010b).

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 the entire reservoir area, associated marshes, rocky and plain areas, and agriculture land were surveyed.

Reptiles and Amphibians

Various survey techniques have been employed to record the reptiles and amphibians (Khan *et al*., 2010a).

A: Direct Counting:

1. Plot Searching

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

2. Pitfall Traps

Reptiles and amphibians are also detected using a line or pitfall traps. Each pitfall line consists of 30 meter 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.

3. 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 animals.

4. Study of Basking Behavior

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

B: Indirect Counting

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

Evidences from the impression of finger or footprints, or tail, presence of fecal pellets, tracks and existence of tunnels (egg laying excavation) are collected to record the occurrence of various reptiles.

Fishes

Samples of fishes were collected through gill netting and cast netting. The data collected through these two methods were pooled and this formed the representative sampling of the study site.

RESULTS AND DISCUSSION

In the present study, water quality parameters were analyzed to assess the impact of environmental pollution on aquatic biodiversity, while inventory of vertebrate fauna of Hub Dam was also prepared.

A: Water Quality

Physico – chemical Parameters

The water of the reservoir was found to be clear, odourless and tasteless. During the study period, Air Temperature, Water Temperature, Color, pH, Total Dissolved Solids, COD, BOD, Alkalinity, Salinity, Conductivity, Hardness, Phosphate, Nitrate, Bicarbonate, Sulfate, Chloride, Carbon Dioxide, Dissolved Oxygen, Turbidity, Calcium, Magnesium, Sodium, Potassium and Fluoride along with a few trace metals were recorded viz. Chromium, Iron, Nickel, Copper, Zinc, Cadmium, Lead, Mercury and Arsenic at the Main Dam, Spill Way, Hub Canal and in shallow water.

The results of all selected physico – chemical parameters and trace metals were compared with the given WHO standard values.

Total amount of annual rainfall recorded in 2007 was, 465.6 mm, in 2008, 121.6 mm, in 2009, 279.9 mm and in 2010, 372.9 mm.

Results of all the physico-chemical and trace metals are shown in tables 3 and 4. All the physico – chemical and biological properties are dependant on the temperature as it is essential for aquatic environment. Temperature is important for the aquatic environment, the growth and death of aquatic life depends on maximum and minimum temperatures that fluctuate during summer and winter season.The minimum temperature of water was recorded at 17°C in November and 29°C in June. The maximum temperature in June indicates the season of extreme summer before rain when the DO declines and concentration of salt becomes higher and disturbs the aquatic life. The value of color of water body as per WHO Standard is 6 Hazen and the observed value during present study is under the limits set by WHO. In a previous study Beg *et al*. (1988) the color was recorded in the range 3-6. The mean value of water color observed during 2007 – 2010 in Hazen scale shown in table 4, a slight fluctuation was noted in summer and winter season in all the sampling sites. The pH which is approximately neutral is an indication of unpolluted water (Fakoyode, 2005), here pH of Hub Dam water were 6.8 to 7.5 in all sampling sites which is best for the survival of aquatic organisms, WHO recommended the value of pH 6.5 - 9.0, while Beg *et al*. (1988) reported 7.2 to 8.0. The mean of TDS was observed shown in table 4, these values are under WHO limits, while Beg *et al*. (1988) recorded range 1176 - 1309 mg/l. High value of BOD means decline in DO that could create trouble for survival of the fish and other aquatic organisms. Chemical Oxygen Demand and Biochemical Oxygen Demand were not detected during present investigation. No detection of COD and BOD indicated that no industrial effluent comes in the water body. Higher value of Alkalinity causes higher level of pollution in the water, recorded values of Alkalinity shown in table 4. Alkalinity was previously recorded between 60-90 mg/l (Beg *et al.,* 1988) all recorded values are under the permissible value of WHO standard limits i.e. 50 - 500 mg/l. The mean salinity of all sampling sites was recorded having no adverse impact on aquatic biodiversity. Higher value of Salinity presented during summer may be due to evaporation and low value was recorded during rainy season. Conductivity indicates the level of the soluble salts that are present in water body. Higher value of conductivity indicates highly polluted water not fit for drinking and for supplying but in the present study the results show that the water is not polluted having no adverse effect on aquatic life. The hardness was observed to be within the prescribed value

of WHO standard i.e. 200 – 500 mg/l and estimated value indicates that there is no pollution in water body. Mean value of Nitrate was recorded. The maximum value of Nitrate was recorded in shallow water 0.518 mg/l near plantation area, it slightly exceeded in shallow water because of agricultural land near by this site and water drainage during rains on this site that indicated a slightly exceeded value as compared to other site but its value did not indeed exceed the limit of WHO Standard limits (40 mg/l). Phosphate was not detected during the present study. No concentration of phosphate was recorded in all sampling sites which indicate that water is unpolluted and safe for aquatic biodiversity. Bicarbonate was found to have the higher values than the Sulphate and Chloride in all sampling sites. The mean value of Bicarbonate, Sulphate and Chloride were estimated. In a previous study the bicarbonates were measured ranging between 98-154 mg/l during 1978 – 1985 (Beg *et al*.,1988).Carbon Dioxide was observed to be very low. In the present study, low level of Carbon dioxide in water as compared to DO indicated favourable conditions for fish. The recorded value of Carbon Dioxide indicates that there is no adverse effect of CO_2 on aquatic organisms. DO were recorded as a high value in rainy period in all sampling sites and lower value were measured after rainy period in winter. These values of DO in all sites are under the limit of WHO Standard that indicates the safe site for aquatic biodiversity survival. In present study, turbidity values were also within acceptable range in all sites. Highest level of turbidity has an adverse effect on aquatic life and high value of turbidity could be due to the discharge of untreated effluent so in the present investigation no such untreated effluents were found. Fluoride is an important constituent for drinking water and for aquatic organisms, if a higher value of Fluoride is present in water it is caused by pollution. Recorded value of Fluoride indicated no adverse effect on aquatic biodiversity and the level of Fluoride is lower than the prescribed value of WHO standards (1.5 mg/l). Calcium plays an important role in aquatic environment. The concentration of Ca was recorded at higher value during summer; minimum concentration was recorded in rainy period due to dilution of Dam water. The higher value of Ca may adversely affect quality of water. The mean value of Magnesium was estimated at 14.189 mg/l. Sodium is an important element in drinking water. During study period the measured value of Sodium is in range 51.192 – 51.305 mg/l. Physiological problems may be produced in water for flora and fauna in aquatic environment due to higher value of Sodium and Potassium (Khuwar and Mastoi, 1996). In the present study, the mean recorded value of K and Na in all sampling sites ranged between 5.37 – 5.52 mg/l. The concentration of cations during present study were estimated in Ca > Na > Mg > K while in previous study the concentration was recorded in this order Na > Ca > Mg > K.

(ii) Trace Metal Analysis

Trace metals get access into aquatic environment from anthropogenic sources and get distributed in water, suspended solids and sediments from the course of their transportation (Olajre and Imeo Kparia, 2000). The mean concentrations of trace metals of Hub Dam were recorded from all sampling sites (Table 4). The concentrations of trace metals are widely found in all samples and with values comparatively higher as per limits of WHO Standard. The Variation in values of trace metals were measured during summer, rainy season and winter. The recorded values of trace metal in water of Hub Dam indicated a little pollution caused due to drainage of water, human waste and other human activities. The recorded value of Cr in present study indicates a higher value as compared to the set limit of WHO Standard i.e. 0.05 mg/l. Fe is a most abundant metal found in natural water body within the range of 0.5 – 50 mg/l (WHO, 1993). The recommended value of WHO standard is 0.3 mg/l and estimated value slightly exceeds the limit of WHO standard. In the present study, Fe level does not have high adverse effect on biodiversity as it is under acceptable limits. Some micro organisms convert ferrous into ferric hydroxide by taking dissolved iron as an energy source (Trivedi, 1993). Nickel is normally found in water bodies by the drainage of sewage water. The WHO Guidline value is 0.02 mg/l and our observed value of Ni was found to exceed the WHO limit. The concentration of Ni was generally found in low level. The level of copper indicated a higher value as per WHO standard i.e 2.0 mg/l but observed value is acceptable having no adverse effect on aquatic biodiversity. Recorded value of Zn indicates the acceptable range in all sites and did not exceed the WHO limit of 3.0 mg/l. Cadmium toxicity affects kidney, heart and liver (Mench *et al*., 1997), and even the low concentration of Cd affects aquatic life. In the present study, the mean value of Cd of all sampling sites was slightly higher than WHO Standard i.e. 0.003 mg/l. It can affect aquatic biodiversity and human health. Pb is a normally toxic and cumulative poisonous metal present in water bodies. Pb value was significantly higher than the prescribed value of WHO standard i.e. 0.01 mg/l during present study. Mercury is a highly toxic metal and yearly mean was recorded. Arsenic is a highly toxic metal and it affects the digestive tract, abdominal cavity and muscle tissue in fish with highly adverse effects but in the present investigation no traces of arsenic were observed in sampling sites.

Based on chemical examination, the water of this reservoir was fit for drinking purposes. But there are some agriculture lands near the margins which may in the long run affect the water quality of the reservoir. There are few social impacts like washing of clothes and grazing of cattle. These social impacts may affect and pollute the water but not to a great extent.

(iii) Microbial Analysis

The range of bacteria is determined by heterotrophic count (HPC) in any environment (EPA, 2002). In all water samples, the total bacterial counts were exceeded the limits of WHO standard 1998, of heterotrophic count which is 100 cfu / dl.The microbiological analysis of the reservoir was taken for HPC, total coliforms and faecal coliforms. In year 2007, HPC $1.7x10^3$ cfu/ml, total coliforms 6.3×10^1 cfu/ml, and faecal coliforms $6.0 x10^1$ cfu/ml. In year 2008, HPC $1.6^3 \times 10$ cfu/ml, total coliforms 7.1×10^1 cfu/ml, and faecal coliforms $5.2 x10^1$ cfu/ml. In year 2009, HPC 1.5×10^3 cfu/ml, total coliforms 7.2×10^1 cfu/ml, and faecal coliforms $5.0 x10^1$ cfu/ml, and in year 2010, HPC 1.6×10^3 cfu/ml, total coliforms 6.9×10^1 cfu/ml, and faecal coliforms $4.9 x10^1$ cfu/ml were measured. The present investigation indicated that the water is microbiologically unfit for drinking purpose as per limit of WHO guidline and needs to be treated before supplying.

Table 3. Mean Composition of Physico-chemical Analysis of all Sampling Sites during 2007-2010.

Parameters	Main Dam	Spill Way	Hub Canal	Shallow Water	WHO's Stand.
Temperature in air (°c)	25.07	25.36	25.1	25.27	-
Temperature in water (°c)	22.315	21.86	21.93	22.2	-
Color (Hazen Scale)	2.65	2.56	2.575	2.55	6 Hazen Scale
pH	7.18	7.1	7.125	7.07	6.5 - 9.0
TDS (mg/l)	514.9	515.84	515.69	516.09	-
COD	ND	ND	ND	ND	-
BOD	ND	ND	ND	ND	-
Alkalinity (mg/l)	74.43	74.52	74.45	74.91	30 - 500 mg / l
Salinity (mg/l)	0.364	0.346	0.343	0.348	-
Conductivity (µs/cm)	564.21	564.68	560.21	528.41	NS (No standard)
Hardness (mg/l)	177.9	177.51	177.44	177.9	100 - 200 mg / l
Phosphate	ND	ND	ND	ND	-
Nitrate (mg/l)	0.414	0.416	0.409	0.518	50.0 mg / l
Bicarbonate (mg/l)	122.96	125.32	123.6	129.6	-
Sulphate (mg/l)	74.28	74.28	73.95	73.97	250 mg / l
Chloride (mg/l)	97.3	96.83	97.25	97.237	250 mg / l
Carbon Dioxide (mg/l)	1.41	1.392	1.421	1.41	-
Dissolved Oxygen (mg/l)	4.145	4.162	4.268	4.198	-
Turbidity (NTU)	1.341	1.334	1.4	1.382	5 NTU
Fluoride (mg/l)	0.397	0.394	0.384	0.393	1.5 mg / l
Calcium (mg/l)	56.08	52.105	52.16	52.555	-
Magnesium (mg/l)	14.189	14.313	14.2	14.4	-
Sodium (mg/l)	51.27	51.302	51.305	51.192	200 mg / l
Potassium (mg/l)	5.37	5.487	5.383	5.52	-

ND: Not Detected in mg/l

Table 4. Mean Composition of Trace Metal Analysis of all Sampling Sites during 2007-2010.

Metals	Main Dam	Spill Way	Hub Canal	Shallow Water	WHO's Standards
Chromium (mg / l)	0.0825	0.077	0.072	0.085	0.05 mg / l
Iron (mg / l)	0.759	0.727	0.746	0.74	0.3 mg / l
Nickel (mg / l)	0.0625	0.07	0.075	0.071	0.02 mg / l
Copper (mg / l)	2.567	2.621	2.608	2.677	2.0 mg / l
Zinc (mg / l)	1.208	1.151	1.137	1.242	3.0 mg / l
Cadmium (mg / l)	0.097	0.09	0.079	0.086	0.003 mg / l
Lead (mg / l)	0.199	0.187	0.188	0.26	0.01 mg / l
Mercury (mg / l)	0.015	0.017	0.015	0.016	0.001 mg /
Arsenic (mg / l)	BDL	BDL	BDL	BDL	0.01 mg / l

BDL = Below Detection Limit

B: Current Inventory

During the study, 16 species of mammals, 160 species of birds, 23 species of reptiles, 3 species of amphibians, 19 species of fishes, and 25 species of plants were recorded from Hub Dam and surrounding areas.

Mammals

Sixteen species of mammals belonging to 6 orders and 10 families were recorded (Table 5).

Asiatic Jackal (*Canis aureus*), Red Fox (*Vulpes vulpes*), Grey Mongoose (*Herpestes edwardsi)*, Small Indian Mongoose (*Herpestes javanicus)*, House Mouse (*Mus musculus*), Desert Jird (*Meriones hurrianae*), Indian Porcupine (*Hystrix indica*), Five-striped Palm Squirrel (*Funambulus pennantii*), Desert Hedgehog (*Hemiechinus collaris*) and Roof Rat / House Rat (*Rattus rattus*) were recorded as common.

Indian Fox (*Vulpes bengalensis)*, Red Fox *(Vulpes vulpes),* Jungle Cat *(Felis chaus),* Small Mongoose (*Herpestes javanicus)* and Grey Mongoose (*Herpestes edwardsi*), Pangolin (*Manis crassicaudata*), Porcupine (*Hystrix indica*), Cairo Spiny Mouse (*Acomys cahirinus*) and Indian Hare (*Lepus nigricollis*) are the important mammals of the area.

Birds

Out of the total of 197 species of birds recorded so far (Table 6), 68 species were new findings and 37 species reported earlier were not recorded during the present study (Table 6).

There are 79 resident species, 72 winter visitors, 03 summer breeding visitors, 01 summer visitor and 06 passage migrants.

Waterbirds form the largest group of the birds recorded comprising of 71 species, while there are 41 species of passerines, 27 species of birds of prey, 07 species of game birds and 14 species of other birds recorded during the present study.

Garganey, Demoiselle Crane, Kentish Plover, Yellow Wagtail, and Black – headed Bunting were recorded as passage migrants. Common Swift and Blue-cheeked Bee-eater were recorded as summer breeding visitors, while Common Tern was recorded as a summer visitor.

The most common birds of the area include Little Grebe, Large Cormorant, Grey Heron, Pond Heron, Large Egret, Little Egret, Pintail, Shoveller, Common Pochard, Black Kite, Marsh Harrier, Black Headed Gull, Little Tern, Ring Dove, House Swift and Indian Pied Kingfisher.

WATER BIRD CENSUS

The winter visitors are mainly water birds which migrate to Pakistan along the Central Asian / Indus Flyway during the migratory season ranging from October to April. January is the peak season for these birds. Annual Waterbird Censuses have been undertaken on Hub Dam during 2000 to 2004 and in 2010, while from 2005 to 2009 the censuses were not undertaken (Fig.6).

The population of the waterbirds has declined drastically during recent years as compared to earlier records mainly due to disturbances and commercial fishing activities in the reservoir.

Reptiles

Twenty three species of reptiles were recorded. The common species of reptiles of the area include Spotted Indian House Gecko (*Hemidactylus leschnaultii*), Yellow-bellied House Gecko (*Hemidactylus flaviviridis*), Common Tree Lizard (*Calotes versicolor*) and Indian

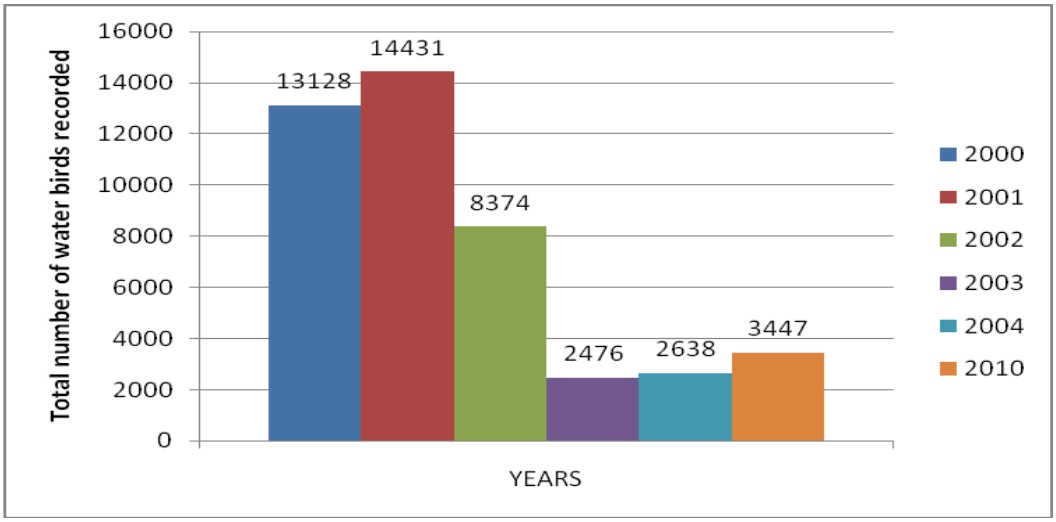

Fig. 6. Graph showing results of annual Waterbird census at Hub Dam.

Fringed-toad Lizard (*Acanthodactylus cantoris*) (Table 7). Marsh Crocodile (*Crocodylus palustris*), Brilliant Agama (*Trapelus agilis*), Indian Spiny – tailed Lizard (*Saara hardwickii*), Indian Monitor Lizard (*Varanus bengalensis*), Indian Cobra (*Naja naja*), Indian Fringed toed Lizard (*Acanthodactylus cantoris*), Indian Desert Monitor (*Varanus griseus*) Indian Sand Boa (*Eryx johnii*), Common Krait (*Bungarus caeruleus*) and Saw Scaled Viper (*Echis carinatus*) are the important species of reptiles of the area.

Amphibians

Three species of amphibians were recorded viz. Indus Valley Toad (*Bufo stomaticus*), Skittering Frog (*Euphlyctis cyanophlyctis*) and Burrowing Frog (*Sphaerotheca breviceps*) (Table 8).

Table 5. List of Mammals Recorded from Hub Dam.

S. No.	Order	Family	Scientific Name	Common Name	Status
01	Insectivora	Erinaceidae	*Hemiechinus collaris*	Long eared or Desert Hedge hog	C
02	Chiroptera	Pteropidae	*Rousettus egyptiacus*	Egyptain Bat	L/c
03	Carnivora	Canidae	*Canis aureus*	Asiatic Jackal	C
04	Carnivora	Canidae	*Vulpes bengalensis*	Indian Fox	L/c
05	Carnivora	Canidae	*Vulpes vulpes*	Red fox	C
06	Carnivora	Herpestidae	*Herpestes edwardsi*	Grey Mongoose	C
07	Carnivora	Herpestidae	*Herpestes javanicus*	Small Indian Mongoose	C
08	Carnivora	Felidae	*Felis chaus*	Jungle Cat	R
09	Lagomorpha	Leporidae	*Lepus nigricollis*	Indian Hare	L/c
10	Pholidota	Manidae	*Manis crassicaudata*	Indian Pangolin	R
11	Rodentia	Sciuridae	*Funambulus pennanti*	Five striped Palm Squirrel	C
12	Rodentia	Hystricidae	*Hystrix indica*	Indian Porcupine	C
13	Rodentia	Muridae	*Rattus rattus*	Roof Rat / House Rat	L/c
14	Rodentia	Muridae	*Mus musculus*	House mouse	C
15	Rodentia	Muridae	*Acomys cahirinus*	Cairo Spiny Mouse	L/c
16	Rodentia	Muridae	*Meriones hurrianae*	Desert Jird	C

Status: L / c = Less common C = Common R= Rare

Table 6. Consolidated List of Birds recorded from the Hub Dam.

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	Recorded earlier (Ghalib *et al*., 2000)	Recorded during present study (2007-2010)
1	Podicipediformes	Podicipedidae	*Podiceps cristatus*	Great Crested Grebe	WV	L/c	+	+
2	Podicipediformes	Podicipedidae	*Podiceps grisegena*	Red necked Grebe	WV	Ra	+	_
3	Podicipediformes	Podicipedidae	*Podiceps nigricollis*	Black necked Grebe	WV	L / c	+	+
4	Podicipediformes	Podicipedidae	*Tachybaptus ruficollis*	Little Grebe	R	C	+	+
5	Pelecaniformes	Pelecanidae	*Pelecanus onocrotalus*	Great White Pelican	WV	L / c	+	+
6	Pelecaniformes	Pelecanidae	*Pelecanus crispus*	Dalmatian Pelican	WV	Ra	+	+
7	Pelecaniformes	Phalacrocoracidae	*Phalacrocorax carbo*	Large Cormorant	WV	C	+	+
8	Pelecaniformes	Phalacrocoracidae	*Phalacrocorax niger*	Little Cormorant	R	C	+	+
9	Pelecaniformes	Anhingidae	*Anhinga rufa*	Indian Darter	R	L / c	_	+
10	Ciconiiformes	Ardeidae	*Ardea cinerea*	Grey Heron	WV	C	+	+

Continued…

Table 7. Continue…

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	Recorded earlier (Ghalib *et al*., 2000)	Recorded during present study (2007-2010)
11	Ciconiiformes	Ardeidae	*Ardea purpurea*	Purple Heron	R	L / c	+	+
12	Ciconiiformes	Ardeidae	*Ardeola grayii*	Pond Heron	R	C	+	+
13	Ciconiiformes	Ardeidae	*Egretta alba*	Large Egret	WV/R	C	+	+
14	Ciconiiformes	Ardeidae	*Egretta intermedia*	Median Egret	R	L/c	+	_
15	Ciconiiformes	Ardeidae	*Egretta garzetta*	Little Egret	R	C	+	+
16	Ciconiiformes	Ardeidae	*Egretta gularis*	Indian Reef Heron	R	L / c	_	+
17	Ciconiiformes	Ardeidae	*Ixobrychus minutus*	Little Bittern	R	L/c	+	_
18	Ciconiiformes	Ardeidae	*Dupetor flavicollis*	Black Bittern	R	Ra	+	_
19	Ciconiiformes	Threskiornithidae	*Plegadis falcinellus*	Glossy Ibis	R/WV	L / c	+	+
20	Ciconiiformes	Threskiornithidae	*Platalea leucorodia*	Spoonbill	WV/R	L / c	+	+
21	Ciconiiformes	Phoenicopteridae	*Phoenicopterus ruber*	Great Flamingo	NBR	L / c	+	+
22	Anseriformes	Anatidae	*Anser anser*	Greylag Goose	WV	Ra	+	_
23	Anseriformes	Anatidae	*Tadorna tadorna*	Common Shelduck	WV	L / c	+	+
24	Anseriformes	Anatidae	*Anas angustirostris*	Marbled t\Teal	WV	Ra	+	_
25	Anseriformes	Anatidae	*Anas acuta*	Pintall	WV	C	+	+
26	Anseriformes	Anatidae	*Anas crecca*	Common Teal	WV	C	+	+
27	Anseriformes	Anatidae	*Anas platyrhynchos*	Mallard	WV	L / c	+	+
28	Anseriformes	Anatidae	*Anas strepera*	Gadwall	WV	L / c	+	+
29	Anseriformes	Anatidae	*Anas penelope*	Wigeon	WV	L / c	+	+
30	Anseriformes	Anatidae	*Anas querquedula*	Garganey	PM	Ra	+	+
31	Anseriformes	Anatidae	*Anas clypeata*	Shoveller	WV	C	+	+
32	Anseriformes	Anatidae	*Netta rufina*	Red Crested Pochard	WV	Ra	+	+
33	Anseriformes	Anatidae	*Aythya ferina*	Common Pochard	WV	C	+	+
34	Anseriformes	Anatidae	*Aythya nyroca*	Ferruginous Duck	WV	Ra	+	+
35	Anseriformes	Anatidae	*Aythya fuligula*	Tufted Duck	WV	L / c	+	+
36	Falconiformes	Accipitridae	*Elanus caeruleus*	Black winged Kite	R	L / c	+	+
37	Falconiformes	Accipitridae	*Milvus migrans*	Black Kite	R	C	+	+

Continued…

Table 7. Continue…

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	Recorded earlier (Ghalib *et al*., 2000)	Recorded during present study (2007-2010)
38	Falconiformes	Accipitridae	*Haliastur indus*	Brahminy Kite	R	L / c	_	+
39	Falconiformes	Accipitridae	*Accipiter badius*	Central Asian Shikra	R	L/c	+	+
40	Falconiformes	Accipitridae	*Buteo rufinus*	Long legged Buzzard	WV	L / c	_	+
41	Falconiformes	Accipitridae	*Hieraaetus pennatus*	Booted Hawk-Eagle	WV	L / c	_	+
42	Falconiformes	Accipitridae	*Aquila heliaca*	Imperial Eagle	WV	L / c	+	+
43	Falconiformes	Accipitridae	*Aquila rapax*	Tawny Eagle	R	L / c	_	+
44	Falconiformes	Accipitridae	*Aquila nipalensis*	Steppe Eagle	WV	L / c	_	+
45	Falconiformes	Accipitridae	*Hieraaetus fasciatus*	Bonelli's Eagle	R	Ra	+	_
46	Falconiformes	Accipitridae	*Aquila clanga*	Greater Spotted Eagle	WV	L / c	_	+
47	Falconiformes	Accipitridae	*Haliaeetus leucoryphus*	Pallas's Fishing Eagle	R	L / c	_	+
48	Falconiformes	Accipitridae	*Aegypius monachus*	Black Vulture / Cinereous Vulture	R	L/c	+	_
49	Falconiformes	Accipitridae	*Gyps fulvus*	Griffon Vulture	R	L/c	+	+
50	Falconiformes	Accipitridae	*Gyps bengalensis*	White backed Vulture	R	Ra	+	_
51	Falconiformes	Accipitridae	*Neophron percnopterus*	Egyptian Vulture	R & B	L/c	+	+
52	Falconiformes	Accipitridae	*Circus cyaneus*	Hen Harrier	WV	L / c	_	+
53	Falconiformes	Accipitridae	*Circus macrourus*	Pallid Harrier	WV	L/c	+	+
54	Falconiformes	Accipitridae	*Circus pygargus*	Montagu's Harrier	WV	L / c	_	+
55	Falconiformes	Accipitridae	*Circus aeruginosus*	Marsh Harrier	WV	C	+	+
56	Falconiformes	Accipitridae	*Circaetus gallicus*	Short-toed Eagle	R	L / c	+	+
57	Falconiformes	Pandionidae	*Pandion haliaetus*	Osprey	WV	L / c	+	+
58	Falconiformes	Falconidae	*Falco jugger*	Lagger Falcon	R	L / c	_	+
59	Falconiformes	Falconidae	*Falco columbarius*	Pallid Merlin	WV	L / c	_	+
60	Falconiformes	Falconidae	*Falco tinnunculus*	Common Kestrel	R/WV	L / c	_	+
61	Galliformes	Phasianidae	*Francolinus francolinus*	Black Partridge	R	Ra	_	+
62	Galliformes	Phasianidae	*Francolinus pondicerianus*	Grey Partridge	R	L / c	_	+

Continued…

Table 7. Continue…

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	Recorded earlier (Ghalib *et al*., 2000)	Recorded during present study (2007-2010)
63	Gruiformes	Gruidae	*Grus grus*	Common Crane	M	L / c	+	+
64	Gruiformes	Gruidae	*Anthropoides virgo*	Demoiselle Crane	PM	L / c	+	+
65	Gruiformes	Rallidae	*Rallus aquaticus*	Water Rail	WV	L / c	_	+
66	Gruiformes	Rallidae	*Amaurornis phoenicurus*	White-breasted Water Hen	R	C	_	+
67	Gruiformes	Rallidae	*Gallinula chloropus*	Indian Moorhen	R	C	_	+
68	Gruiformes	Rallidae	*Fulica atra*	Coot	WV	C	+	+
69	Charadriiformes	Jacanidae	*Hydrophasianus chirurgus*	Pheasant Tailed Jacana	R	L/c	+	+
70	Charadriiformes	Charadriidae	*Vanellus leucurus*	White-tailed Lapwing	WV	L / c	+	+
71	Charadriiformes	Charadriidae	*Vanellus gregarius*	Sociable Lapwing	WV	Ra	+	_
72	Charadriiformes	Charadriidae	*Vanellus vanellus*	Lapwing	WV	Ra	+	_
73	Charadriiformes	Charadriidae	*Vanellus indicus*	Red wattled Lapwing	R	C	+	+
74	Charadriiformes	Charadriidae	*Vanellus malabaricus*	Yellow-wattled Lapwing	SBV	L / c	+	+
75	Charadriiformes	Charadriidae	*Charadrius leschenaultii*	Large Sand Plover	WV	L / c	+	+
76	Charadriiformes	Charadriidae	*Charadrius hiaticula*	Ringed Plover	WV	L / c	+	+
77	Charadriiformes	Charadriidae	*Charadrius dubius*	Little Ringed Plover	R	L / c	+	+
78	Charadriiformes	Charadriidae	*Charadrius alexandrinus*	Kentish Plover	SBV/WV/PM	L / c	_	+
79	Charadriiformes	Charadriidae	*Charadrius mongolus*	Lesser Sand Plover	WV	L / c	_	+
80	Charadriiformes	Scolopacidae	*Numenius phaeopus*	Whimbrel	WV	L / c	_	+
81	Charadriiformes	Scolopacidae	*Numenius arquata*	Curlew	WV	L / c	_	+
82	Charadriiformes	Scolopacidae	*Limosa limosa*	Black Tailed Godwit	WV	L / c	+	+
83	Charadriiformes	Scolopacidae	*Limosa lapponica*	Bartailed Godwit	WV	L / c	_	+
84	Charadriiformes	Scolopacidae	*Tringa totanus*	Common Redshank	WV	L / c	+	+
85	Charadriiformes	Scolopacidae	*Tringa stagnatilis*	Marsh Sandpiper	WV	L / c	_	+
86	Charadriiformes	Scolopacidae	*Tringa nebularia*	Green Shank	WV	L / c	_	+
87	Charadriiformes	Scolopacidae	*Tringa hypoleucos*	Common Sandpiper	WV	C	+	+
88	Charadriiformes	Scolopacidae	*Arenaria interpres*	Turn Stone	WV	L/c	+	_

Continued…

Table 7. Continue…

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	Recorded earlier (Ghalib *et al*., 2000)	Recorded during present study (2007-2010)
89	Charadriiformes	Scolopacidae	*Calidris minutus*	Little Stint	WV	C	–	+
90	Charadriiformes	Scolopacidae	*Calidris temminckii*	Temminck's Stint	WV	L / c	–	+
91	Charadriiformes	Scolopacidae	*Philomachus pugnax*	Ruff	WV	L / c	–	+
92	Charadriiformes	Rostratulidae	*Rostratula benghalensis*	Painted Snipe	R	L/c	–	+
93	Charadriiformes	Recurvirostridae	*Himantopus himantopus*	Black winged Stilt	R	C	+	+
94	Charadriiformes	Burhinidae	*Burhinus oedicnemus*	Stone Curlew	R	Ra	+	–
95	Charadriiformes	Glareolidae	*Cursorius cursor*	Cream Coloured Courser	R	L / c	+	+
96	Charadriiformes	Laridae	*Larus argentatus*	Herring Gull	WV	L / c	+	+
97	Charadriiformes	Laridae	*Larus fuscus*	Lesser Black backed Gull	WV	L / c	–	+
98	Charadriiformes	Laridae	*Larus ichthyaetus*	Great Black headed Gull	WV	L / c	–	+
99	Charadriiformes	Laridae	*Larus brunnicephalus*	Brown Headed Gull	WV	L / c	–	+
100	Charadriiformes	Laridae	*Larus ridibundus*	Black Headed Gull	WV	C	+	+
101	Charadriiformes	Laridae	*Larus canus*	Common Gull	WV	L / c	–	+
102	Charadriiformes	Sternidae	*Chlidonias hybrida*	Indian Whiskered Tern	M	L / c	+	+
103	Charadriiformes	Sternidae	*Chlidonias leucopterus*	White – winged Black Tern	PM	L / c	–	+
104	Charadriiformes	Sternidae	*Gelochelidon nilotica*	Gull bellied Tern	WV	Ra	+	+
105	Charadriiformes	Sternidae	*Sterna aurantia*	Indian River Tern	R	L / c	–	+
106	Charadriiformes	Sternidae	*Sterna hirundo*	Common Tern	SV	L / c	–	+
107	Charadriiformes	Sternidae	*Sterna acuticauda*	Black – bellied Tern	R	L / c	–	+
108	Charadriiformes	Sternidae	*Sterna albifrons*	Little Tern	R	C	+	+
109	Charadriiformes	Sternidae	*Sterna sandvicensis*	Sandwich Tern	M	L / c	–	+
110	Columbiformes	Pteroclididae	*Pterocles exustus*	Chestnut-bellied Sandgrouse	R	Ra	–	+
111	Columbiformes	Pteroclididae	*Pterocles alchata*	Painted Sandgrouse	R	Ra	–	+
112	Columbiformes	Columbidae	*Columba livia*	Blue Rock Pigeon	R	C	–	+
113	Columbiformes	Columbidae	*Streptopelia decaocto*	Ring Dove	R	C	+	+

Continued…

Table 7. Continue…

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	Recorded earlier (Ghalib *et al*., 2000)	Recorded during present study (2007-2010)
114	Columbiformes	Columbidae	*Streptopelia senegalensis*	Little Brown or Senegal Dove	R	C	_	+
115	Psittaciformes	Psittacidae	*Psittacula krameri*	Rose ringed Parakeet	R	L / c	+	+
116	Cuculiformes	Cuculidae	*Eudynamys scolopacea*	Indian Koel	R	L / c	+	+
117	Strigiformes	Tytonidae	*Tyto alba*	Indian Barn Owl	R	L / c	_	+
118	Strigiformes	Strigidae	*Bubo bubo*	Eagle Owl	R	L / c	+	+
119	Strigiformes	Strigidae	*Bubo coromandus*	Dusky Eagle or Horned Owl	WV	Ra	_	+
120	Strigiformes	Strigidae	*Athene brama*	Spotted Owlet	R	L / c	+	+
121	Strigiformes	Strigidae	*Asio otus*	Long eared Owl	WV	L / c	_	+
122	Caprimulgiformes	Caprimulgidae	*Caprimulgus europaeus*	European Nightjar	R	Ra	+	+
123	Caprimulgiformes	Caprimulgidae	*Caprimulgus mahrattensis*	Syke's Nightjar	R	L / c	+	_
124	Caprimulgiformes	Caprimulgidae	*Caprimulgus asiaticus*	Indian Nightjar	R	L/c	+	+
125	Apodiformes	Apodidae	*Apus apus*	Common Swift	SBV	L/c	+	_
126	Apodiformes	Apodidae	*Tachymar-ptis melba*	Alpine Swift	M	L / c	+	_
127	Apodiformes	Apodidae	*Apus affinis*	House Swift	SV	Ra	_	+
128	Coraciiformes	Alcedinidae	*Ceryle rudis*	Indian Pied Kingfisher	R	C	+	+
129	Coraciiformes	Alcedinidae	*Alcedo atthis*	Indian Small Blue Kingfisher	R	L / c	+	+
130	Coraciiformes	Alcedinidae	*Halcyon smyrnensis*	White breasted Kingfisher	R	C	_	+
131	Coraciiformes	Meropidae	*Merops persicus*	Blue Cheeked Bee-eater	SBV/PM	L / c	+	+
132	Coraciiformes	Meropidae	*Merops orientalis*	Common Bee-eater	R	L/c	+	_
133	Coraciiformes	Coraciidae	*Coracias benghalensis*	Roller or Blue Jay	R	C	+	+
134	Coraciiformes	Upupidae	*Upupa epops*	Hoopoe	WV	C	_	+
135	Piciformes	Picidae	*Dinopium benghalense*	Sind Golden Backed Woodpecker	R	L / c	_	+
136	Piciformes	Picidae	*Dendrocopos assimilIs*	Sind pied Woodpecker	R	C	+	+
137	Passeriformes	Alaudidae	*Mirafra erythroptera*	Indian Bush Lark / Sind Redwinged Bush Lark	R	L/c	+	+
138	Passeriformes	Alaudidae	*Eremopterix grisea*	Ashy Crowned Finch-Lark	R	C	+	+

Continued…

Table 7. Continue…

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	Recorded earlier (Ghalib *et al*., 2000)	Recorded during present study (2007-2010)
139	Passeriformes	Alaudidae	*Eremopterix nigriceps*	Black Crowned Finch Lark	R	C	+	+
140	Passeriformes	Alaudidae	*Ammomanes desertri*	Desert Finch Lark	R	C	_	+
141	Passeriformes	Alaudidae	*Alaemon alaudipes*	Greater Hoopoe Lark	R	R	+	_
142	Passeriformes	Alaudidae	*Calandrella rufescens*	Lesser Short-Toed Lark	WV	L / c	_	+
143	Passeriformes	Alaudidae	*Galerida cristata*	Crested Lark	R	C	+	+
144	Passeriformes	Hirundinidae	*Riparia riparia*	Collared Sand Martin	WV	C	_	+
145	Passeriformes	Hirundinidae	*Hirundo concolor*	Dusky Crag Martin	R	L / c	_	+
146	Passeriformes	Hirundinidae	*Hirundo rupestris*	Crag Martin	R	L/c	+	_
147	Passeriformes	Hirundinidae	*Hirundo fuligula*	Pale Crag or Rock Martin	R	L/c	+	_
148	Passeriformes	Hirundinidae	*Hirundo smithi*	Wire-tailed Swallow	R	L / c	_	+
149	Passeriformes	Hirundinidae	*Hirundo daurica*	Redrumped Swallow	R	L/c	+	_
150	Passeriformes	Laniidae	*Lanius isabellinus*	Isabelline Shrike	PM	L/c	+	_
151	Passeriformes	Laniidae	*Lanius excubitor*	Grey Shrike	R	L / c	+	+
152	Passeriformes	Laniidae	*Lanius vittatus*	Bay backed Shrike	R	C	_	+
153	Passeriformes	Laniidae	*Lanius schach*	Rufous-backed Shrike	R	L / c	_	+
154	Passeriformes	Dicruridae	*Dicrurus adsimilis*	King Crow / Black Drongo	R	C	+	+
155	Passeriformes	Sturnidae	*Acridotheres tristis*	Common Myna	R	C	+	_
156	Passeriformes	Sturnidae	*Acridotheres ginginianus*	Bank Myna	R	C	+	+
157	Passeriformes	Sturnidae	*Sturnus roseus*	Rosy Starling	WV	L/c	+	+
158	Passeriformes	Corvidae	*Dendrocitta vagabunda*	Indian Tree - pie	R	L/c	+	_
159	Passeriformes	Corvidae	*Corvus splendens*	Sindh House Crow	R	C	+	+
160	Passeriformes	Bombycillidae	*Hypocolius ampelinus*	Grey Hypocolius	WV	Ra	+	_
161	Passeriformes	Campephagidae	*Tephrodornis pondicerianus*	Common Wood Shrike	R	L / c	+	+
162	Passeriformes	Campephagidae	*Pericrocotus cinnamomeus*	Small Minivet	R	L/c	+	_
163	Passeriformes	Pyconotidae	*Pycnonotus leucogenys*	White Cheeked Bulbul	R	C	+	+

Continued…

Table 7. Continue…

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	Recorded earlier (Ghalib *et al*., 2000)	Recorded during present study (2007-2010)
164	Passeriformes	Pyconotidae	*Pycnonotus cafer*	Red-vented Bulbul	R	C	_	+
165	Passeriformes	Timaliidae	*Turdoides caudatus*	Common Babbler	R	C	+	_
166	Passeriformes	Timaliidae	*Turdoides striatus*	Sind Jungle Babbler	R	C	_	+
167	Passeriformes	Sylviidae	*Prinia buchanani*	Rufous Fronted Wren Warbler	WV	L / c	+	+
168	Passeriformes	Sylviidae	*Prinia burnesii*	Long tailed Grass Warbler	R	L / c	_	+
169	Passeriformes	Sylviidae	*Sylvia curruca*	Lesser Whitethroat	WV	L / c	_	+
170	Passeriformes	Sylviidae	*Sylvia nana*	Desert Warbler	WV	C	_	+
171	Passeriformes	Sylviidae	*Phylloscopus sindianus*	Sind Chiffchaff	WV	C	_	+
172	Passeriformes	Sylviidae	*Phylloscopus negletus*	Plain Willow Warbler	WV	Ra	+	_
173	Passeriformes	Sylviidae	*Acrocerphalus dumetorum*	Blyth's Reed Warbler	PM	L/c	+	_
174	Passeriformes	Sylviidae	*Scotocerca inquieta*	Streaked Scrub Warbler	R	L/c	+	+
175	Passeriformes	Turdidae	*Saxicola caprata*	Pied Bush Chat	R	C	_	+
176	Passeriformes	Turdidae	*Oenanthe isabellina*	Isabelline Wheatear	WV	L/c	+	+
177	Passeriformes	Turdidae	*Oenanthe xanthoprymna*	Red tailed Wheatear	WV	L/c	+	_
178	Passeriformes	Turdidae	*Oenanthe deserti*	Desert Wheatear	WV	L / c	+	+
179	Passeriformes	Turdidae	*Oenanthe picata*	Eastern Pied Wheatear	WV	L/c	+	+
180	Passeriformes	Turdidae	*Oenanthe alboniger*	Hume's Wheatear	R	L/c	+	+
181	Passeriformes	Turdidae	*Saxicoloides fulicata*	Indian Robin	R	C	_	+
182	Passeriformes	Turdidae	*Turdus philomelos*	Song Thrush	WV	Ra	+	_
183	Passeriformes	Motacillidae	*Anthus similis*	Long billed Pipit	R	Ra	+	_
184	Passeriformes	Motacillidae	*Motacilla flava*	Yellow Wagtail	PM	C	+	+
185	Passeriformes	Motacillidae	*Motacilla alba*	White or Pied Wagtail	WV	C	_	+
186	Passeriformes	Motacillidae	*Motacilla cinerea*	Grey Wagtail	WV	L / c	_	+
187	Passeriformes	Motacillidae	*Motacilla citreola*	Citrine Wagtail	WV	Ra	+	_
188	Passeriformes	Nectariniidae	*Nectarinia asiatica*	Purple Sunbird	R	C	+	+
189	Passeriformes	Passeridae	*Passer domesticus*	House Sparrow	R	C	_	+

Continued…

Table 7. Continue…

S. No.	Order	Family	Scientific Name	Common Name	Occurrence	Status	Recorded earlier (Ghalib *et al*., 2000)	Recorded during present study (2007-2010)
190	Passeriformes	Passeridae	*Passer hispaniolensis*	Spanish Sparrow	R	L/c	+	_
191	Passeriformes	Passeridae	*Passer pyrrhonotus*	Sind Jungle Sparrow	R	C	_	+
192	Passeriformes	Passeridae	*Petronia xanthocollis*	Yellow throated Sparrow	R	C	+	+
193	Passeriformes	Estrildidae	*Lonchura malabarica*	White throated Munia	R	L / c	+	+
194	Passeriformes	Fringillidae	Bucanetes githagineus	Trumpeter Finch	R	L/c	+	_
195	Passeriformes	Emberizidae	*Emberiza melanocephala*	Black-headed Bunting	PM	L / c	+	+
196	Passeriformes	Emberizidae	*Emberiza buchanani*	Grey – necked Bunting	WV	L/c	+	_
197	Passeriformes	Emberizidae	*Emberiza striolata*	House Bunting	R	L/c	+	_

Numbers of birds recorded

Total species of birds recorded (years 2000 +2010) =197, Total species of birds recorded in the present study = 160
Total species of birds recorded previously (year 2000) = 128
Total No. of species of birds recorded during the previous studies but not recorded during present study =37, New findings = 68
Legend:
Occurrence: R = Resident WV = Winter visitor SBV = Summer Breading Visitor PM = Passage migrant SV = Summer Visitor
Status: L / c = Less common C = Common Ra= Rare

Table 7. List of Reptiles Recorded from Hub Dam.

S. No.	Order	Family	Scientific Name	Common Name	Status
01	Chelonia	Emydidae	*Hardella thurjii*	Brahminy River Turtle	L/c
02	Crocodilia	Crocodylidae	*Crocodylus palustris*	Marsh Crocodile	R
03	Squamata	Gekkonidae	*Eublepharus maculatus*	Fat tailed Gecko	L/c
04	Squamata	Gekkonidae	*Hemidactylus brooki*	Spotted Indian House Gecko	C
05	Squamata	Gekkonidae	*Hemidactylus leschnaultii*	Bark Gecko	L/c
06	Squamata	Gekkonidae	*Hemidactylus flaviviridis*	Yellow-bellied House Gecko	C
07	Squamata	Agamidae	*Trapelus megalonyx*	Afghan Ground Agama	L/c
08	Squamata	Agamidae	*Trapelus agilis*	Brilliant Agama	L/c
09	Squamata	Agamidae	*Laudakia nupta*	Yellow-headed Agama	L/c
10	Squamata	Agamidae	*Calotes versicolor*	Common Tree Lizard	C
11	Squamata	Agamidae	*Noveumeces blythianus*	Orange tail Skink	L/c
12	Squamata	Uromastycidae	*Uromastix hardwickii*	Indian Spiny-tailed Lizard	L/c
13	Squamata	Varanidae	*Varanus bengalensis*	Indian Monitor Lizard	L/c
14	Squamata	Varanidae	*Varanus griseus*	Indian Desert Monitor	L/c
15	Squamata	Lacertidae	*Acanthodactylus cantoris*	Indian Fringed-toed Lizard	C
16	Squamata	Typhlopidae	*Typhlops porrectus*	Slender Blind Snake	L/c
17	Squamata	Boidae	*Eryx johnii*	Indian Sand Boa	L/c
18	Squamata	Boidae	*Psommophis candanura*	Indian Sand Snake	L/c
19	Squamata	Colubridae	*Platyceps rhodorachis*	Cliff Racer	L/c
20	Squamata	Colubridae	*Platyceps vertromaculatus*	Glossy bellied Racer	L/c
21	Squamata	Elapidae	*Naja naja*	Indian Cobra	L/c
22	Squamata	Elapidae	*Bungarus caeruleus*	Common Krait	R
23	Squamata	Viperidae	*Echis carinatus*	Saw Scaled Viper	L/c

Status: L /c = Less common C = Common Ra = Rare

Table 8. List of Amphibians Recorded from Hub Dam

S. No.	Order	Family	Scientific Name	Common Name	Status
01	Anura	Bufonidae	*Bufo stomaticus*	Indus Valley Toad	L/c
02	Anura	Ranidae	*Euphlyctis cyanophlyctis*	Skittering Frog	C
03	Anura	Ranidae	*Sphaerotheca breviceps*	Burrowing Frog	L/c

Status: L / c = Less common C = Common R= Rare

Table 9. List of Fishes Recorded from Hub Dam.

S. No.	Order	Family	Scientific Name
01	Clupeiformes	Clupeidae	*Gadusia chapra*
02	Osteoglossiformes	Notopteridae	*Notopterus chitala*
03	Osteoglossiformes	Notopteridae	*Notopterus notopterus*
04	Cypriniformes	Cyprinidae	*Salmostoma bacaila*
05	Cypriniformes	Cyprinidae	*Barbodes sarana*
06	Cypriniformes	Cyprinidae	*Catla catla*
07	Cypriniformes	Cyprinidae	*Cirrhinus mrigala*
08	Cypriniformes	Cyprinidae	*Cirrhinus reba*
09	Cypriniformes	Cyprinidae	*Labeo dyocheilus*
10	Cypriniformes	Cyprinidae	*Labeo gonius*
11	Cypriniformes	Cyprinidae	*Labeo rohita*
12	Cypriniformes	Cyprinidae	*Labeo calbasu*
13	Cypriniformes	Cyprinidae	*Labeo sindensis*
14	Cypriniformes	Cyprinidae	*Labeo diplostomus*
15	Cypriniformes	Cyprinidae	*Cheila bacaila*
16	Cypriniformes	Cyprinidae	*Cheila laubuca*
17	Cypriniformes	Cyprinidae	*Danio devario*
18	Cypriniformes	Cyprinidae	*Tor putitora*
19	Cypriniformes	Cyprinidae	*Barbus ticto*
20	Cypriniformes	Cyprinidae	*Barbus sarana*
21	Cypriniformes	Cyprinidae	*Ctenopharyngodon idella*
22	Cypriniformes	Cyprinidae	*Cyprinus carpio*
23	Siluriformes	Siluridae	*Wallago attu*
24	Siluriformes	Siluridae	*Mystus seenghala*
25	Channiformes	Channidae	*Channa marulia*
26	Perciformes	Gobidae	*Glossogobius giuris*
27	Perciformes	Cichlidae	*Oreochromis mossambicus*
28	Symbranchiformes	Mastacembelidae	*Mastacembelus armatus*
29	Chiocephalioformes	Ophicephalidae	*Ophicephalus.*

Fishes

Twenty nine species of fishes were recorded viz. *Gadusia chapra, Notopterus chitala, Notopterus notopterus, Salmostoma bacaila, Barbodes sarana, Catla catla, Cirrhinus mrigala, Cirrhinus reba, Labeo dyocheilus, Labeo gonius, Labeo rohita, Labeo calbasu, Labeo sindensis, Labeo diplostomus, Cheila bacaila, Cheila laubuca, Danio devario, Tor putitora, Barbus ticto, Barbus sarana, Ctenopharyngodon idella, Cyprinus carpio, Wallago attu, Mystus seenghala. Channa marulia, Glossogobius giuris, Oreochromis mossambicus, Mastacembelus armatus,* and *Ophicephalus* (Table 9).

The most important edible fishes are *Cyprinus carpio, Tor putitora, Labeo sp., Barbus ticto* and *Barbus sarana.*

Flora

Twenty five species of flora were recorded (Table 10). The dominant species were viz. *Acacia jacquemontii, Acacia nilotica, Aerva javanica, Acacia senegal, Alhaji maurorum, Azadirachta indica, Calotropis procera, Capparis decidua, Cassia italica, Cymbopogon jwarancusa, Cymbopogon schoenanthus, Eleusine compressa, Euphorbia caducifolia, Eucalyptus sp., Ficus religiosa, Lasiurus hirsutus, Leptadenia pyrotechnica, Olea ferruginea, Prosopis glandulosa, Prosopis juliflora, Rhazia stricta, Tamarix aphylla, Typha elephantiana, Zizyphus mauritiana* and *Zizyphus nummularia*.

Table 10. List of Flora Recorded from Hub Dam.

S. No.	Scientific Name
01	*Acacia jacquemontii*
02	*Acacia nilotica*
03	*Aerva javanica*
04	*Acacia senegal*
05	*Alhaji maurorum*
06	*Azadirachta indica*
07	*Calotrotpis procera*
08	*Capparis decidua*
09	*Cassia italica*
10	*Cymbopogon jwarancusa*
11	*Cymbopogon schoenanthus*
12	*Eleusine compressa*
13	*Euphorbia caducifolia*
14	*Eucalyptus sp.*
15	*Ficus religiosa*
16	*Lasiurus hirsutus*
17	*Leptadenia pyrotechnica*
18	*Olea ferruginea*
19	*Prosopis glandulosa*
20	*Prosopis juliflora*
21	*Rhazia stricta*
22	*Tamarix aphylla*
23	*Typha elephantiana*
24	*Zizyphus mauritiana*
25	*Zizyphus nummularia*

CONCLUSION

Regarding the effects of environmental pollution, there are no serious effects on the aquatic biodiversity of the wetland. There is a serious decline in waterbird population but these are mainly due to social disturbances. Areas near spillway, main dam area, agriculture land/ shallow water, and Hub Canal are the prime habitats of birds in the wetland.

During the study no adverse effect of environment pollution was found on the aquatic biodiversity except for slightly higher concentrations of some trace metals in water. All the physico – chemical parameters were recorded as per limits of WHO Standard.The present investigation indicates that all the physico-chemical parameters are not exceeding the limits significantly for aquatic life of the Dam and no significant excessive concentration of heavy metals were recorded during the present study. Therefore the water of Hub Dam is chemically safe and fit for human consumption, irrigation supply and for the growth of aquatic flora and aquatic biodiversity.

It was also found that the Dam Water is polluted with microbial infestation and the assessed value is higher than the set limits of WHO Standard. Therefore the water must be treated periodically before supplying particularly for domestic use.

There was not an observed correlation or significant differences between selected physico – chemical parameters and the different sites. The significant differences found between the metals will assist in the selection of an appropriate treatment method to minimize the contamination of the water of Hub Dam.

There are no serious threats to the biodiversity of the area. Hunting of wildlife has been controlled to a great extent.

RECOMMENDATIONS

- To maintain the water quality of Hub Dam, long-term monitoring program may be undertaken and regular environmental assessment must be made to ensure the safety of this wildlife sanctuary, Ramsar Site and its aquatic life.
- It is concluded that the area is rich in biodiversity. It is suggested that the management plan of the reservoir should be implemented in its true letter and spirit.
- Studies on the migration of water birds may be undertaken and ringing/ banding programmes may be started.
- Steps for the development of fisheries may be taken up, as the reservoir is an important area for fishes, particularly the Mahseer.
- Public awareness programmes may be taken up for the conservation and sustainable utilization of the natural resources.

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