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Descriptions and Seasonal Variations of Various Biotopes and Ecotones of Indus River Bed at Chashma Barrage, Pakistan

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A B S T R A C T

The aim of the study was to find the diversity index of flora, investigation of species at pond area and biomass calculation of economic plants at Chashma Barrage, Pakistan. The study area consisted of river Bella, pond area and eastern edge of river bed near Ali Wali Ghandi village at Chashma Barrage. The seasonal variation in the abundance of floral species was also related with the increase in temperature. *Cyperus deformus, Phragmites kerka, Saccharum spontaneum* were most abundant in the river 'Bella' habitat. *Persicassia amphibian, Cyperus deformus* and *Polygonum royleanum* were abundant in Aliwali Ghandi habitat. Aquatic plants of families *Potamogetonaceae, Nymphaeaceae, Najadaceae* and *Hydrocharitaceae* were most common in pond area . The ecotones were wide and variable between the aquatic biotopes and the river bed biotopes. On the Aliwali Ghandi site the moist soil with puddles and small channels of water were found and *Cyperus deformus* biotope prevailed. In the river 'Bella' site *Phragmites, Sacharum* was the biotope and in water *Hydrilla* biotope was recorded. An increase in biomass of *Phragmites, Sacharum* and *Typha* was recorded with the passage of time. The species of the area have significant importance in socio economics of the local community of Chashma Barrage.

Introduction

Ecological systems or ecosystems are self-interacting systems which operate as separate entities in biosphere (Trivedi, 2004). Ecosystems are adaptive systems which are formed by the combination of many biotic and abiotic components having inter-relationships and inter-interactions bringing forth structural and functional changes. Evolution shapes ecosystems properties and leads these systems to ecological and evolutionary development (Levin, 1998).

Biodiversity can be measured by measuring the richness and evenness considering the differences among the species. Biodiversity provides biological and atmospheric regulations and refers all types of animals, plants and microorganisms in an ecosystem (Qureshi and Ali, 2011). Each biotope has its own array in its typical site with specified structural features (Anonymous, 2012). The biosphere is characterized by number of gradients of physical factors like temperature and moisture, depth gradients of water bodies, as well as the organisms adapted to these conditions, sometime there are points of abrupt change, known as ecotones. An ecotone is created by the juxtaposition of different habitats, or ecosystem types so it is active interaction between two or more ecosystems (or patches within ecosystem), which results in the ecotone having properties that do not exist in either of the adjacent ecosystems (Naiman and Decamps, 1990).

Wetlands are transitional habitat between deep water aquatic systems and terrestrial systems. The varied hydrological regimes associated with wetlands create a diverse set of environmental conditions that require plants to tolerate different degrees of wetness. Some plants are characteristics of wetlands as they show their climatic conditions and habitat type. Hydrophytic vegetation is a major determinant of regulated wetlands. Wetlands have two types of plants; hydrophytes (with submerged organs) and helophytes (on wet soil). Hence plants growing in water like ponds, lakes, coastal water and rivers are unquestionably hydrophytes (Tiner, 1991). It is the hydrological regime of wetlands, with varying wet and drier periods, that makes them different from terrestrial and fully aquatic ecosystems. Even slight changes in hydrology may result in significant alteration of wetland processes, species composition and ecological functions (Acreman et al., 2007).

Pakistan has more than 225 significant man-made and natural wetlands which cover about 10% of the total area of the country. The man made wetlands includes lakes, canals, dams and reservoirs which are the major part of Pakistan's extensive Indus basin Irrigation System. The country has different vegetation and climatic zones which are dependent upon water resources. After independence, three water storage reservoirs, sixteen barrages, twelve

interlink canals, two siphons and forty three main canals were built to prosper the agro based economy of the country (Akbar et al., 2009).

Chashma Barrage was constructed in 1971 on the River Indus close to the village Chashma, about 57 kilometers downstream of Jinnah Barrage. It is southwest of Mianwali on Dera Ismail Khan Road in the Punjab province. The barrage is 1077.8 meters long with 951 meters of clear waterway and with a maximum design discharge of 0.031 million m^3/s. The maximum flood level height of the Barrage is 11.3 meters. It has 52 bays, each 18.3 meters wide. The length of the left and right marginal bund is 1311 meters each (Haq, 1997). It was declared as Wildlife Sanctuary on January 31, 1974 for a period of five years under the provisions of the Punjab Wildlife Act, 1974 and it was renotified in July 1984. Since then it continuously existed as a Wildlife Sanctuary till now. It is a wetland of international importance and is also a Ramsar Site (Akbar et al., 2009).

The study area consisted of river Bella, pond area and eastern edge of river bed near Ali Wali Ghandi village at Chashma Barrage. The main objective of the study was to find the diversity index of flora, investigation of species at pond area and biomass calculation of economic plants at Chashma barrage, Pakistan. The seasonal biomass increase of some economically important plants was also studied to determine its socio economic value to the local community.

Material and Methods

Study Areas

The chosen study sites were; a) Ali Wali Ghandi mud flats b) River 'Bella' beyond the '' machi kanda'' embankment, c) pond area adjacent to the fish kanda embankment on the eastern side. These sites were plotted on the imagery obtained from Water and Power Development Authority (WAPDA) Pakistan (Figure-1). The visits were made to Chashma Jhelum link and Chashma reservoir bank canal to collect additional data. An overview map was also developed to show the study areas (Figure-1). The study areas were photographed with digital camera as well.

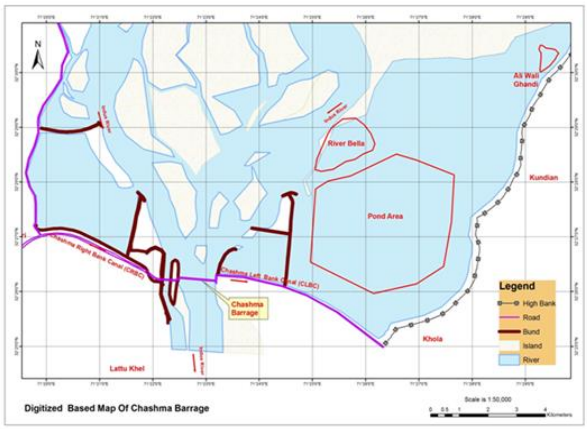

Figure 1 An illustration of digitized map of Chashma Barrage showing areas of study

Data collection

The primary data was collected personally on the site. The secondary data about the resources was collected by interviewing the livestock persons in the river bed. Sampling was done in the field to collect plants for identification and to find relative abundance of plants to find their diversity. Samples were marked in a straight direction at a distance of nearly 15 meters each. These samples were plotted on ground by marking with a stiff stick. The bed was moist enough to have a clear mark. The vegetation was thick so circular samples were given preference over the quadrates for convenience. One person stood in the center with a string of the length of 30 centimeters tightly held to the body. Another person marked the circle with a stick held tight to the other edge of the string. With this radius the sample covered an area of 40.5 square meters. The number and the kind of plants in each circle were counted separately.

Realizing the thickness of the vegetation and its uniformity in the sample, each circle was divided into four equal parts by drawing the two lines (diameters) perpendicular to each other in the circle. Number of plants of one specific variety were counted in one-fourth part of one the circle and multiplied with 4 to get total number of plants of that specific variety in that complete circle. Same method of calculation was done for each and every other variety of plant in that circle. Every other circle went through the same procedure.

Plants were collected from the selected sites from each sample. Every sample was taken after every 15 steps randomly in one direction and 10 samples were taken from every site on each visit. The plants were then pressed and dried for identification.

Samples of aquatic plants from selected pond area were collected by visiting the pond area with the help of boat and some samples were collected from the bank of pond where plants were drifted due to wind. Plant species from each sample were collected in polythene bags and then pressed in paper sheets. The identifications of these species were performed in Department of Botany, Government College University Lahore, Pakistan taking the help from experts in the respective area.

Biomass calculation

The total vegetation cover of selected sites at Chashma was measured by using a method adopted by Mirza (1970). The circular plot of 40.5 square meters was marked with the help of string of 30 centimeters to access the density. Average biomass of each species was calculated in samples of 40.5 square meters each by weighing the collected mature and young plants (excluding the roots) with the help of electric balance. The density of each species collected was calculated by counting the number of plants in 40.5 square meters and using the formula;

Density=No. of plants /area

Three areas from each selected site were sampled and vegetation of different types was collected. The maximum and minimum density of these plants in different season was recorded.

Plant diversity

Relative abundance of the sampled plants was found by the following formula and further more plant density was calculated using Shannon Weaver (Shannon-Weiner Species Diversity Index) Index. The greater the value of Shannon weaver index, greater is the diversity and vice versa.

$$H=\sum Pi\times\ln(Pi)$$

$$R.A.=\frac{\text{Total No. of plants of 1 species in all the samples}}{\text{Total No. of all plants in all the quadrates}}x100$$

Where ∑= Symbol of addition, H'= the Shannon-Weaver Diversity Index, ln= Natural logarithm, Pi= the relative abundance of each group of organisms, S-W index is expressed as e^H

Results and Discussion

The present study research provides observations and analysis of the river bed including aquatic plants habitat of Indus River at Chashma barrage. The state of the habitats caused by anthropogenic impacts is also studied, including the biotopes and ecotones in the river bed that included three types of habitats i.e. habitat of pond area, ecotones and biotopes.

The seasonal variation of flora in the habitats under study was significant and this variation was interpreted as due to seasonal temperature variations because in early winter the growth of flora was depressed due to cold weather (Table-1 and 5). The state of habitat looked dry and the dried flora appeared less thick than it became in hot season whereas data collected in the months of March and April (Table-3 and 4) showed that number of species increased with increase in temperature. The floral diversity remained moderate in the month of February (Table-2; Figure-2).

The increase in floral diversity in months of March and April was attributed to the high temperature and favorable state of the soil (i.e. high rate of fermentation due to degradation of dead organic matter increase the fertility of soil) as this degradation is more in warm season than in cold season. During these months, the preference for the food changes because number of species increases and livestock eat or prefer to eat more nutritious food. It is well evident now that the temperature correlates with an increase in species diversity as established by Rahbek (1995).

Table 1 Diversity Index of plants collected at both sites during month of January

Sr. No	Plants species name		Pi(Relative abundance)		lnPi		Pi*ln(Pi)	
	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
1.	*Cyperus difformis*	*Persicassia amphibian*	0.5	0.15	-0.693	-1.897119	-0.347	-0.284567
2.	*Phragmites karka*	*Cyperus deformus*	0.14	0.25	-1.966	-1.386295	-0.275	-0.346573
3.	*Polygonum royleanum*	*Schoenoplectus litoralis*	0.08	0.08	-2.525	-2.525728	-0.202	-0.202058
4.	*Tamarix aphylla*	*Polygonum royleanum*	0.02	0.17	-3.912	-1.771956	-0.078	-0.301232
5.	*Saccharum spontaneum*	*Eleocharis melanocarpa*	0.1	0.21	-2.302	-1.560647	-0.230	-0.327736
6.	*Arundo donax*	*Cynodon dactylon*	0.05	0.09	-2.995	-2.407945	-0.149	-0.216715
7.	*Persicassia amphibian*		0.06		-2.813		-0.168	
8.	*Ruma dentatus*		0.05		-2.995		-0.149	
							∑Pi*lnPi =-1.598	∑Pi*lnPi =-1.678881

Site 1: Diversity index (e^H) of River 'Bella' site = 4.943; Site 2: Diversity index (e^H) of Ali Wali Ghandi site = 5.359

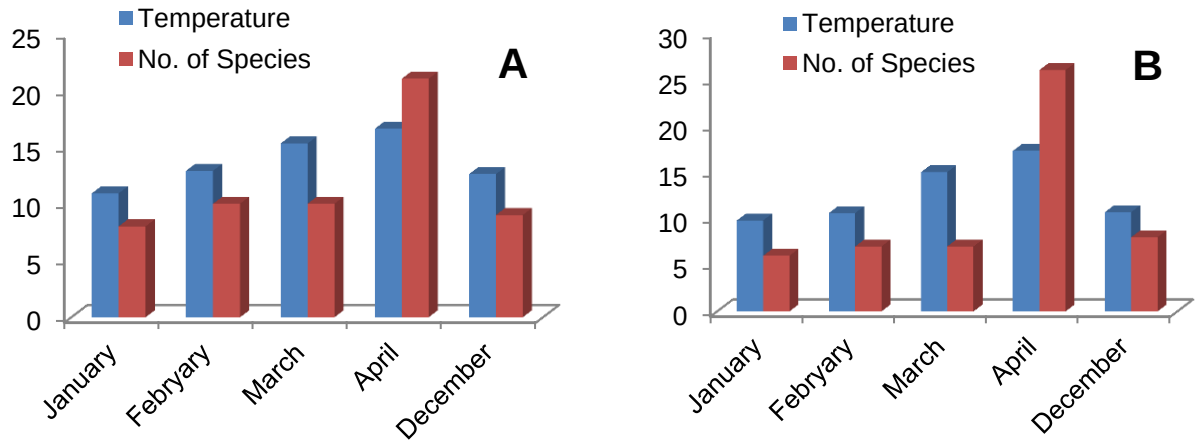

Figure 2 Effects of temperature on number of species at River Bella (A) and Ali Wali Gandhi (B) sites during visits.

Table 2 Diversity Index of plants collected at both sites during month of February

Sr. No	Plants species name		Pi(Relative abundance)		lnPi		Pi*ln(Pi)	
	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
1.	*Cyperus deformus*	*Cyperus deformus*	0.12	0.35	-2.120263	-1.049822	-0.254431	-0.3674377
2.	*Phragmites kerka*	*Schoenoplectus litoralis*	0.13	0.16	-2.040221	-1.832581	-0.265228	-0.293213
3.	*Polygonum royleanum*	*Polygonum royleanum*	0.11	0.11	-2.207274	-2.207274	-0.242800	-0.242800
4.	*Tamarix aphylla*	*Eleocharis melanocarpa*	0.04	0.25	-3.218875	-1.386295	-0.128755	-0.346573
5.	*Saccharum spontaneum*	*Cynodon dactylon*	0.12	0.05	-2.120263	-2.995732	-0.254431	-0.149786
6.	*Amarantus viridus*	*Amarantus viridus*	0.07	0.05	-2.659260	-2.995732	-0.1861482	-0.149786
7.	*Eclipta alba*	*Eclipta alba*	0.08	0.03	-2.525728	-3.506557	-0.202058	-0.105196
8.	*Ruma dentatus*		0.05		-2.995732		-0.149786	
9.	*Cynodon dactylon*		0.06		-2.813410		-0.168804	
10.	*Coronopus didymus*		0.04		-3.218875		-0.128755	
							∑Pi*lnPi =-1.9811912	∑Pi*lnPi =-1.654791

Site 1: Diversity index (e^H) of River 'Bella' site = 7.625, Site 2: Diversity index (e^H) of Ali Wali Ghandi site = 6.093

Table 3 Diversity Index of plants collected at both sites during month of March

Sr. No	Plants species name		Pi(Relative abundance)		lnPi		Pi*ln(Pi)	
	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
1.	*Cyperus deformus*	*Cyperus deformus*	0.12	0.35	-2.120263	-1.049822	-0.254431	-0.3674377
2.	*Phragmites kerka*	*Schoenoplectus litoralis*	0.13	0.16	-2.040221	-1.832581	-0.265228	-0.293213
3.	*Polygonum royleanum*	*Polygonum royleanum*	0.11	0.11	-2.207274	-2.207274	-0.242800	-0.242800
4.	*Tamarix aphylla*	*Eleocharis melanocarpa*	0.04	0.25	-3.218875	-1.386295	-0.128755	-0.346573
5.	*Saccharum spontaneum*	*Cynodon dactylon*	0.12	0.05	-2.120263	-2.995732	-0.254431	-0.149786
6.	*Amarantus viridus*	*Amarantus viridus*	0.07	0.05	-2.659260	-2.995732	-0.1861482	-0.149786
7.	*Eclipta alba*	*Eclipta alba*	0.08	0.03	-2.525728	-3.506557	-0.202058	-0.105196
8.	*Ruma dentatus*		0.05		-2.995732		-0.149786	
9.	*Cynodon dactylon*		0.06		-2.813410		-0.168804	
10.	*Coronopus didymus*		0.04		-3.218875		-0.128755	
							∑Pi*lnPi =-1.9811912	∑Pi*lnPi =-1.654791

Site 1: Diversity index (e^H) of River 'Bella' site = 7.252, Site 2: Diversity index (e^H) of Ali Wali Ghandi site = 5.232

The aquatic plants in the pond area were collected and identified at the study area (Table-6). The results showed that most of these plants belong to *Potamogetonaceae*, *Nymphaeaceae* and *Najadaceae* families. *Hydrila verticillata* was the abundant species that prevailed in the pond area of the reservoir as recorded by visual observations. The river Bella and Aliwali Ghandi village both biotopes of *Phragmites kerka* - *Saccharum spontaneum* that grew on moist soil with puddles of water and made it a reasonable habitat for many of wader bird species. These aquatic plants supported macroinvertibrates and birds of that habitat and diversity and are the habitats for most of macroinvertibrates. A similar kind of studies was conducted by Shelly et al. (2011) who did the relative study on the macro-invertebrates of Mangla dam and Chashma Barrage Pakistan and also made the ecological linkages of the vegetation and faunal community of pond areas of these wetlands. Emmanuel et al. (2012) reported comparative study of ecological conditions of four wetlands of Punjab using macroinvertebrates as bioindicators

Table-7 indicates the height and biomass of economically important young and mature plants at study sites in 0.40 hectare. The young plants become mature after period of six months i.e. gained the same height as the adult plants. It showed that biomass of these plants became available after every six months to use as resource not only for grazing of livestock but also for use in other purposes like burning in kilns and to make handicrafts contributing to the socio economic factors. Most important economically important plants at Chashma Barrage are *Phragmites, Sacharum* and *Typha*. It was found that biomass of *Phragmites* increased from 1013 kg to 5850 kg, *Sacharum* increased from 567 kg to 8505 kg and *Typha* increased from 1198 kg to 18569 kg within period of six months. The sustainable use of biomass for energy and bio-products offers multiple economic and environmental benefits (Kaffka et al. 2013).

Conclusion and Recommendation

The habitat of Chashma barrage wildlife sanctuary is being degraded very fast due to overexploitation of resources. The aquatic plant species and macroinvertebrates of sanctuary have been disturbed due to fishing practice. Fishing has shown negative impacts on aquatic wildlife to the extent that smooth coated Otter and Indus blind dolphin have become locally extinct. The increasing population of the water is likely to give negative impact on the flora and fauna of the reservoir habitat.

Table 4 Diversity Index of plants collected at both sites during month of April

Sr. No	Plants species name		Pi(Relative abundance)		lnPi		Pi*ln(Pi)	
	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
1.	*Cynodon dactilon*	*Cyperus deformus*	0.11	0.10	-2.207274	-2.302585	-0.242800	-0.230258
2.	*Pharagmites kerka*	*polygonum royleanum*	0.08	0.06	-2.525728	-2.813410	-0.202058	-0.168804
3.	*Tamarix aphylla*	*Schoenoplectus litoralis*	0.02	0.08	-3.312023	-2.525728	-0.078240	-0.202058
4.	*Cyperus deformus*	*Eleocharis melanocarpa*	0.14	0.09	-1.966112	-2.407945	-0.275255	-0.216715
5.	*Coronopus didymus*	*Cynodon dactila*	0.07	0.03	-2.659260	-3.506557	-0.1861482	-0.105196
6.	*Rumex dentatus*	*Eclpita alba*	0.04	0.06	-3.218875	-2.813410	-0.128755	-0.168804
7.	*Eclipta alba*	*Amaranthus viridus*	0.06	0.03	-2.813410	-3.506557	-0.168804	-0.105196
8.	*Amarantus viridus*	*Coronopus didymus*	0.05	0.04	-2.995732	-3.218875	-0.149786	-0.128755
9.	*Mazus pumilus*	*Cotula anthenoides*	0.04	0.03	-3.218875	-3.506557	-0.128755	-0.105196
10.	*Brumus Sp*	*Dichanthium annulatum*	0.03	0.04	-3.506557	-3.218875	-0.105196	-0.128755
11.	*Luteo album*	*Lippai nodiflora*	0.04	0.02	-3.218875	-3.312023	-0.128755	-0.078240
12.	*Malvastrum coromandelianum*	*Zygophyllum propinquum*	0.03	0.03	-3.506557	-3.506557	-0.105196	-0.105196
13	*Carex cespitosa*	*Melilotus indica*	0.02	0.04	-3.312023	-3.218875	-0.078240	-0.128755
14.	*Cynosurus cristatus*	*Melilotus officinalis*	0.07	0.03	-2.659260	-3.506557	-0.1861482	-0.105196
15.	*Centaurium pulchellum*	*Persicaria amphibian*	0.03	0.03	-3.506557	-3.506557	-0.105196	-0.105196
16.	*Phyla nodiflora*	*Ranunculus sceleratus*	0.02	0.04	-3.312023	-3.218875	-0.078240	-0.128755
17.	*Eleusine indica*	*Veronica laxa*	0.01	0.03	-4.605170	-3.506557	-0.046051	-0.105196
18.	*Veronica polita*	*Alonsoa warscewiczii*	0.03	0.04	-3.506557	-3.218875	-0.105196	-0.128755
19.	*Ranunculus sceleratus*	*Rumex dentatus*	0.04	0.03	-3.218875	-3.506557	-0.128755	-0.105196
20.	*Stetonia sp & carvex sp*	*Veronica polita*	0.05	0.03	-2.995732	-3.506557	-0.149786	-0.105196
21.	*Chelonanthus albus*	*Gnaphalium lutcoallum*	0.04	0.03	-3.218875	-3.506557	-0.128755	-0.105196
22.		*Conyza ambigua*		0.04		-3.218875		-0.128755
23.		*Mazus pumilus*		0.03		-3.506557		-0.105196
24.		*Dicliptera bupleuroides*		0.04		-3.218875		-0.128755
25.		*Polypogon monspeliensis*		0.06		-2.813410		-0.168804
							∑Pi*lnPi =-2.9061152	∑Pi*lnPi =-3.292084

Site 1 Diversity index (e^{H}) in April on River 'Bella' site = 18.2856, Site 2: Diversity index (e^{H}) in April on Ali Wali Ghandi site = 26.898

Table 5 Diversity Index of plants collected at both sites during month of December

Sr. No	Plants species name		Pi(Relative abundance)		lnPi		Pi*ln(Pi)	
	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
1.	*Cyperus deformus*	*Cyperus deformus*	0.25	0.27	-1.386295	-1.309333	-0.346573	-0.353519
2.	*Phragmites kerka*	*Schoenoplectus litoralis*	0.15	0.18	-1.897119	-1.714798	-0.284567	-0.308664
3.	*Polygonum royleanum*	*Polygonum royleanum*	0.13	0.05	-2.040220	-2.995732	-0.265228	-0.149786
4.	*Tamarix aphylla*	*Eleochasis melanocarpa*	0.05	0.24	-2.995732	-1.427116	-0.149786	-0.342507
5.	*Saccharum spontaneum*	*Cynodon dactylon*	0.10	0.08	-2.302585	-2.525728	-0.230258	-0.202058
6.	*Coronopus didymus*	*Coronopus didymus*	0.15	0.03	-1.897119	-3.506557	-0.284567	-0.105196
7.	*Rumex dentatus*	*Dichanthium annilatum*	0.08	0.05	-2.525728	-2.995732	-0.202058	-0.149786
8.	*Cynodon dactylon*	*Persicacia amphibian*	0.09	0.10	-2.407945	-2.302585	-0.216715	-0.230258
							∑Pi*lnPi =-1.979752	∑Pi*lnPi =-1.841774

Site 1 Diversity index (e^{H}) in December on River 'Bella' site = 7.241, Site 2 Diversity index (e^{H}) in December on Ali Wali Ghandi site = 6.307

Table 6 Aquatic vegetation with their families and their local names found in pond area at Chashma Barrage

Sr. No.	Family	Common name	Botanical name
1	Hydrocharitaceae	Hydrilla	*Hydrilla verticillata*
2	*Potamogetonaceae*	Curly-leaf pondweed	*Potamogeton crispus*
3	*Potamogetonaceae*	Pond weeds	*Potomogeton natans*
4	*Nymphaeaceae*	Waterlily	*Nymphia lotus*
5	*Nymphaeaceae*	Blue Waterlily	*Nymphia stellate*
6	*Najadaceae*	Slender Naiad	*Najas major*
7	*Najadaceae*	Naiad	*Najas graminea*
8	*Najadaceae*	Water nymph	*Najas gudalupensis*
9	*Typhaceae*	Lesser Indian Reed Mace	*Typha angustata*
10	*Hydrocharitaceae*	Italian Val	*Vallisneria spiralis*
11	*Potamogetonaceae*	Horned pond weed	*Zannichellia palustris/*
12	*Potamogetonaceae*	Ribbon weed	*potamogeton pectinatus*

Table 7 The calculation of biomass of economically important plants at study area of Chashma barrage

Plant name	Wt.&Height YP[1]	Wt.&Height MP[2]	NoP[3].	BYP[4]	BMP[4]
Phragmites kerka	Weight=9g Height=1ft	Weight=52g Height=8ft	1125	1013	5850
Sacharum spontanum	Weight=7g Height=2ft	Weight=105g Height=12ft	810	567	8505
Typha	Weight=10g Height=2ft	Weight=155g Height=8ft	1198	1198	18569

[1]Wt. & Height (from tips of top leaves to the soil) of young plant, [2]Wt. & height (from tips of top leaves to the soil) of mature plant, [3]No. of plants in 40.5 m^2, [4]Biomass of young plants in 0.40 hectare (kg), [5]Biomass of mature plants in 0.40 hectare (kg)

Based on our study we composed some recommendation that wildlife Sanctuary must be guarded against the illegal negative impacts. The various departments are managing wetlands independently and separately. Instead there should be a joint management committee for Chashma Barrage Sanctuary. There should be an interdepartmental management of habitat of the Sanctuary. This includes prohibition of medical waste pollution in water of wetlands in the Sanctuary. The favorable mitigation measures should be implemented to stop degradation as wetlands are habitat for both the local communities and waterfowls. Since it is a sanctuary there should be no harvesting of vegetation in the sanctuary. Fisheries is a major wetland resource in the Sanctuary which creates contradictions of sanctuary laws and effects the natural fauna of the sanctuary however being an important financial resource it also be managed by the proposed interdepartmental management. The scientific research in the Sanctuary should be encouraged. The measures should be taken to increase the biodiversity and to preserve the habitat for migratory birds.

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