ECOLOGICAL INVENTORY OF YAMUNA RIVER IN NCT DELHI

2015



NATURAL HERITAGE DIVISION

INTACH Indian National Trust for Art and Cultural Heritage

ECOLOGICAL INVENTORY OF YAMUNA RIVER IN NCT DELHI

A STUDY OF THE STREAM BIODIVERSITY AND ECOLOGICAL PARAMETERS OF YAMUNA RIVER IN NCT DELHI

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Introduction

1.0 Rivers across India are in a crisis. Yamuna, which is the lifeline of Delhi and one of the major Rivers of the country, is no exception. Excessive water abstractions and diversions for rural and urban uses and high pollution loads, both upstream and in Delhi, have resulted in nearly killing the River. Thus, the Delhi reach now exhibits little biological life in the flowing stream as well as in the riparian areas. Downstream of Delhi the River carries only wastewater most of the year, except during three months of monsoon rains. It is only after confluence with River Chambal that River Yamuna regains life.

2.0 Alarmed at these developments environmentalists, judiciary and government agencies are engaged for the last two decades and more in efforts to restore the health of the River. While there is baseline data for water quality and flow and reasonably detailed hydrological history of the basin, there is little research on the ecological characteristics of the River. These characteristics are the indicators against which future improvements can be measured. As Yamuna enters Delhi, it is impounded at Wazirabad Barrage, the water diverted for potable use in the city. This barrage is the location of striking change in Yamuna's hydrology as well as ecology.

3.0 This study attempts to plug the existing gaps on the ecological baseline status of the River. The fieldwork was carried out from April 2014 to February 2015.

4.0 **The River Yamuna:** This is what the Delhi Gazetteer [1975] has to say: "The river Yamuna enters the Union Territory over a mile north of Palla Village, at an altitude of 690 ft. above sea level, and leaves it near Jaitpur below Okhla at an altitude of 650 ft. above sea level. It course within the limits of Delhi extends roughly over some 32 miles with the fall ranging between 18 to 20 inches to the mile. During the rainy season, the river expands considerably in breadth, swelling in places to several miles. The maximum depth in this season is about 25 ft and the discharge at Okhla is above 4,100 cusecs. In the dry weather, however, the river gets reduced in breadth: the maximum depth dwindles to about 4 ft., and the discharge to less than 200 cusecs. Having been drained of its waters to a considerable extent by the two canals before it enters the territory, the Yamuna meanders across the plains of Delhi as a narrow stream, fordable almost at any point except during the rains. The river is flanked by low sandy banks on either side and flows over a bed of riverain sands, though firm rock has also been detected in the bed of the Okhla Weir."

5.0 River Yamuna originates from the Yamunotri glacier near Bundarpoonch in the Mussourie range of the lower Himalayas at an elevation of about 6320 meter above mean sea level in Uttarkashi District of Uttarakhand and merges with river Ganga at Triveni Sangam, Allahabad in Uttar Pradesh after traversing a distance of around 1370 km in which it is joined by several tributaries. The second largest tributary of river Ganga, Yamuna is a sacred river and worshipped as a Goddess. According to mythology, Yamuna is the daughter of Sun God and sister of Yama, the God of Death. She desenced upon earth to purify the

world and to meet her beloved Lord Krishna. Legends say that bathing in its sacred waters frees one of the torments of death.

6.0 Geological evidence indicates that Yamuna was earlier a tributary of river Ghaghar that flowed into the Saraswati. Neotectonic events forced the river Yamuna to change course several times, finally to become tributary of the Ganga. The river has four main tributaries in the Himalayan region: Rishi Ganga, Hanuman Ganga, Tons, and Giri; in the plains, the main tributaries are Hindon, Chambal, Sindh and Betwa. The construction of diversion structures in upper and middle reaches of the river for irrigation, domestic and industrial water supply has not only modified the water regime but has had severe negative effects on the ecology of the river and its flood plains. Further, groundwater abstraction in the catchment has led to water table depletion causing disruption in in linkage between surface and groundwater. This has resulted in change in lean season flows or the base flows of the river. The inflow of wastewater from various towns throughout the length of the river further aggravates water quality issues.

7.0 **The river has a catchment area** of 366,223 km^2 (catchment basin area in various states= 3,45,848 km^2; Yamuna river area = 20,375 km^2), that covers parts of Uttrakhand, Himachal Pradesh, Uttar Pradesh, Haryana, Rajasthan, Madhya Pradesh and NCT Delhi.

Table No. 1 : Catchment Area Details Of Yamuna Basin

		Area in the major sub-basins (km^2)					
State	Area In River Yamuna Catchment	River Hindon	River Chambal	River Sind	River Betwa	River Ken	Other sub-basin
Uttaranchal	3771	-	-	-	-	-	3771
Uttar Pradesh	70437	7083	452	748	14438	3336	44380
Himachal Pradesh	5799	-	-	-	-	-	5799
Haryana	21265	-	-	-	-	-	21265
Rajasthan	102883	-	79459				23388
Madhya Pradesh	140208	-	59838	25131	33504	21090	647
NCT - Delhi	1485	-	-	-	-	-	-
Total	345848 (100%)	7083 (2.0%)	139785 (40.5%)	25879 (7.5%)	47940 (13.9%)	24426 (7.1%)	100735 (29.1%)

Source : CPCB, 2006

Table No. 2 : Distinguished Independent Segments Of River Yamuna

Himalayan Segment	From origin to Tajewala Barrage	(172 kms)
Upper Segment	Tajewala Barrage to Wazirabad Barrage	(224 kms)
Delhi Segment	Wazirabad Barrage to Okhla Barrage	(22 kms)
Eutriphicated Segment	Okhla Barrage to Chambal Confluence	(490 kms)
Diluted Segment	Chambal Confluence to Ganga Confluence	(468 kms)

Source : Central Water Commission

8.0 The Himalayan segment 172 km in length has three barrages - Dak Pathar, Asan Barrage and Tajewala/Hathinikund. The next segment is upto Wazirabad Barrage in Delhi, followed by Okhla barrage in Delhi forming the next distinguished segment - the Delhi segment.

9.0 As per Central Water Commission upper Yamuna sub-basin has six dams, nine barrages, six lift irrigation structures and 14 powerhouses. This section comprises of river in Delhi and upstream. The Yamuna Upper sub-basin has two major water resource projects, the Yamuna Canal System and Agra and Gurgaon Canal System. The Yamuna canal system has two main projects Western Yamuna Canal which make use of the additional water available from the storages on the Sutlej and the Beas (Indus Basin) to irrigate the areas in Haryana State and Eastern Yamuna Canal to irrigate the areas of Saharanpur, Muzaffarnagar and Meerut districts of Uttar Pradesh. The major structure associated with Yamuna canal system is Hathnikund Barrage located at Yamunanagar district in Haryana. The Agra and Gurgaon Canal System contains New Okhla barrage as associated structure located in Gautam Buddh Nagar district of Uttar Pradesh which irrigates the areas of Haryana and Rajasthan.

10.0 One of the significant structures on the river is Tajewalla Barrage near Yamunanagar. Completed in 1873 this was low masonry barrage was used to divert a part of the river flow into the Eastern and Western Yamuna canals. Since the construction of Hathini Kund barrage in 1998 the flow in Yamuna is almost entirely diverted into the East and West Yamuna Canals rendering the downstream course nearly dry.

11.0 Whatever water flows downstream of Wazirabad Barrage is the untreated or partially treated domestic and industrial wastewater contributed through several drains along with the river water which is diverted to Agra Canal at the Okhla Barrage. No water is allowed to flow through barrage during dry season.

12.0 Major dams proposed in the Himalayan reach of the Yamuna such as Renuka Dam on the Giri tributary and Lakhwar Vyasi on the Asan tributary [which already has Dhalipur Barrage] are likely to reduce the flow in the lean season altogether. Several more hydroelectric power projects are under construction or are proposed in the upper reaches of Yamuna in Uttarakhand. According to SANDRP[1] report on July 10, 2013 – two Hydroelectric projects were under construction while 33 projects were proposed totaling a capacity of 3259.185 MegaWatts on Yamuna basin in Uttarakhand.

[1] Uttarakhand: Existing, under construction and proposed Hydropower Projects: How do they add to the state's disaster potential? SANDRP Blog, July 13, 2013 [Link: https://sandrp.wordpress.com/2013/07/10/uttarakhand-existing-under-construction-and-proposed-hydropower-projects-how-do-they-add-to-the-disaster-potential-in-uttarakhand/]

Map No. 1 : Yamuna Upstream Of Delhi



Source : SoI

13.0 Intensive farming in the watershed and in the flood plains right up to the edge of the lean season channel has deprived the river banks of protective riparian vegetation that acted as a buffer. As a result soil sediments and chemical fertilizers flow into the stream course in the rainy season increasing pollution and nutrient load. Moreover, industrialization of upstream towns situated along the river like Yamuna Nagar, Panipat and Kundli etc. has contributed chemical and toxic contaminants to the river flow.

Map No. 2: Barrages In NCT Delhi



14.0 The Delhi reach of the Yamuna has a length of 52 km. entering NCT Delhi's boundary at Palla village in the north and exiting near Jaitpur village in the south. Whilst the right bank of the river is contiguous to higher ground the areas to the east of the left bank are a part of the *doab* with the Hindon river. Over the years the river has been jacketed by the left and right main embankments [LME and RME] to protect the urban areas from seasonal flooding. In effect the embankments visually cut off the river from the city and reduced it to a neglected urban backyard where activities destructive of the river ecology could be carried out with impunity. In addition this has severely reduced the natural flood plain i.e. the area where the river expands in the monsoons and given an artificial impression that the flood plain is the area within the embankments. Several spurs jut out from these embankments into the flood plain as protectors to the embankments themselves. The embankment construction was accelerated after the flood of 1964 and the establishment of the LME enabled the urban colonization of the *doab*.

15.0 On both the banks, embankments which are under control of Irrigation and Flood Control Department, run along Yamuna in the NCT of Delhi. Before the construction of barrages and embankments, the flood plain area was vast and during the monsoons, the flood basin used to be submerged under water[2]. Construction of bundhs in 1960's by the Delhi Government Drainage schemes prevented the low lying areas from flooding which consequently got inhabited. Since 1900, Delhi has experienced eight major floods in the years 1924, 1947, 1958, 1964, 1967, 1976, 1978, 1988 and 1995. During annual flooding the river swells and recharges the aquifers in the vicinity. In the lean season, ground water from such aquifers seeps into the river channel and contributes to the base flow.

16.0 Barrages and bridges constructed over the years in NCT Delhi divided the river into segments – Okhla barrage was constructed in 1874 to divert water to Agra Canal followed by Wazirabad barrage constructed in 1959 to meet drinking water supply requirement of the capital. Another barrage at ITO was constructed in the year 1964 to divert water to Indraprastha Power Station which reduced the flow further downstream towards Okhla. Generally, the barrages have channelized the flow towards the RME and therefore the left side of the flowing channel has become encumbered with sediment deposits often used for farming but certainly narrowing the flow channel in most parts of the year. The barrages have also curtailed the migration of aquatic fauna, as many of the fishes need to migrate upstream to breed.

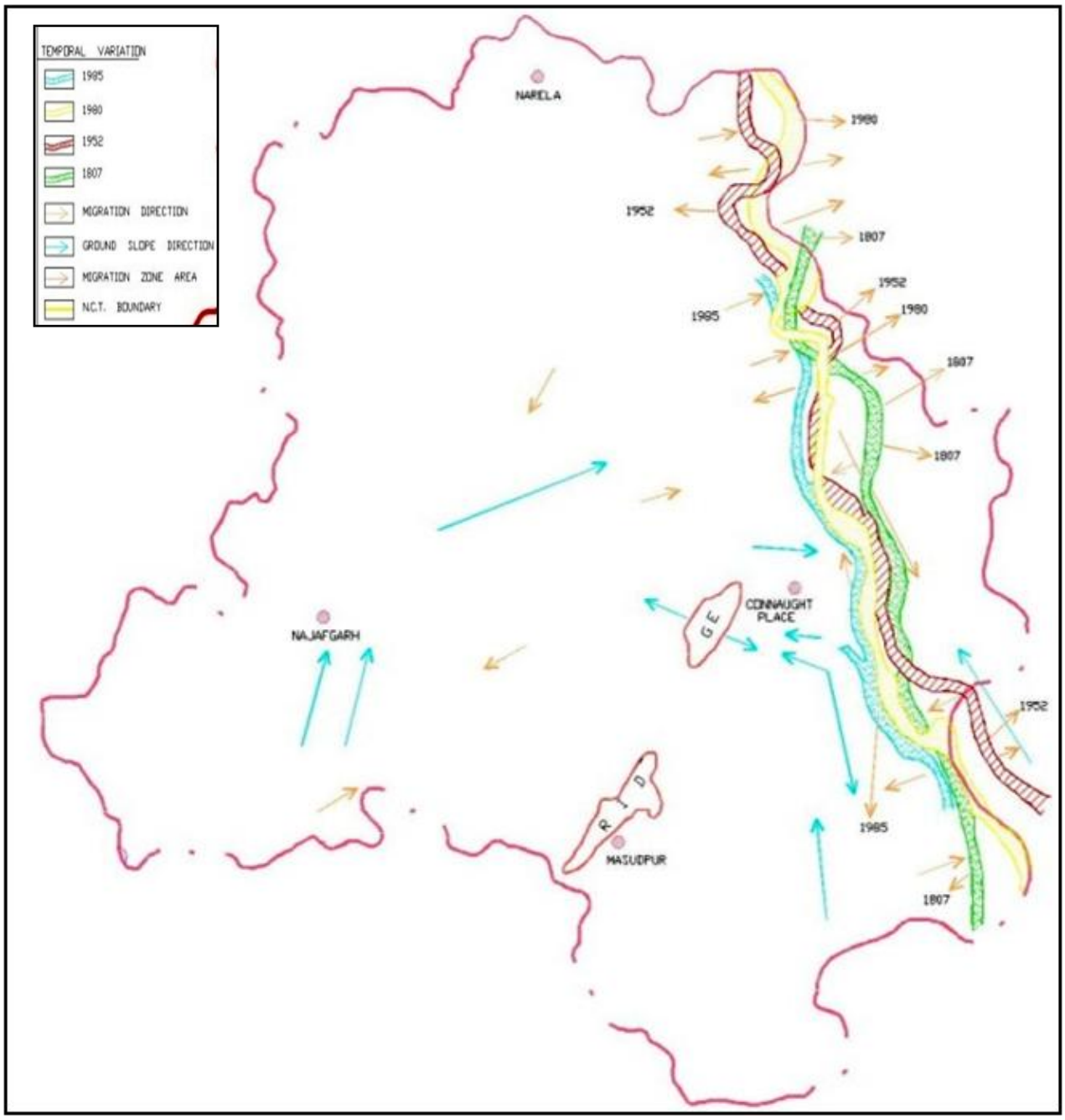
17.0 Before the embankments the river was free to migrate and its general movement was eastwards. In fact the 'Budhi Yamuna' flowed much eastward [as recorded in the Gazetteer of 1912] and the course of the 'Budhi' coincided with the Drain No.6. Traces of the famed Yamuna sand have been found west of Ridge reinforcing the belief that at one time the river flowed on the west of the Ridge and was in fact a tributary of the Saraswati.

Fig. No. 1 : A Braid Of The Yamuna Flowed On Ring Road Between Red Fort & Salimgarh Fort [1955]



[2] Narratives of the Environment of Delhi (2010) by Meenakshi Dhawale, INTACH

Map No. 3 : Migration Courses Of River Yamuna



Source : GSI

18.0 Moreover, due to three major barrages, the Yamuna river in Delhi has distinct ecological characteristics in each segment. Palla to Wazirabad section has comparatively wide active channel and good water quality, whereas section from Wazirabad to ITO barrage has narrow active channel and poor water quality due to water abstraction at Wazirabad barrage and pollution inflows from outfalling drains. Water quality gets worse as Yamuna progresses from downstream to Okhla. After crossing Okhla barrage, the active river channel gets reduced to a trickle.

19.0 Furthermore, road bridges such as Old ISBT bridge near Kashmere Gate, Yamuna rail cum road bridge near Gandhi Nagar, Nizamuddin railway bridge near Nizamuddin Railway Station, DND (Delhi-Noida-Direct) flyway near Maharani Bagh, restricts the river flow to a 500 metre-wide channel. Further plans of Delhi Development Authority (DDA) to channelise the river to gain land for development purposes would have adverse impact on the river and floodplain ecology. European countries learned a lesson from channelisation approach on Rhine River in which the river was shortened in the braided section by 14 percent and in the meander zone by 37 percent. The loss of 130 km^2 of watershed through construction of a dam onthe Rhine has caused a rise in extreme flood discharge as well as an increase in flow velocity. Because of accelerated flows, the flood peaks of the Rhine and those of tributaries have increased the flood danger immensely[3]. Restoration efforts later recognised the flood plain areas as ecologically important and reconnected them with the river main channel[4].

20.0 Downstream of Wazirabad, the river receives outfall from 22 drains[5] which contribute 80% of the pollution load of the river making it worse in terms of water quality with almost no dissolved oxygen and consequently little aquatic life [thus earning the sobriquet of a dead river]. According to the Central Pollution Control Board (CPCB), the water quality of Yamuna river falls under the category "E" which makes it unfit for drinking or bathing. Under this category water of the river can only be used for irrigation, industrial cooling, and controlled waste disposal.

21.0 Presently, the sewage treatment capacity of STPs in Delhi is 575 MGD with only 60% capacity utilization. The treatment is of uneven quality while the rest of the uncollected sewage falls directly into the river. Presence of heavy metals has also been reported from the river (Sehgal et al.,2012) from Delhi segment of Yamuna basin from Wazirabad barrage till Okhla barrage. As per CPCB report[6]of Yamuna basin [1977-1978] the BOD level at Wazirabad was 1.6 mg/l and at Okhla 10.6 mg/l which rose to 8.4 mg/l and 30 mg/l respectively during Dec 2014 as measured by DPCC.

22.0 Water impoundment at Okhla Barrage at the border of NCT Delhi and Uttar Pradesh created a pondage which over the years has become the habitat of migratory birds and eventually declared as a wildlife sanctuary in 1990, popularly known as Okhla Bird Sanctuary. In past, Okhla was a popular site for many recreational activities such as fishing, boating, swimming, and picnics. Boating however remained a favourite pastime − many residents would go to Okhla with their personal boats. The Okhla Sailing Club, a popular site at one time, would host National Regatta and parties at night as the river created the perfect ambience[2].

[3] Thirsty Planet: Strategies for Sustainable Water Management, Constance Elizabeth Hunt (2004), Zed Books Ltd., London

[4] Van Dijk, G. M., Marteijn, E. C. L., Schulte-Wulwer-Leidig, A. 1995. Ecological rehabilitation of the River Rhine: plans, progress and perspectives. Regulated Rivers: Research & Management. 11: 377-388

[5] Restoration and Conservation of River Yamuna, Final Report submitted to NGT with reference to Main Application no. 06 of 2012

[6] Basin Sub-Basin Inventory of Water Pollution, The Ganga Basin Part-I : The Yamuna Sub-Basin, (April 1977-Dec 1978] Central Board for the Prevention and Control of Water Pollution, New Delhi

Table No. 3 : Water Quality Parameters In Yamuna River
Date of Sampling 03-06-2014 Report No :DPCC/W/Y/1415/1927

S.No	Locations	pH	COD (mg/l)	BOD (mg/l)	DO (mg/l)	Total Coliform (MPN/100ml)
Water Quality Criteria ('C' Class)		6.0- 9.0	-	3(max)	4(min)	5000
1	Palla	8.7	12	1.6	9.2	-
2	Surghat (Down stream of Wazirabad Barrage)	8.1	24	3.2	6.1	-
3	Khajori Paltoon Pool (Downstream Najafgarh Drain)	7.8	160	52	Nil	-
4	Kudesia Ghat	7.4	100	31	Nil	-
5	ITO Bridge	7.8	80	29	Nil	-
6	Nizamudin Bridge	7.1	100	36	0.3	-
7	Agra Canal (Okhla)	7.2	72	24	Nil	-
8	After meeting Shahdara Drain (Downstream Okhla Barrage)	7.5	130	40	Nil	-
9	Agra Canal (Jaitpur)	7.4	100	30	Nil	-

Table No. 4 : Water Quality Parameters In Yamuna River [Post Monsoon]
Date of Sampling: 10-10-2014 Report No :DPCC/W/Y/1415/055063

S.No	Locations	pH	COD (mg/l)	BOD (mg/l)	DO (mg/l)	Total Coliform (MPN/100ml)
Water Quality Criteria ('C' Class)		6.0- 9.0	-	3(max)	4(min)	5000
1	Palla	7.5	16	2.1	8	-
2	Surghat (Down stream of Wazirabad Barrage)	7.1	20	4.2	NIL	-
3	Khajori Paltoon Pool (Downstream Najafgarh Drain)	7.3	220	64	NIL	-
4	Kudesia Ghat	7.8	140	48	NIL	-
5	ITO Bridge	7.8	104	35	Nil	-
6	Nizamudin Bridge	7.1	80	23	NIL	-
7	Agra Canal (Okhla)	7.9	108	32	NIL	-
8	After meeting Shahdara Drain (Downstream Okhla Barrage)	7.8	140	40	Nil	-
9	Agra Canal (Jaitpur)	7.8	120	33	NIL	-

Table No. 5 : Water Quality Parameters In Yamuna River

Date of Sampling: 04-12-2014 Report No :DPCC/W/Y/1415/073081

S.No	Locations	pH	COD (mg/l)	BOD (mg/l)	DO (mg/l)	Total Coliform (MPN/100ml)
Water Quality Criteria ('C' Class)		6.0- 9.0	-	3(max)	4(min)	5000
1	Palla	7.4	20	2.3	7.8	-
2	Surghat (Down stream of Wazirabad Barrage)	7.5	36	8.4	4.1	-
3	Khajori Paltoon Pool (Downstream Najafgarh Drain)	7.3	260	66	NIL	-
4	Kudesia Ghat	7.4	128	35	NIL	-
5	ITO Bridge	7.6	96	39	NIL	-
6	Nizamudin Bridge	7.3	72	23	1.7	-
7	Agra Canal (Okhla)	7.7	128	30	NIL	-
8	After meeting Shahdara Drain (Downstream Okhla Barrage)	7.6	196	47	NIL	-
9	Agra Canal (Jaitpur)	7.5	144	29	NIL	-

23.0 The flood plains of the river have been under immense anthropogenic pressure owing to different landuse which affected the ecology of flood plains. The total area[7] of river zone is about 9700 ha. Flood plain area from Palla to Wazirabad barrage is 4123 ha and from Wazirabad barrage to Jaitpur is 5577 ha. The width of the flood plains is 2 to 3 km whereas the active water channel in the urban stretch of Delhi from Wazirabad to Okhla is confined to a mere 450 to 800 m width during dry weather condition for about 9 months of the year. [NEERI, 2005][8]. Large scale agriculture on flood plain areas have resulted in the removal of riparian vegetation on both the banks. Riparian vegetation is essential habitat for stream biodiversity and prevents silting and soil erosion. Further, Delhi Development Authority [DDA] paved the way for the development of manicured gardens on the right bank, construction of Akshardham Temple and Common Wealth Games Village apartments on the left bank have brazenly destroyed flood plain area of the river in the capital. Other recent structures such as Delhi Metro Rail Corporation (DMRC) Depot (Metro Vihar) and Yamuna Bank Station, Delhi Govt.s' IT Park near Shastri Park, DTC Bus Depot at Nagli Macchi near NH 24 Road Bridge, Delhi Jal Board's Sonia Vihar Water Treatment Plant and various power plants [Rajghat, Indraprastha and Pragati] have nibbled large chunks from the remaining flood plain. Besides encroaching flood plain area, these power plants and associated flyash pond have contaminated the underlying aquifer through effluent discharges and leaching.

[7] Zonal Development Plan for Yamuna Area (2006), Delhi Development Authority (DDA)

[8] Environmental Management Plan for the Rejuvenation of River Yamuna in NCT Delhi (2005), DDA, Delhi and NEERI, Nagpur

24.0 The water flow across the year between lean season [non monsoon period from October to June] and monsoon season [July to September] varies greatly. Data from the Irrigation and Flood department on monthly release of water from the Wazirabad barrage in Delhi, indicates total release of 3.8 TMCM [Thousand Million Cubic Metre] in the monsoon months and 0.3 TMCM during rest of the year[9]. A certain minimum environmental flow is required to maintain ecological integrity of a river. The National River Conservations Directorate under the Ministry of Environment and Forest, Govt. of India, in the year 1997 constituted a 'High Powered Committee' to decide the requirement of minimum flow in the river. The committee under the order of Supreme Court on 14th May 1999 decided that 10 cumec (353 cusec) may be released into the river system as minimum environmental flow which must also be contributed by basin states, this however, has not practised and the river's condition remains pathetic. The emerging view amongst the environmental community seems to be that under the current circumstances of extreme dependence on river waters the minimum flow should be at least 60% of the virgin flow for any season.

25.0 Delhi Gazetteers of 1883-4, 1912 and 1976 provide a fair account of Yamuna's ecosystem and species that were present in the river in the past. Gazetteer of 1976 mentions the presence of crocodile [*Crocodilus palustris*] which were responsible for occasional fatalities while Gazetteer (1883-4) and (1912) mentions the presence of both Muggurs [crocodile] and Gurryal [gharial; *Gavialis gangeticus*]. Gazetteer of 1912 observes that turtles were abundant in both river and lakes, while Gazetteer of 1976 records the presence of two species viz. Pond turtle [*Lissemys punctata*] and Box turtle [*Trionyx gengeticus*]. Among amphibians, the toad [*Bufo melanostictus*] and the Indian bull frog [*Rana Tigrina*] were very common. Dr. Kavanagh's note on wild animals in Gazetter (1883-4) mentions the presence of pigs all around Yamuna river in *Jhau* jungle [*Tamarix dioica*]. Foxes and hares were plentiful on the eastern bank of Yamuna. Other mammals frequenting the Yamuna landscape were nilgai, jackal, chikara, common monkey, mongoose, hedge hog etc. With the change in water quality of the river and adjoining ponds, the fish diversity also changed tremendously with time. Gazetteer of 1883-4 mentions the presence of Mahsir [*Barbus tor*], Rahu [*Labeo rohita*], Batchwa [*Entroplichthys vacha*] species of fish which are rare today in Yamuna waters. Gazetteer of 1912 states that the Yamuna river, the canals, the big jhils and man-made tanks had the following principle varieties: Mahsir [*Barbus tor*], Rahu [*Labeo rohita*], Batchwa [*Entroplichthys vacha*], Mulley [*Wallago attu*], Tengra [*Macrones*], Silund [*Silundia gangetica*], Mohi [*Notopterus kapirat*], Mirga [*Cirrhina mrigala*], Kalbans [*Labeo kalbasu*], Chilwa [*Chela gora*], Gunch [*Bagarus yavelli*]. Gazetteer [1976] mentions 65 species of fish [Refer Annexure I] available in river Yamuna, tanks, ponds of Delhi. The different fish species covered the range of 41 genera and 17 families, belonging to 8 orders. Carps and catfish constituted the bulk of this fresh water fauna and were the most important commercial groups. Meenakshi Dhawale (2010)[2] in the Narratives of the Environment of Delhi mentions the presence of Gangetic dolphins downstream of Okhla barrage which are now found only in Ganga River.

26. 0There have been many studies which record the pollution level and water quality parameters at any particular time (Kaushik et al, 2009[10]; Aleem and Malik, 2005[11]), but

[9] Babu, C. R., Kumar, P., Prasad, L. and Agarwal, R., Valuation of ecological functions and benefits: a case study of wetland ecosystem along the Yamuna River corridors of Delhi Region, Report, Indira Gandhi Institute of Development Research, Mum-bai, India, 2003, p. 185.

[10] Kaushik et al (2009) Heavy metal contamination of river Yamuna, Haryana, India:Assessment by Metal Enrichment Factor of the Sediments. Journal of Hazardous Material 164 : 265–270

records on the vegetation and ecological characterization of the river are rare. Sah (1990) studied important species along the hydrological gradient and the nutrient status of soil on the flood plains of river Yamuna in Delhi. The study identificed *Ipomea fistulosa, Thypha* and other grasses on the islands formed due to siltation. The vegetation exhibited stratification - the highest stratum (more than 2m tall) comprised of *Typha eliphantina, T. angustata, Saccharum spp.* and *Phragmites karka.* the second stratum (about 70 - 120 cm) comprise of sedges and herbs - *Polygonum, Scripus, Cyperus, Eleocharis and Equisetum.* The ground stratum was dominated by *Paspalum distichum, Alternenthera spp., Eclipta alba, Phyla nodiflora,* in the marshy areas and *Cynodon dactylon, Polygonum plebeium and Euphorbia thymifolia* in the uplands. Recently, a study was conducted on plant communities of floodplain of OBS [12]. The findings are summarised below:

Table No. 6 : Species Distribution In Yamuna

S. no.	Dominant species	Associate Species	Lower stratum species
1	*Saccharum spontaneum*	*Typha angustifolia, Saccharum bengalense*	*Rannunculus sceleratus, Rorippa nasturtum-aquaticum, Paspalum distichum, Polygonum hydropiper, Pyla nodiflora*
2	*Saccharum bengalense*	*Typha angustifolia*	*Chenopodium ambrosioides, Alternanthera philoxeroides, Rannunculus sceleratus, Cirsium arvense, Phyla nodiflora*
3	*Typha angustifolia*	*Typha elephantina, Dactyloctenium aegyptium*	*Polygonum hydropiper, P. Barbatum, Rannunculus sceleratus, Cyperus bulbosus*
4	*Typha elephantina*	*Typha angustifolia*	*Cyperus kyllingia, Comelina bengalensis, Rannunculus sceoleratus,Rannunculus sceleratus, Rorippa nasturtium-aquaticum*
5	*Phragmites Karka and Arundo donax*	*Typha angustifolia, Typha elephantina*	*Chenopodium ambrosioides , Rorippa nasturtium-aquaticum, Cirsium arvense, Alternenthera philoxeroides, A. sessilis*
6	*Alternenthera spp*	*Paspalum distichum*	*Cyperus conpressus, Ipomea fistulosa, Polygonum hydropiper*
7	*Ipomea fistulosa, I. Aquatica*		*Polygonum hydropiper, Cyprus kyllinga*

[11] Aleem & Malik, (2005), Genotoxicity of the Yamuna River water at Okhla (Delhi), India, Ecotoxicology and Environmental Safety 61 : 404–412

[12] Manral, U., Raha, A., Solanki, R., Hussain, S.A., Mohan, D, Talukdar, G., and Veeraswami, G.G., 2012, Hydrological characteristics and floodplain vegetation of human impacted wetlands: A case study from Okhla Bird Sanctuary, National Capital Region, India. Asian Journal of Conservation Biology, Vol. 1 (2) 110-119

27.0 DDA and other interested parties have eyed Yamuna floodplains as real estate, time and again. The channelization program pushed for confining the river to a 500m wide channel and 'releasing' the floodplain for building activity. However, all these threats have now been rendered infructuous with the NGT's order of 13 January, 2015 known as 'Maili to Nirmal Yamuna'. The order deals with preventing sewage inflows, prevention of debris dumping, prevention of construction and agriculture on the floodplain. This will doubtless allow regeneration of riparian vegetation and riverine forests thereby restoring the ecological integrity of the remaining floodplain.

28.0 At the Okhla Barrage the left bank pondage area along with some terrestrial habitat has been notified as Okhla Bird Sanctuary in 1990 which comes under the jurisdiction of the UP Forest Department. The sanctuary is designated as an Important Bird Area by BNHS [Bombay Natural History Society] and plays host to several resident and migratory bird species. It is observed that the number of species as well as the populations is adversely affected by the pollution in the Yamuna generated in the NCT Delhi.

29.0 The Upper Yamuna River Board came into existence through a Memorandum of Understanding (MoU)[13] signed amongst the five basin states on 12th May, 1994 for sharing of the water of Upper Yamuna upto Okhla barrage. The functions of the Board primarily include regulation of the allocation of available flows amongst the beneficiary states and also for monitoring the return flows; monitoring conserving and upgrading the quality of surface and ground water; maintaining hydro-meteorological data for the basin; over viewing plans for watershed management; monitoring and reviewing the progress of all projects upto and including Okhla barrage. Considering their irrigation and consumptive drinking water requirements, the basin states agreed on the following allocation of the utilisable water resources of River Yamuna assessed on mean year availability.

Table No. 7 : Seasonal Allocation Of Yamuna Water By Beneficiary States

States	Seasonal Allocation of Yamuna Waters [BCM]			
	July-Oct	**Nov-Feb**	**March-June**	**Annual**
Haryana	4.107	0.686	0.937	5.730
Uttar Pradesh	3.216	0.343	0.473	4.032
Rajasthan	0.963	0.070	0.086	1.119
Himachal Pradesh	0.190	0.108	0.080	1.378
Delhi	0.580	0.068	0.076	0.724
Total	9.056	1.275	1.652	11.983

Source: Reviving River Yamuna, Peace Institute Charitable Trust, [2009] [Appendix-2]; BCM - Billion Cubic Metres

[13] Upper Yamuna River Board India WRIS http://indiawris.nrsc.gov.in/wrpinfo/index.php?title=Upper_Yamuna_River_Board

Objective

30.0 The present study seeks to build on previous reports in order to develop ecological understanding of the River Yamuna and its flood plains in NCT Delhi and to provide an overview of the current diversity of flora and fauna, water quality and landscape characteristics.

31.0 The key objectives of this study are to review the state of knowledge and provide baseline information on the ecology of Yamuna River and its flood plains.

a) To document the flora and fauna of River and riparian zone and compare with earlier records.
b) To explore the potential habitats and key areas for ecological restoration.
c) To record current landscape information and evaluate anthropogenic pressures.
d) To develop baseline information against which changes consequent to the impending improvements in River water quality and increased flow can be measured.

Methodology

32. 0 Prior to the survey, accessibility to the flood plain area on both the banks of the River was ascertained with the help of maps and interactions with local people. Extensive floristic surveys were carried out on flood plain areas on both the banks of the River at Wazirabad, ITO and Okhla; on left bank for Gandhi Nagar and Mayur Vihar. Accessible sand beds within the River channel wherever possible were also considered to lay quadrats. Transects identified from the Riverbank to the fringe of highest levee or embankment bordering it. For shrubs and herbs cover estimation, sites were selected to cover different microhabitats. For baseline fish diversity survey, the sites were identified in consultation with local fishermen and the boat owner. Many observations of both the banks of River were made during boat surveys conducted between Wazirabad barrage to ITO barrage in the first phase and from Palla to Wazirabad barrage in the second phase. Water quality data was collected from accessible points at all the sites during the field visits.

33. 0 **Flora and Fauna :** Quadrat and Line Transect method was used to document the flora and obtain information on the vegetation of the flood plain area. Quadrats of 1 metre square were used to identify and assess the richness of herbs and small shrubs. For trees and larger shrubs, the quadrat size was increased to 100 metre square. To obtain information on fauna, a combination of direct observations, secondary information, informal interviews conducted with local inhabitants, fisherman and anglers at study sites, was used. Point count method was used to obtain information on birds at all the sites.

34. 0 **Fish :** To assess current fish diversity present in Yamuna River in NCT Delhi, a preliminary survey was conducted. Survey was carried out in two phases viz. Wazirabad to ITO Barrage to cover downstream area in the first phase and Wazirabad to Palla to cover upstream area in the second phase. A motorboat was used with required personnel and safety equipments. Equipments carried to conduct the study were Cast net [Mesh size 1 sq. inch],

Dipnet [Mesh size less than 1 mm], thermocol box, scale, gloves, Garmin GPS eTrex 30, Borosil bottles with formalin solution. Cast net was used after every kilometer 3-4 times at different spots at one single site. The distance was tracked with the help of Waypoint Manager of Garmin eTrex-30. Cast net with a mesh size of 1 sq. inch was used during the survey to avoid any harm to juveniles. Dipnet with a very fine mesh size of less than 1mm fitted in a circular frame with diameter 9 inch was also used along the shoreline. Dipnets are mostly used for the collection of bottom dwelling fish and for those live amongst dense aquatic vegetation. Mostly cast nets are used in flowing slow streams which are not very deep to catch surface dwellers and shallow water species while dragnets are used where there is some depth and the two banks of the River or pond or lake are not too far. All of the fish collected were identified to the lowest possible taxon. Standard length was measured with a ruler to the nearest mm. Fish species were identified with the help of available field guides[14] and online database[15].

35. 0 **Water Quality :** Water quality monitoring was carried out onsite with field water analysis kits. Turbidity was measured using secchi tubes with scale 12 to 240 NTU (Nephelometric Turbidity Unit). Physico-chemical parameteres measured were Nitrate, Phosphate, Electrical Conductivity, TDS and DO .

Study Sites

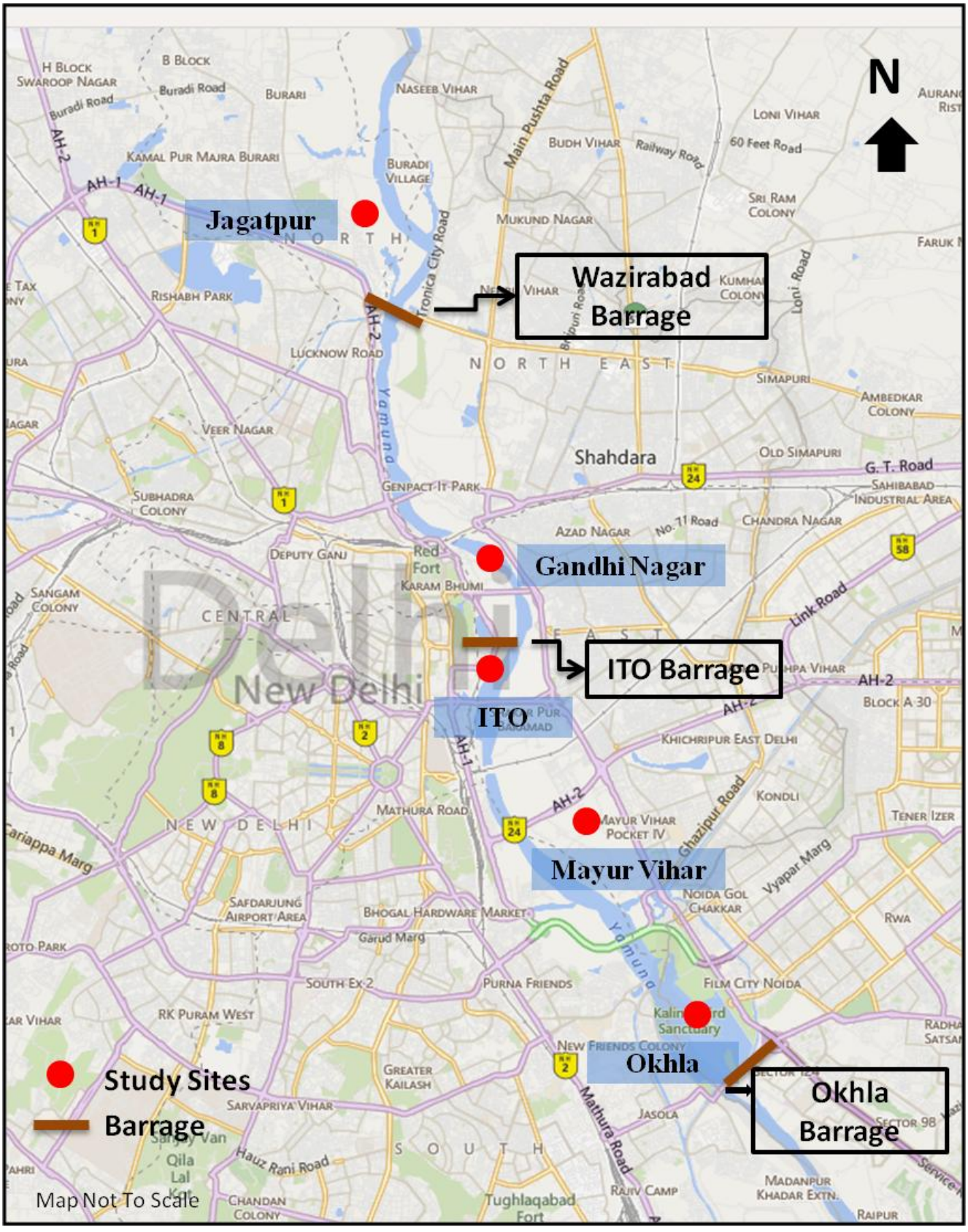
36. 0 Five locations were identified for monitoring. The sites surveyed include Jagatpur Bundh near Wazirabad, Gandhi Nagar Pushta near old railway bridge at Gandhi Nagar, ITO Ghat flood plain area near Rajghat Power House, Mayur Vihar Ghat near Mayur Vihar Metro Station, Okhla area near Okhla Bird Sanctuary.

Observations

37. 0 The observations include information on flora, fauna and landscape characteristics of the Yamuna River and its floodplain areas in the study sites mentioned above in NCT Delhi.
   a) Flora section consists of a list of trees, herbs and shrubs recorded during the study.
   b) Fauna section details the findings and observations on birds, mammals and insects.
   c) Landscape observation section includes a brief note on various activities and observations recorded during field surveys in and around River and its floodplain area

[14] Nilesh Heda [2009] Freshwater Fishes of Central India: A Field Guide, Vigyan Parishar and K.C. Jayaram [2013] The Fresh Water Fishes of the Indian Region
[15] Fish Base Database [www.fishbase.org]

Map No. 4 : Study Sites And Barrages On The Course Of Yamuna River In NCT Delhi



STUDY SITE 1 : JAGATPUR AREA

38. 0 Jagatpur bund, lies on the right bank of the River and is located around 3 km upstream of Wazirabad barrage. The site is accessible from the Wazirabad road which runs parallel to River flood plain area on the right bank. A 50-60 cm levee at around 2-3 m from the water edge separates the River from the flats behind it. A narrow path on the levee runs parallel to the River course upstream. The characteristic vegetation comprises of *Saccharum, Typha, Phragmites, Ricinus, Cynodon* etc. Fishing, agriculture, grazing, harvesting of reeds and grasses, religious ceremonies are significant human activities at this site. Accessibility to river bank, natural leeves, flood plain, presence of depressions, upstream location, were factors that make this site a representative one, appropriace for study.

39. 0 Yamuna River at Jagatpur Bund area is a mix of rural and peri-urban landscape with Jagatpur Village located on the left of Wazirabad road, which runs parallel to River flood plain area. People from Jagatpur village and adjacent areas are linked socio-economically with the River and its flood plains. While the flood plains are mostly used to grow cucurbits crops and other cereals, to make and dry dung cakes, livestock grazing the River is a resource for fishing, bathing and immersing idols and statues during various religious ceremonies.

40. 0 The tall vegetation strata comprises of *Typha, Phragmites, Ipomoea*, Alligator weed, *Saccharum* and several grasses belonging to family cyperaceae. Villagers cut this riparian vegetation seasonally mostly for cucurbits cultivation. Other crops that are grown include wheat, rice, mustard and vegetables. The water quality remains comparatively good throughout the year. Dragonflies, damselflies and waterbirds indicates healthy ecosystem.

41. 0 Several small water bodies formed as a result of depression on the flood plain area are good foraging grounds for resident as well as migratory birds. Phragmites and saccharum species were found as ideal habitats for warblers, tailorbirds, munias, sparrows etc.

42. 0 Jagatpur Bund area is a preferred site for fishing. People who have superficial controls over fishing sites employ labourers from the state of Bengal and Bihar. They work in a group of 10-12 people and live a very basic life. The fish caught are then sold in the local markets. Several different methods of catching fish were observed from Jagatpur Bund area to Palla. Dragnets are mostly used by the fishermen, which they drag from one bank to another across the river in a concerted manner.

Map No. 5 : Yamuna River And Its Flood Plains At Jagatpur Area Near Wazirabad



Fig. No. 2 : Yamuna As Seen From Jagatpur Bund (Looking North) Near Wazirabad [Date: 07/07/2014]



Fig. No. 3 : Tall Stands Of Typha And Phragmites At Jagatpur Bund Area Towawds East From Jagatpur Road [Date: 01/10/2014]



Fig. No. 4 : Large Scale Removal Of Riparian Vegetation For Cucurbits Crops At Jagatpur Bund Area [Date: 04/02/2015]



Fig. No. 5 : Country Mallow [*Abutilon indicum]* Near Jagatpur Bund Towards South [Date: 07/07/2014]



a) FLORA

The flora-trees, herbs and shrubs observed at Jagatpur area are listed below:

Table No. 8 : List Of Trees

S.No.	Species	Common Name	Family
1.	*Azadirachta indica*	Neem	Meliaceae
2.	*Acacia nilotica*	Babool/Kikar	Fabaceae
3.	*Albizzia lebbeck*	Siris	Fabaceae
4.	*Prosopis juliflora*	Vilaiti Keekar	Fabaceae
5.	*Ziziphus mummularia*	Ber	Rhamnaceae
6.	*Morus alba*	White Mulberry	Moraceae
7.	*Syzygium cumini*	Jamun	Myrtaceae
8.	*Ficus religiosa*	Peepal	Moraceae
9.	*Ficus virens*	Pilkhan	Moraceae
10.	*Dalbergia sissoo*	Shisham	Fabaceae
11.	*Ficus benghalensis*	Banyan	Fabaceae
12.	*Mangifera indica*	Mango	Anacardiaceae
13.	*Phoenix sylvestris*	Wild Date Palm	Arecaceae

Table No. 9 : List Of Herbs/ Shrubs

S.No.	Species	Common Name	Family
1.	*Dhatura innoxia*	Safed dhatura	Solanaceae
2.	*Adathoda vasica*	Vasaka, Malabar Nut	Acanthaceae
3.	*Lantana camara*	Common Lanatana/Wild Sage	Verbenaceae
4.	*Phragmites karka*	Common Reed	Poaceae
5.	*Tridax procumbens*	Coat Buttons	Compositeae
6.	*Parthenium hysterophorus*	Congress Grass	Asteraceae
7.	*Malvastrum coromandelianum*	False Mallow	Malvaceae
8.	*Abutilon indicum*	Country Mallow	Malvaceae
9.	*Solanum indicum*	Common Indian Nightshade	Solanaceae
10.	*Dhatura innoxia*	Safed dhatura	Solanaceae
11.	*Pergularia daemia*	Pergularia	Asclepiadaceae
12.	*Ageratum conyzoides*	Goat Weed	Asteraceae

13.	*Cynodon dactylon*	Bermuda Grass	Poaceae
14.	*Setaria viridis*	Green Bristle Grass	Poaceae
15.	*Typha spp.*	Elephant Grass	Typhaceae
16.	*Tridax procumbens*	Coat Buttons	Compositeae
17.	*Abutilon indicum*	Country Mallow	Malvaceae
18.	*Ipomea aquatica*	Water Spinach	Convolvulaceae
19.	*Achyranthes aspera*	Chirchita	Amaranthaceae
20.	*Sacharum spontaneum*	Wild Sugarcane	Poaceae
21.	*Phyla nodiflora*	Frog Fruit	Verbenaceae
22.	*Ricinus communis*	Castor Oil Plant	Euphorbiaceae

Fig. No. 6 : Wild Sugarcane [*Saccharum spontaneum*] At Jagatpur Bund Area Towards East [Date: 22/07/2014]



Fig. No. 7 : Castor Oil Plant Thriving On Agricultural Field Edges Towards South [Date: 22/07/2014]



Fig. No. 8 : Frog Fruit [*Phyla nodiflora]* One Characteristic Plant Of Yamuna Flood Plains [Date: 22/05/2014]



Frequency

Given below is the frequency of occurrence of each species.

Table No. 10 : Frequency Table For Trees

S. No.	Species	Frequency	Relative Frequency
1.	*Azadirachta indica*	0.4	6.06
2.	*Acacia nilotica*	0.2	3.03
3.	*Albizzia lebbeck*	0.6	9.09
4.	*Prosopis juliflora*	0.8	12.12
5.	*Ziziphus mummularia*	0.6	9.09
6.	*Morus alba*	0.6	9.09
7.	*Syzygium cumini*	0.4	6.06
8.	*Ficus religiosa*	0.4	6.06
9.	*Ficus virens*	0.2	3.03
10.	*Dalbergia sissoo*	0.6	9.09
11.	*Ficus benghalensis*	0.4	6.06
12.	*Mangifera indica*	0.6	9.09
13.	*Phoenix sylvestris*	0.8	12.12
14	Total	6.6	100.0

Table No. 11 : Frequency Table For Herbs/Shrubs

S. No.	Species	Frequency	Relative Frequency
1.	*Dhatura innoxia*	0.4	4.12
2.	*Adathoda vasica*	0.3	3.09
3.	*Lantana camara*	0.3	3.09
4.	*Phragmites karka*	0.7	7.22
5.	*Tridax procumbens*	0.4	4.12
6.	*Parthenium hysterophorus*	0.6	6.19
7.	*Malvastrum coromandelianum*	0.4	4.12
8.	*Abutilon indicum*	0.5	5.15
9.	*Solanum indicum*	0.6	6.19
10.	*Dhatura innoxia*	0.4	4.12
11.	*Pergularia daemia*	0.2	2.06
12.	*Ageratum conyzoides*	0.3	3.09
13.	*Cynodon dactylon*	0.9	9.28
14.	*Setaria viridis*	0.6	6.19
15.	*Typha spp.*	0.6	6.19
16.	*Tridax procumbens*	0.3	3.09
17.	*Abutilon indicum*	0.5	5.15
18.	*Ipomea aquatica*	0.3	3.09
19.	*Achyranthes aspera*	0.6	6.19
20.	*Saccharum spontaneum*	0.7	7.22
21.	*Phyla nodiflora*	0.3	3.09
22.	*Ricinus communis*	0.5	5.15

Fig. No. 9 : Representation Of Various Tree Species At Jagatpur

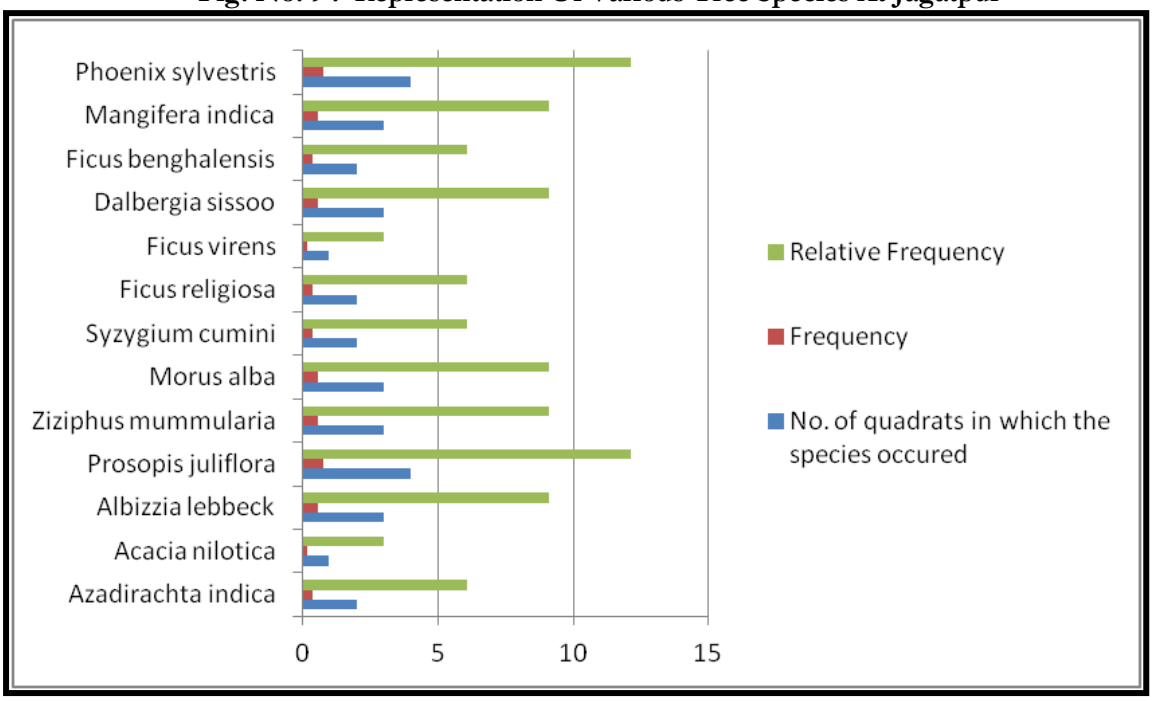
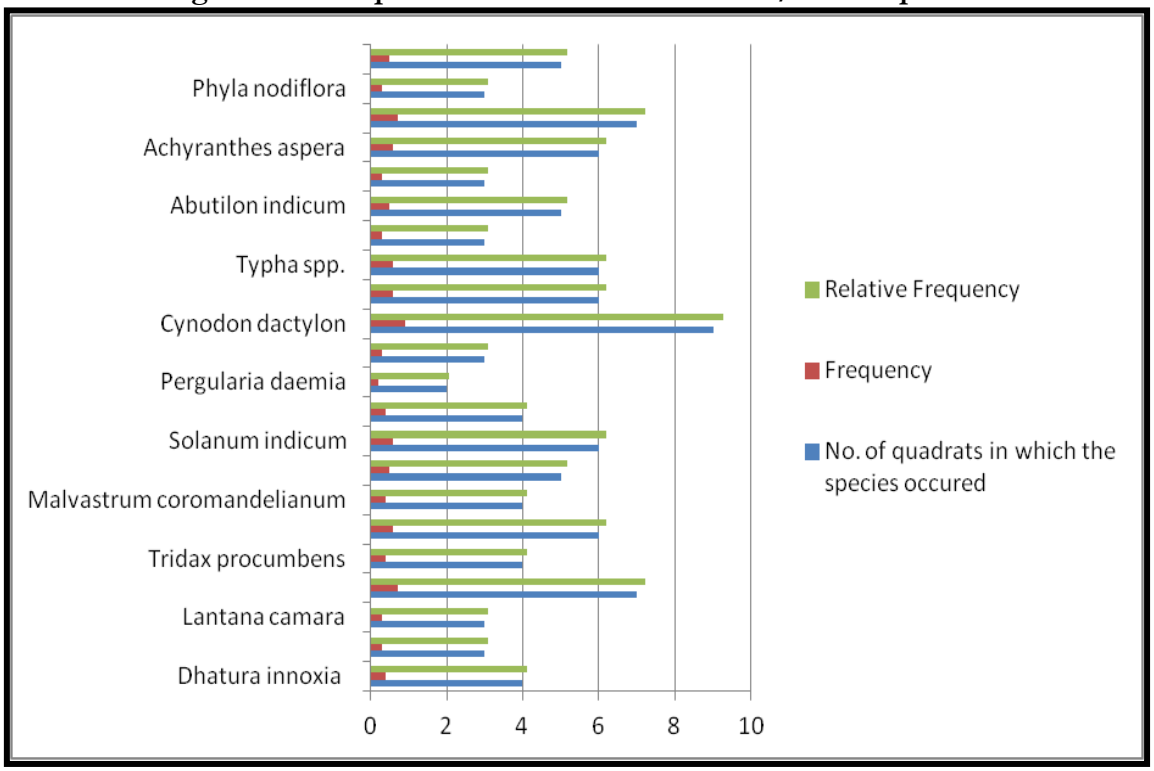


Fig. No. 10 : Representation Of Various Herb/Shrub Species



b) FAUNA

43. 0 The fauna observed and according to information conveyed by local people and fishermen includes Indian Bush Rat (*Golunda ellioti*), Indian Grey Mongoose (*Herpestes edwardsii*), Indian Monitor Lizard (*Varanus bengalensis*), Garden Lizard (*Calotes versicolor*), Indian Palm Squirrel (*Funambulus palmarum*), Indian Jackal (*Canis aureus indicus*), Nil Gai (*Boselaphus tragocamelus*), and some snake species. Numerous insects were observed during the surveys belonging to group Dragonflies and Damselflies (Order: Odonata), Grasshoppers and Crickets (Order: Orthoptera), Butterflies and Moths (Order: Lepidoptera), Stick insects and Leaf insects (Order: Phasmatodea), True Bugs (Order: Hemiptera) and Beetles (Order: Coleoptera).

List of Birds

The following birds were sighted during the study period.

Table 1 : List Of Birds

S. No.	Species	Scientific Name
1.	Black Kite	*Milvus migrans*
2.	Eurasian Collared Dove	*Streptopelia decaocto*
3.	Shikra	*Accipiter badius*
4.	Common Hoope	*Upopa epops*
5.	Rock Pegion	*Columba livia*
6.	Jungle Babbler	*Turdoides striatus*
7.	Rose-ringed Parakeet	*Psittacula krameri*
8.	Green Bee-eater	*Merops orientalis*
9.	Asian Koel	*Eudynamys scolopacea*
10.	Indian Robin	*Saxicoloides fulicatus*
11.	Brown Rockchat	*Cercomela fusca*
12.	Purple Sunbird	*Cinnyris asiaticus*
13.	House Sparrow	*Passer domesticus*
14.	Red-vented Bulbul	*Pycnonotus cafer*
15.	Oriental Magpie Robin	*Copsychus saularis*
16.	Common Myna	*Acridotheres tristis*
17.	White-browed Wagtail	*Motacilla maderaspatensis*
18.	Redwattled Lapwing	*Vanellus indicus*
19.	Whitebreasted Waterhen	*Amaurornis phoenicurus*
20.	Blackwinged Stilt	*Himantopus himantopus*
21.	Black Ibis	*Pseubidis papillosa*

22.	Black-tailed Godwit	*Limosa limosa*
23.	Common Coot	*Fulika atra*
24.	Painted Stork	*Mycteria leucocephala*
25.	Brown-headed Gull	*Larus brunnicephalus*
26.	Redcrested Pochard	*Rhodonessa rufina*
27.	Little Cormorant	*Phalacrocorax niger*
28.	Great Cormorant	*Phalacrocorax carbo*
29.	Barheaded Geese	*Anser indicus*
30.	Common Teal	*Anas crecca*
31.	White-throated Kingfisher	*Halcyon smyrmensis*
32.	Asian Openbill Stork	*Anastomus oscitans*
33.	Cattle Egret	*Bubulcus ibis*
34.	Great Egret	*Ardea alba*
35.	Purple Heron	*Ardea purpurea*
36.	Grey Heron	*Ardea cinerea*
37.	Barn Swallow	*Hirundo rustica*
38.	Common Stonechat	*Saxicola torquata*

Fig. No. 11 : Common Stonechat [*Saxicola torquata*] At Jagatpur Bund [Date: 04/02/2015]



Fig. No. 12 : Flock Of Migratory Birds During Winter Season And Typha And Phragmites In The Backdrop. [Date: 18/12/2014]



Fig. No. 13 : White-Browed Wagtail At Jagatpur Bund Area [Date: 04/02/15]



Fig. No. 14 : Black-Tailed Godwit (*Limosa limosa*) Sighted At Yamuna Biodiversity Park Phase-2 Area [Date: 04/02/2015]



Fig. No. 15 : Common Club Tail Dragon Fly (*Ictinigomphus rapax*) At Jagatpur Bund Area [Date: 01/10/2014]



Fig. No. 16 : Ladybird Beetle [*Menochlius sexmaculatus*] Attached To Flower Of Dhatura Plant At Jagatpur Bund Area [Date: 22/05/2014]

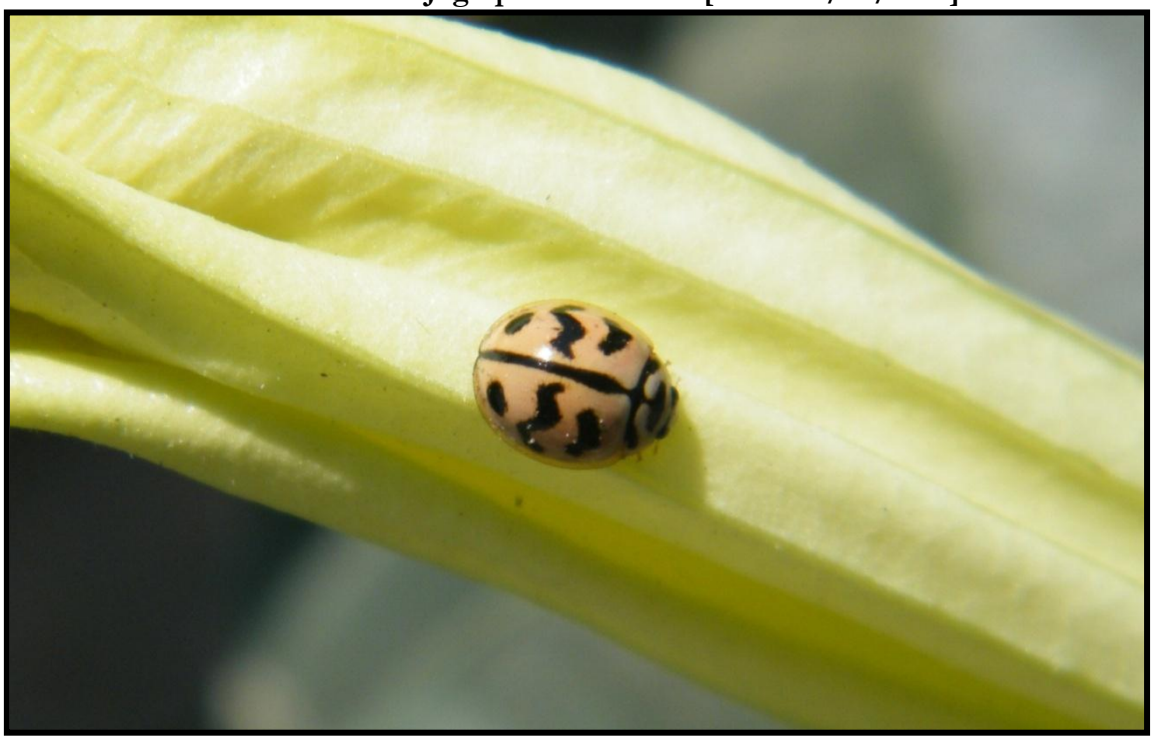


Fig. No. 17 : Grasshoppers on Leaf [Ventral Side] Of Water Hyacinth At Jagatpur Bund Area [Date: 22/07/2014]



Fig. No. 18 : Dead Assasin Bug In Water At Jagatpur Bund [Date: 01/10/2014]



Fig. No. 19 : Indian Grey Mongoose (*Herpestes edwardsii*) Are Common Dwellers Along Jagatpur Bund Area. [Date: 04/02/2015]



Fig. No. 20 : Checkered Keelback Snake [*Xenochrophis piscator]* Sighted At Yamuna Bank Near Jhangola Area [Date: 18/12/2014]



Fig. No. 21 : Indian Garden Lizard [*Calotes versicolor*] Spotted In Water Hyacinth Patch At Jagatpur Bund Area [Date: 01/10/2014]



c) WATER QUALITY

44. 0 Water quality data of three seasons is divided into months July-Sept, 2014; Oct-Dec, 2014; Jan-Feb, 2015, for the convenience of analysis.

Table No. 12 : Water Quality Parameters At Jagatpur Bund

S.No.	Parameter	Recorded Value [22/07/14]	Recorded Value [01/11/14]	Recorded Value [04/02/15]
1.	Dissolved Oxygen (D.O.) [in %/ppm]	75.6/5.74	50.9/4.0	18.50/1.3
2.	pH	6.36	6.96	7.5
3.	Electrical Conductivity (in μs)	210	233	920
4.	Total Dissolved Solids (TDS) [mg/L]	112	103	450
5.	Turbidity	>240	50	40
6.	Temperature [˚C]	33.4	29.5	34.7
7.	Phophate [mg/L]	4	5	0.5
8.	Nitrate [mg/L]	1	1	0

Fig. No. 22 : Graph Showing Variation Of DO, pH, Phosphate And Nitrate Levels

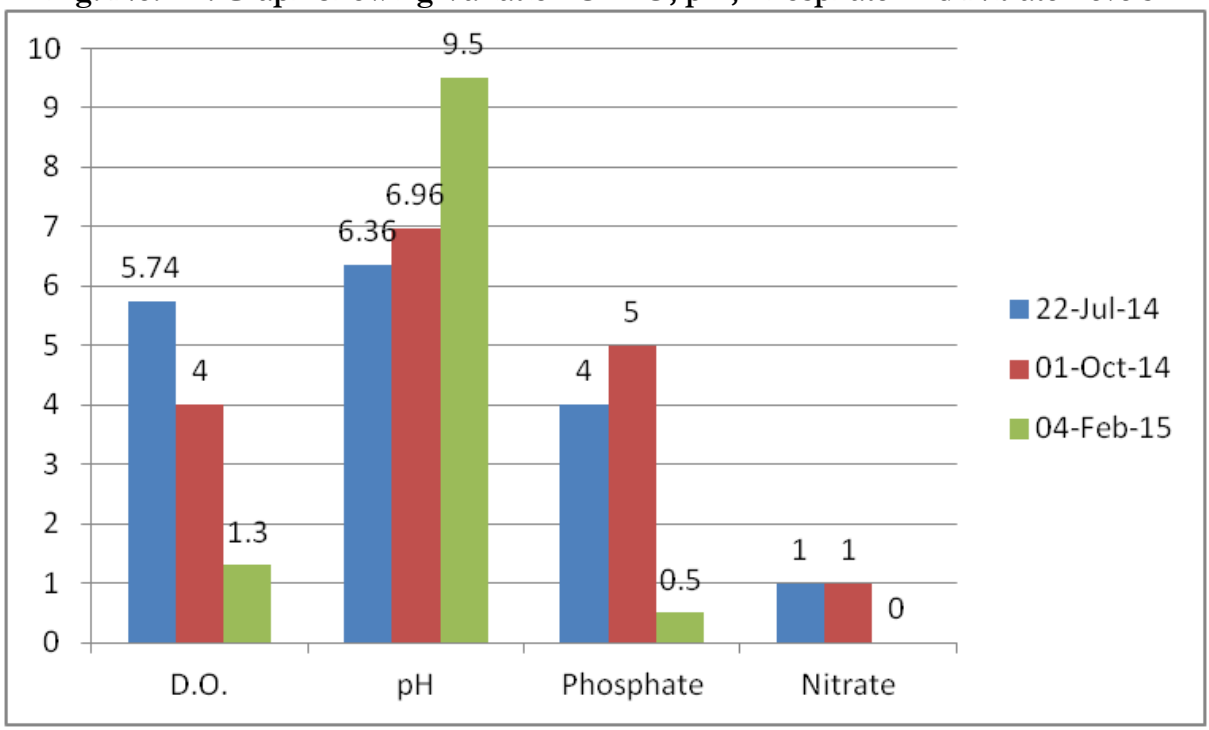
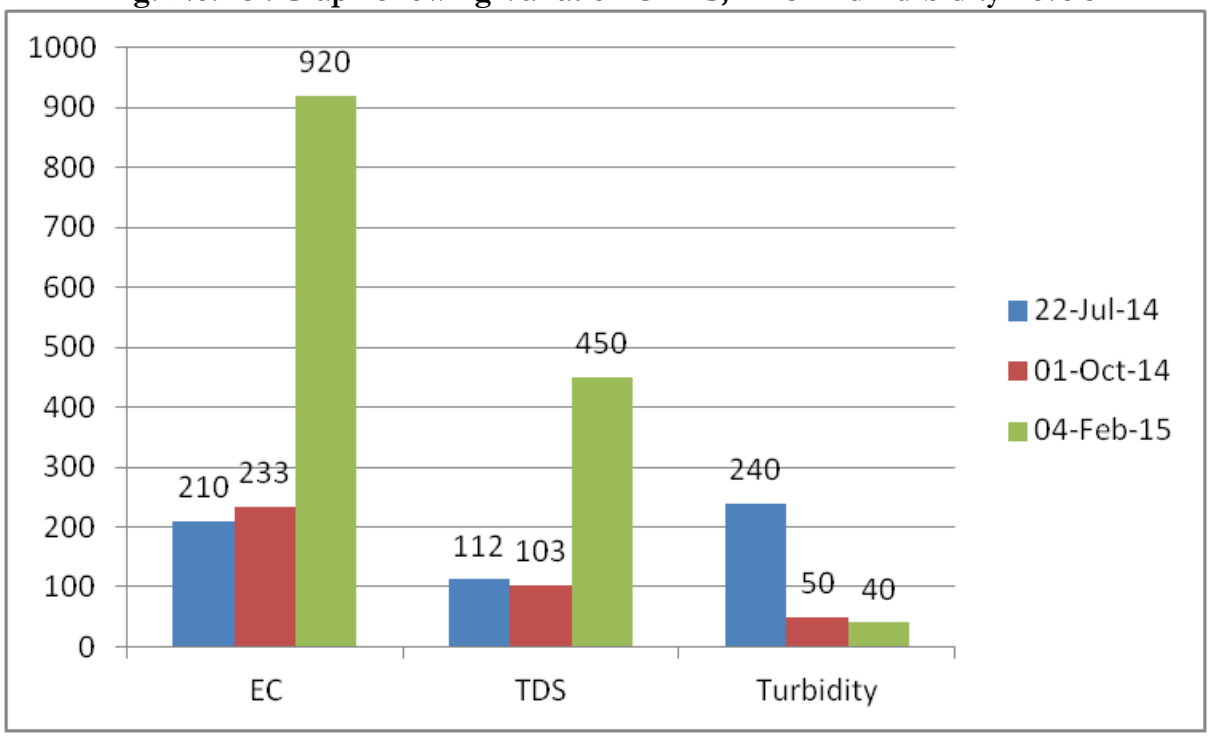


Fig. No. 23 : Graph Showing Variation Of EC, TDS And Turbidity Levels



Map No. 6 : Yamuna River And Its Flood Plains At Gandhi Nagar Area



STUDY SITE 2: GANDHI NAGAR

45. 0 The study site lies on the left bank of the River and is located around 800 metres from Old Yamuna bridge and around 250 meters from Gandhi Nagar market. The site is accessible through 3-4 spurs joined to main Pushta road or Marginal Bund road (NH-24) which runs parallel to the left bank of the River and leads to Mayur Vihar and Noida in the south. The characteristic vegetation comprises of Saccharum, Typha, Phramites, Ricinus, Cynodon etc. Fishing, agriculture, grazing, harvesting of reeds and grasses, religious ceremonies are important human activities at this site. River bank is accessible here, several drains like Najafgarh Drain, Supplementary Drain outfall upstream of the site, making it representative for this stretch of River.

46. 0 The flood plain area running parallel to the Gandhi Nagar road is known as 'Pushta' locally. Many people residing nearby are connected with the River and its flood plain area in many ways–agriculture, worship and religious ceremonies at temple located on the bank, people resting under trees at afternoon hours are some observations documented during the surveys.

47. 0 The vegetation is sparse and typically comprises of Saccharum, Alligator Weed, Phragmites, Lantana, Eclipta. The water quality is poor due to discharge from Najafgarh Drain and Supplementary Drain, which are located 6-7 km from this site. The malignant growth of Water Hyacinth is a good indicator of the pollution levels. Temporary huts of people engaged in agriculture can be seen across the River on uplands.

48. 0 One can see a number of people including children from Loha Pul to Geeta Colony Area collecting trash from the River using their locally made floating aids constructed by combining trash poly-bags together.

Fig. No. 24 : Yamuna As Seen From Gandhi Nagar Area (Looking North) [Date: 22/09/2014]



Fig. No. 25 : Yamuna River As Seen At Gandhi Nagar [Date: 22/09/2014]



Fig. No. 26 : Temporary Huts Of Inhabitants Living At Flood plain Area As Across The River From Gandhi Nagar Pushta [Date: 07/07/2014]



Fig. No. 27 : Sparse Riparian Vegetation At Gandhi Nagar Pushta [Date: 22/09/2014]



a) FLORA

The flora-trees, herbs and shrubs observed at Gandhi Nagar area are listed below:

Table No. 13 : List Of Trees

S.No.	Species	Common Name	Family
1.	*Ficus religiosa*	Peepal	Moraceae
2.	*Prosopis juliflora*	Vilaiti Keekar	Fabaceae
3.	*Mangifera indica*	Mango	Anacardiaceae
4.	*Bauhinia variegata*	Orchid Tree/Kachnar	Caesalpiniaceae
5.	*Psidium Guavajava*	Guava	Myrtaceae
6.	*Phoenix sylvestris*	Wild Date Palm	Arecaceae
7.	*Ficus virens*	Pilkhan	Moraceae
8.	*Acacia nilotica*	Babool/Kikar	Fabaceae
9.	*Leucaena leucocephala*	Subabool	Fabaceae
10.	*Dalbergia sissoo*	Shisham	Fabaceae
11.	*Putranjiva roxburghii*	Putranjiva/Lucky Bean Tree	Putranjivaceae
12.	*Cordia myxa*	Lasora	Boraginaceae

Table No. 14 : List Of Herbs/Shrubs

S.No.	Species	Common Name	Family
1.	*Sacharum spontaneum*	Kaans	Poaceae
2.	*Digera muricata*	False Amaranth, Lesua	Amaranthaceae
3.	*Cucumis melo*	Kharbuza, Musk melon	Cucurbitatceae
4.	*Leucas chephalotes*	Gubbha	Lamiaceae
5.	*Mazus pumilus*	Asian Mazus, Japanese Mazus	Scrophulariaceae
6.	*Alternanthera philoxeroides*	Alligator Weed	Amaranthaceae
7.	*Malvastrum coromandelianum*	False Mallow	Malvaceae
8.	*Abutilon indicum*	Country Mallow	Malvaceae
9.	*Solanum indicum*	Common Indian Nightshade	Solanaceae
10.	*Dhatura innoxia*	Safed dhatura	Solanaceae
11.	*Pergularia daemia*	Pergularia	Asclepiadaceae
12.	*Ageratum conyzoides*	Goat Weed	Asteraceae
13.	*Cynodon dactylon*	Bermuda Grass	Poaceae
14.	*Setaria viridis*	Green Bristle Grass	Poaceae
13.	*Typha spp.*	Elephant Grass	Typhaceae
14.	*Tridax procumbens*	Coat Buttons	Compositeae
15.	*Malva parviflora*	Cheese Weed	Malvaceae
16.	*Ipomea aquatica*	Water Spinach	Convolvulaceae
17.	*Achyranthes aspera*	Chirchita	Amaranthaceae
18.	*Phragmites Karka*	Common Reed	Poaceae
19.	*Phyla nodiflora*	Frog Fruit	Verbenaceae

20.	*Ricinus communis*	Castor Oil Plant	Euphorbiaceae
21.	*Lantana camara*	Common Lanatana/Wild Sage	Verbenaceae
22.	*Parthenium hysterophorus*	Congress Grass	Asteraceae
23.	*Cyperus rotundus*	Nut Grass	Cyperaceae
24.	*Hibiscus hirtus*	Lesser White Mallow	Malvaceae
25.	*Stellaria media*	Chickweed	Caryophyllaceae
26.	*Coccinia Grandis*	Ivy Gourd	Cucurbitaceae
27.	*Chenopodium album*	Lamb's Quarter	Chenopodiaceae

Fig. No. 28 : False Amaranth or Lesua [*Digara muricata*] At Gandhi Nagar Pushta [Date: 22/09/2014]



Fig. No. 29 : Gubbha [*Leucas cephalotes*] At Gandhi Nagar Floodplain [Date: 22/09/2014]



Fig. No. 30 : Asian Mazus [*Mazus pumilus*] Gandhi Nagar Floodplain [Date: 22/09/2014]



Fig. No. 31 : Wild Musk Melon [*Cucumis melo*] At Gandhi Nagar Floodplain [Date: 22/09/2014]



Frequency

Given below is the frequency of occurrence of each species.

Table No. 15 : Frequency Table For Trees

S. No.	Species	Frequency	Relative Frequency
1.	*Ficus religiosa*	1	14.71
2.	*Prosopis juliflora*	0.6	8.82
3.	*Mangifera indica*	0.6	8.82
4.	*Bauhinia variegata*	0.2	2.94
5.	*Psidium Guavajava*	0.4	5.88
6.	*Phoenix sylvestris*	1	14.71
7.	*Ficus virens*	0.6	8.82
8.	*Acacia nilotica*	0.4	5.88
9.	*Leucaena leucocephala*	0.6	8.82
10.	*Dalbergia sissoo*	0.8	11.76
11.	*Putranjiva roxburghii*	0.4	5.88
12.	*Cordia myxa*	0.2	2.94
	TOTAL	6.8	100

Table No. 16 : Frequency Table For Herbs/Shrubs

S. No.	Species	Frequency	Relative Frequency
1.	*Sacharum spontaneum*	0.4	3.39
2.	*Digera muricata*	0.2	1.69
3..	*Cucumis melo*	0.2	1.69
4.	*Leucas chephalotes*	0.1	0.85
5.	*Mazus pumilus*	0.3	2.54
6.	*Alternanthera philoxeroides*	0.4	3.39
7.	*Malvastrum coromandelianum*	0.3	2.54
8.	*Abutilon indicum*	0.5	4.24
9.	*Solanum indicum*	0.3	2.54
10.	*Dhatura innoxia*	0.7	5.93
11.	*Pergularia daemia*	0.2	1.69
12.	*Ageratum conyzoides*	0.7	5.93
13.	*Cynodon dactylon*	1	8.47
14.	*Setaria viridis*	0.7	5.93
15	*Typha spp.*	0.2	1.69
16.	*Tridax procumbens*	0.3	2.54
17.	*Malva parviflora*	0.6	5.08
18.	*Ipomea aquatica*	0.3	2.54
19.	*Achyranthes aspera*	0.6	5.08
20.	*Phragmites karka*	0.3	2.54
21.	*Phyla nodiflora*	0.3	2.54
22.	*Ricinus communis*	0.4	3.39
23.	*Lantana camara*	0.4	3.39
24.	*Parthenium hysterophorus*	0.4	3.39
25.	*Cyperus rotundus*	0.8	6.78
26.	*Hibiscus hirtus*	0	0.00
27.	*Stellaria media*	0.5	4.24
28.	*Coccinia Grandis*	0.2	1.69
29.	*Chenopodium album*	0.5	4.24
	TOTAL	**11.8**	**100.00**

Fig. No. 32 : Bar Graph Showing The Representation Of Various Tree Species at Gandhi Nagar Site

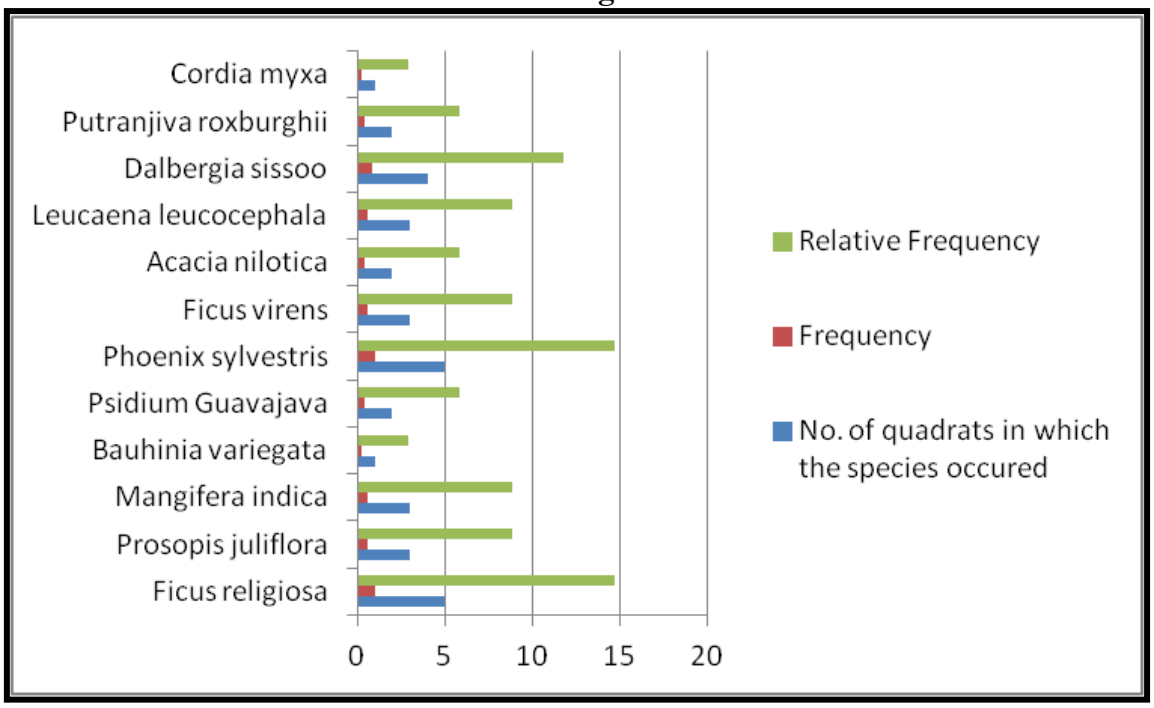
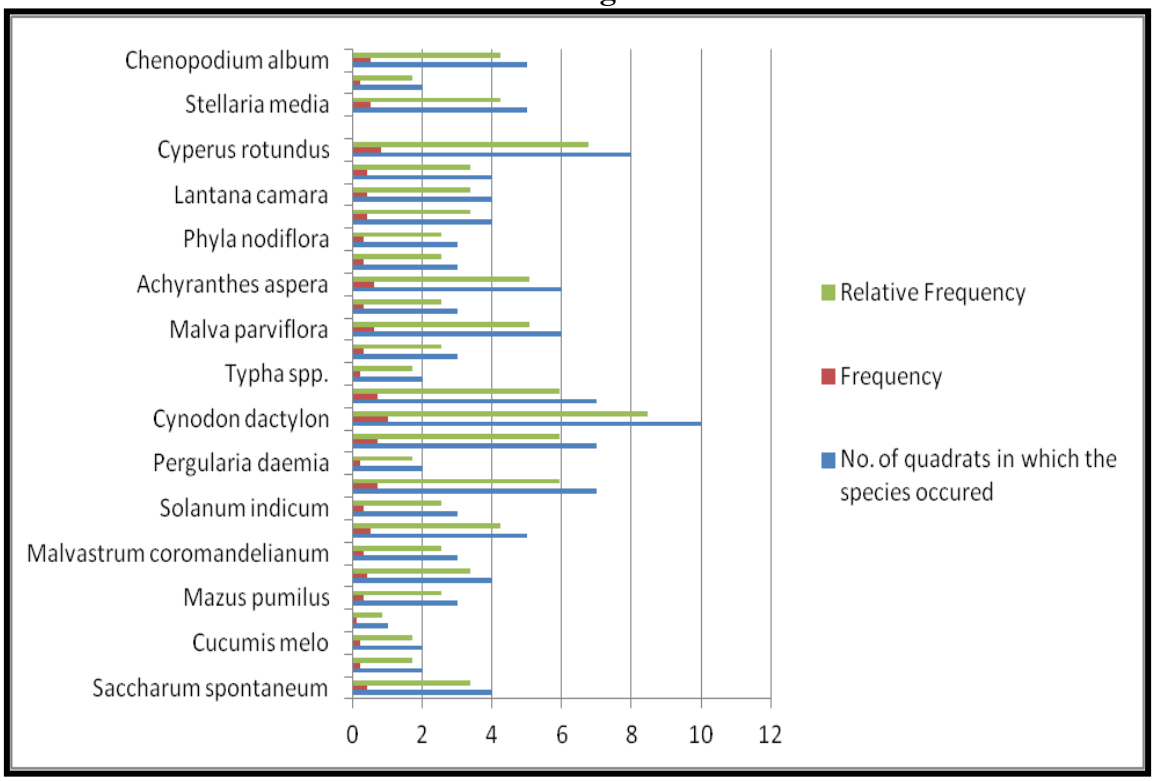


Fig. No. 33 : Bar Graph Showing The Representation Of Various Herb/Shrub Species at Gandhi Nagar site



b) FAUNA

49. 0 The fauna observed and according to information conveyed by local people and fishermen includes Indian Palm Squirrel (*Funambulus palmarum*), Indian Bush Rat (*Golunda ellioti*), Indian Grey Moongose (*Herpestes edwardsii*), Garden Lizard (*Calotes versicolor*), Indian Jackal (*Canis aureus indicus*). Presence of Indian Monitor Lizard (*Varanus bengalensis*), could not be ascertained. Some water snake species were also by local people at different times of the year. Insects species observed during the surveys belonged to the group Grasshoppers and Crickets (Order: Orthoptera), Stick insects and Leaf insects (Order: Phasmatodea), Butterflies and Moths (Order: Lepidoptera), Dragonflies and Damselflies (Order: Odonata).

List of Birds

The following birds were sighted during the study period.

Table No. 17 : List Of Birds

S. No.	Species	Scientific Name
1.	Black Kite	*Milvus migrans*
2.	Eurasian Collared Dove	*Streptopelia decaocto*
3.	Little Cormorant	*Phalacrocorax niger*
4.	Green Bee-eater	*Merops orientalis*
5.	Great Cormorant	*Phalacrocorax carbo*
6.	Jungle Babbler	*Turdoides striatus*
7.	Rose-ringed Parakeet	*Psittacula krameri*
8.	Purple Sunbird	*Cinnyris asiaticus*
9.	Asian Koel	*Eudynamys scolopacea*
10.	Indian Robin	*Saxicoloides fulicatus*
11.	Brown Rockchat	*Cercomela fusca*
12.	Red-vented Bulbul	*Pycnonotus cafer*
13.	House Sparrow	*Passer domesticus*
14.	Whitebreasted Waterhen	*Amaurornis phoenicurus*
15.	Oriental Magpie Robin	*Copsychus saularis*
16.	Common Myna	*Acridotheres tristis*
17.	Common Hoope	*Upopa epops*
18.	Rock Pegion	*Columba livia*
19.	Shikra	*Accipiter badius*
20.	Long-tailed Shrike	*Lanius schach*
21.	Redwattled Lapwing	*Vanellus indicus*
22.	Blackwinged Stilt	*Himantopus himantopus*
23.	White-throated Kingfisher	*Halcyon smyrmensis*
24.	Painted Stork	*Mycteria leucocephala*
25.	Brown-headed Gull	*Larus brunnicephalus*
26.	Cattle Egret	*Bubulcus ibis*
27.	Great Egret	*Ardea alba*

Fig. No. 34 : Black Kite Flying Over Gandhi Nagar Floodplain [Date: 22/09/2014]



Fig. No. 35 : Long-Tailed Shrike At Gandhi Nagar Floodplain [Date: 07/07/2014]



Fig. No. 36 : Peacock Pansy [*Junonia almanac*] Butterfly On Lantana Plant at Gandhi Nagar Flood plain Area [Date: 22/09/2014]



Fig. No. 37 : Damselfly spp. At Gandhi Nagar Flood Plain Area [Date: 07/07/2014]



Fig. No. 38 : Checkered Keel Snake In Yamuna Waters At Gandhi Nagar [Date: 22/09/2014]



c) WATER QUALITY

50. 0 Water quality data of three seasons is devided into months July-Sept, 2014; Oct-Dec, 2014; Jan-Feb, 2015, for the convenience of analysis.

Table No. 18 : Water Quality At Gandhinagar

S.No.	Parameter	Recorded Value [22/08/14]	Recorded Value [24/10/14]	Recorded Value [05/02/15]
1.	Dissolved Oxygen (D.O.) [%/ppm]	19.07/0.9	22/1.1	27/1.44
2.	pH	7.4	6.1	6.9
3.	Electrical Conductivity (in μs)	1320	1210	1190
4.	Total Dissolved Solids (TDS) [mg/L]	660	610	820
5.	Turbidity	75	100	150
6.	Temperature [˚C]	32.6	30.6	29.5
7.	Phosphate [mg/L]	>5	>5	>5
8.	Nitrate [mg/L]	3	2	1

Fig. No. 39 : Graph Showing Variation DO, pH, Phosphate and Nitrate Levels

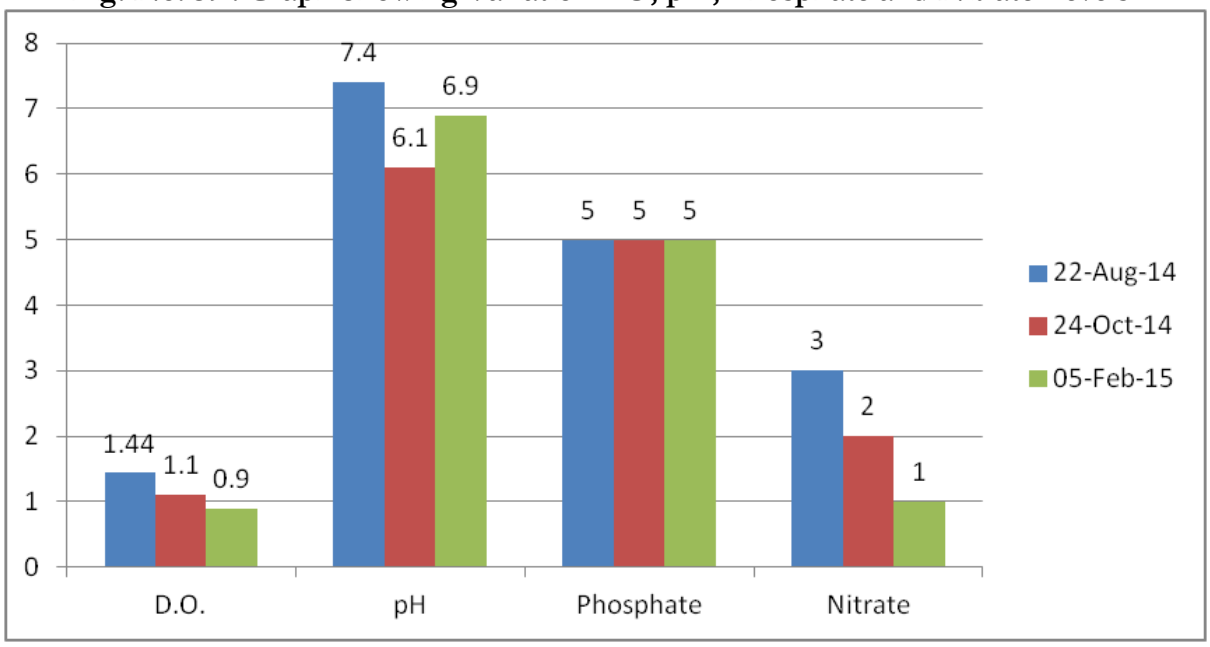
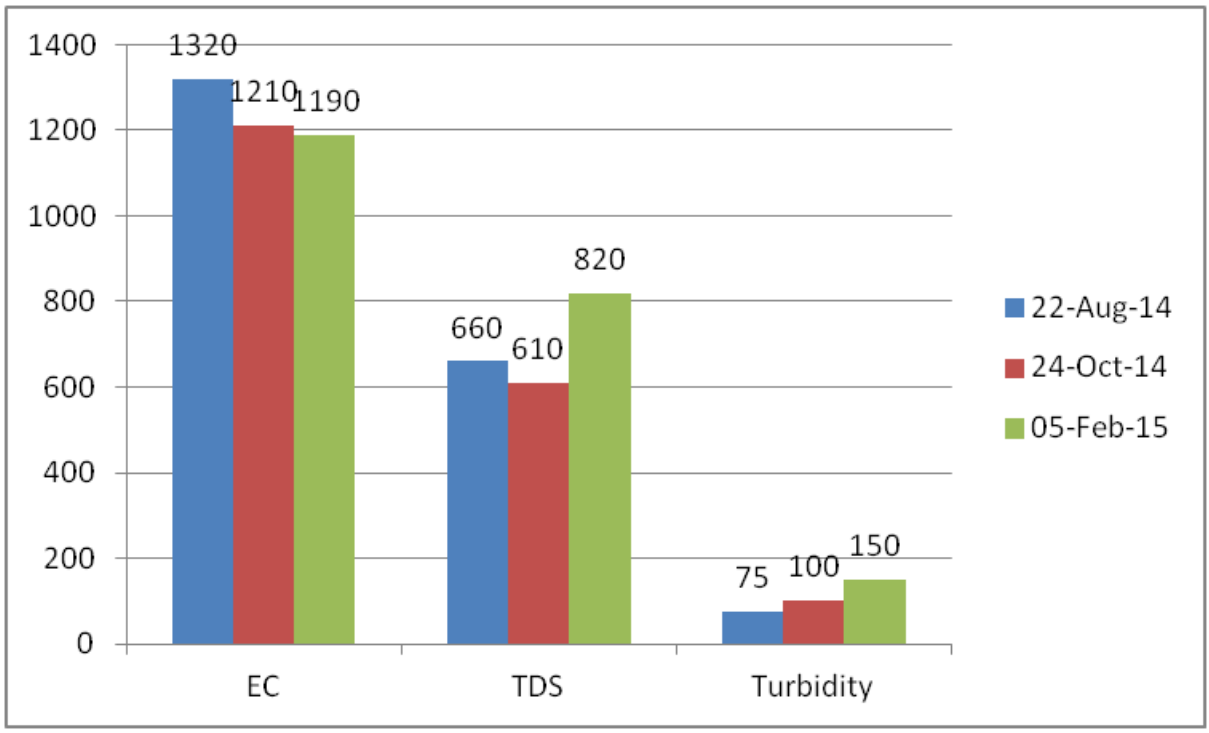


Fig. No. 40 : Graph Showing Variation of EC, TDS and Turbidity Levels



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Map No. 7 : Yamuna River And Its Floodplains At ITO Area Near Rajghat Power Station



STUDY SITE 3 : ITO AREA

51. 0 The site is located near ITO bridge enroute to Vikas Marg adjacent to Rajghat Power House and Delhi Secretariat. The site is accessible from under the flyover of Grand Trunk Road [Power Station on the left] leading towards ISBT Kashmere Gate. The characteristic vegetation comprises of Tamarix, Saccharum, Typha, Phragmites, Ricinus, etc. Fishing, agriculture, grazing, harvesting of reeds and grasses, are important human activities observed at the site. Accessibility to River bank, location upstream of ITO barrage, presences of shallow water depressions on the left bank, presence of riparian vegetation were important factors to consider it as a study site downstream of Gandhi Nagar site.

52. 0 The site is located near ITO bridge enroute to Vikas Marg adjacent to Rajghat Power House and Delhi Secretariat. The presence of Ghat and barrage here makes the site well recognised by people.

53. 0 The vegetation comprises of tall Typha, Phragmites, Ipomoea, Alligator weed, Saccharum and several grasses belonging to Cyperaceae family. Several representative species of marshland areas were observed during the surveys which includes *Tamarix spp., Cyperus rotundus, Paspalum distichum, Alternanthera, Phyla nodiflora* etc. The three layered vegetation stratification was also observed with the primary taller layer consisting of Phragmites, Typha, Saccharaum, etc. second layer of Congress Grass, Dhatura, Tamarix and the third ground layer consisting Knotweed, Cynodon, Ipomoea and other members of cyperaceae.

54. 0 There is one shallow water-filled depression accessible from Geeta Colony road. It is quite popular among anglers who live in nearby areas. The water body has been traditionally utilized for fish rearing by local people. Adjacent to it there are some plant nurseries where ornamental plant varieties are grown. Such areas are preferred site for nurseries due to nutrient rich soil of flood plain areas and availabilty of space. Most of the land is utilized for seasonal vegetable cultivation. The vegetable and fish are eventually sold in the local markets.

Fig. No. 41 : Yamuna As Seen From ITO Ghat Near Rajghat Power Station (Looking North) [Date: 16/09/2014]



Fig. No. 42 : Yamuna Floodplains As Seen From Ring Road Near Rajghat Power Station Towards East [Date: 05/02/2015]



Fig. No. 43 : A Flock Of Pigeons Flying Over Agricultural Fields On Flood Plains Near Krishan Kunj Area [Date: 13/10/2014]



Fig. No. 44 : Vegetation Stratification - Three Layers Of Vegetation Clearly Visible At Krishan Kunj Area [Date: 13/10/2014]



Fig. No. 45 : Grasses Burnt For Agriculture Activities At Flood Plain Area In Front Of Rajghat Power Station [Date: 05/02/2015]



a) FLORA

The flora-trees, herbs and shrubs observed at Yamuna flood plains of ITO area are listed below:

Table No. 19 : List Of Trees

S.No.	Species	Common Name	Family
1.	*Prosopis juliflora*	Vilaiti Keekar	Fabaceae
2.	*Phoenix sylvestris*	Wild Date Palm	Arecaceae
3.	*Mangifera indica*	Mango	Anacardiaceae
4.	*Ficus virens*	Pilkhan	Moraceae
5.	*Psidium Guavajava*	Guava	Myrtaceae
6.	*Leucaena leucocephala*	Subabool	Fabaceae
7.	*Melia azedarach*	Bakain	Meliaceae
8.	*Acacia nilotica*	Babool/Kikar	Fabaceae
9.	*Dalbergia sissoo*	Shisham	Fabaceae
10.	*Ficus religiosa*	Peepal	Moraceae
11.	*Ziziphus mummularia*	Ber	Rhamnaceae
12.	*Albizzia lebbeck*	Siris	Fabaceae
13.	*Acacia auriculiformis*	Earpod Wattle	Fabaceae
14.	*Morus alba*	White Mulberry	Moraceae
15.	*Ailanthus excelsa*	Maharukh/Mahaneem	Simaroubaceae

Table No. 21 : List Of Herbs/Shrubs

S.No.	Species	Common Name	Family
1.	*Malva parviflora*	Cheese Weed	Malvaceae
2.	*Ipomea aquatica*	Water Spinach	Convolvulaceae
3.	*Achyranthes aspera*	Chirchita	Amaranthaceae
4.	*Chenopodium album*	Lamb's Quarter	Chenopodiaceae
5.	*Phyla nodiflora*	Frog Fruit	Verbenaceae
6.	*Ricinus communis*	Castor Oil Plant	Euphorbiaceae
7.	*Malvastrum coromandelianum*	False Mallow	Malvaceae
8.	*Abutilon indicum*	Country Mallow	Malvaceae
9.	*Solanum indicum*	Common Indian Nightshade	Solanaceae
10.	*Dhatura innoxia*	Safed dhatura	Solanaceae
11.	*Pergularia daemia*	Pergularia	Asclepiadaceae
12.	*Ageratum conyzoides*	Goat Weed	Asteraceae
13.	*Cynodon dactylon*	Bermuda Grass	Poaceae
14.	*Setaria viridis*	Green Bristle Grass	Poaceae
15.	*Typha spp.*	Elephant Grass	Typhaceae
16.	*Tridax procumbens*	Coat Buttons	Compositeae
17.	*Oxalis corniculata*	Creeping Woodsorrel	Oxalidaceae
18.	*Sacharum spontaneum*	Kaans	Poaceae
19.	*Digera muricata*	False Amaranth, Lesua	Amaranthaceae
20.	*Cucumis melo*	Kharbuza, Musk melon	Cucurbitatceae
21.	*Lantana camara*	Common Lanatana/Wild Sage	Verbenaceae
22.	*Parthenium hysterophorus*	Congress Grass	Asteraceae
23.	*Cyperus rotundus*	Nut Grass	Cyperaceae
24.	*Coccinia Grandis*	Ivy Gourd	Cucurbitaceae
25.	*Phragmites karka*	Common Reed	Poaceae
26.	*Panicum spp.*	Switch Grass	Poaceae
27.	*Tamarix spp.*	Tamarisk	Tamaricaceae
28.	*Paspalum distichum*	Knotgrass	Poaceae

Fig. No. 46 : Water Spinach [*Ipomea aquatic*] At Krishan Kunj Area Near ITO [Date: 13/10/2014]



Fig. No. 47 : Tamarix spp. At ITO Floodplain Area [Date: 13/10/2014]



Fig. No. 48 : False Daisy (*Eclipta alba*) At ITO Flood Plain Area [Date: 13/10/2014]



Frequency

Given below is the frequency of occurrence of each species.

Table No. 20 : Frequency Table For Trees

S. No.	Species	Frequency	Relative Frequency
1.	*Prosopis juliflora*	0.6	10.00
2.	*Phoenix sylvestris*	0.6	10.00
3.	*Mangifera indica*	0.4	6.67
4.	*Ficus virens*	0.2	3.33
5.	*Psidium Guavajava*	0.4	6.67
6.	*Leucaena leucocephala*	0.4	6.67
7.	*Melia azedarach*	0.2	3.33
8.	*Acacia nilotica*	0.4	6.67
9.	*Dalbergia sissoo*	0.6	10.00
10.	*Ficus religiosa*	0.2	3.33
11.	*Ziziphus mummularia*	0.4	6.67
12.	*Albizzia lebbeck*	0.6	10.00
13.	*Acacia auriculiformis*	0.2	3.33
14.	*Morus alba*	0.6	10.00
15.	*Ailanthus excelsa*	0.2	3.33
	Total	**5.4**	**100.00**

Table No. 2 : Frequency Table For Herbs/Shrubs

S. No.	Species	Frequency	Relative Frequency
1.	*Malva parviflora*	0.5	3.45
2.	*Ipomea aquatica*	0.3	2.07
3.	*Achyranthes aspera*	0.7	4.83
4.	*Chenopodium album*	0.4	2.76
5.	*Phyla nodiflora*	0.3	2.07
6.	*Ricinus communis*	0.6	4.14
7.	*Malvastrum coromandelianum*	0.3	2.07
8.	*Abutilon indicum*	0.5	3.45
9.	*Solanum indicum*	0.6	4.14
10.	*Dhatura innoxia*	0.4	2.76
11.	*Pergularia daemia*	0.3	2.07
12.	*Ageratum conyzoides*	0.6	4.14
13.	*Cynodon dactylon*	0.7	4.83
14.	*Setaria viridis*	0.5	3.45
15.	*Typha spp.*	0.3	2.07
16.	*Tridax procumbens*	0.5	3.45
17.	*Oxalis corniculata*	0.8	5.52
18.	*Sacharum spontaneum*	0.7	4.83
19.	*Digera muricata*	0.3	2.07
20.	*Cucumis melo*	0.2	1.38
21.	*Lantana camara*	0.6	4.14
22.	*Parthenium hysterophorus*	0.7	4.83
23.	*Cyperus rotundus*	0.7	4.83
24.	*Coccinia Grandis*	0.7	4.83
25.	*Phragmites karka*	0.6	4.14
26.	*Panicum spp.*	0.5	3.45
27.	*Tamarix spp.*	0.8	5.52
28.	*Paspalum distichum*	0.4	2.76
	Total	**14.5**	**100.00**

Fig. No. 49 : Bar Graph Showing Representation Of Various Tree Species At ITO Site

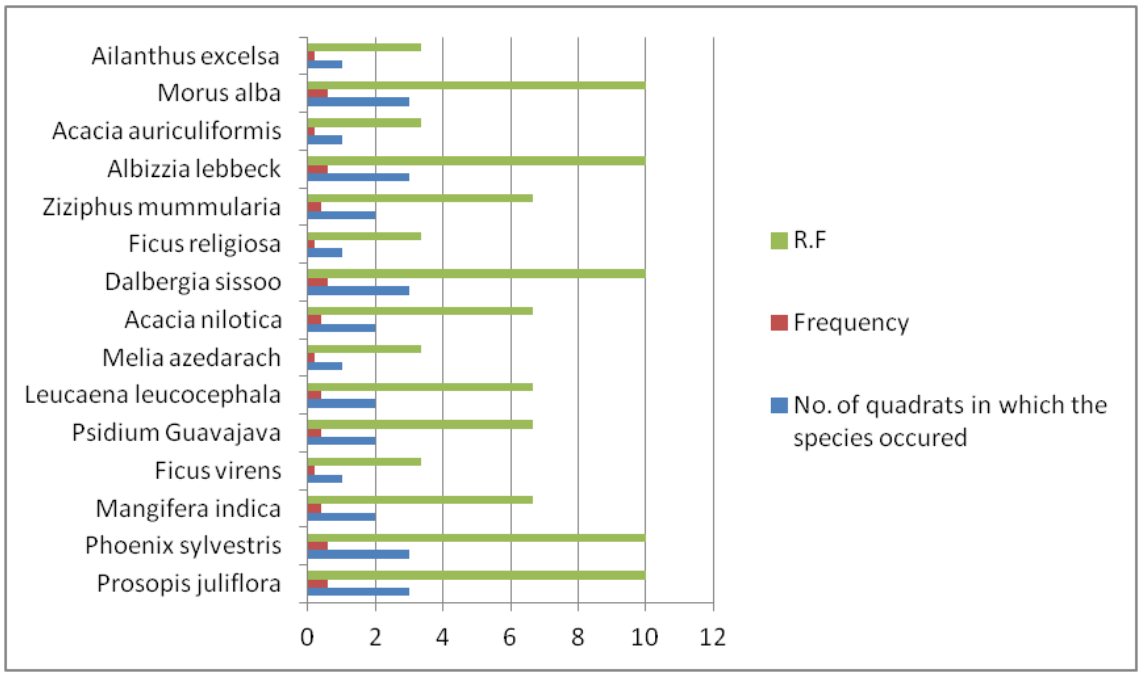
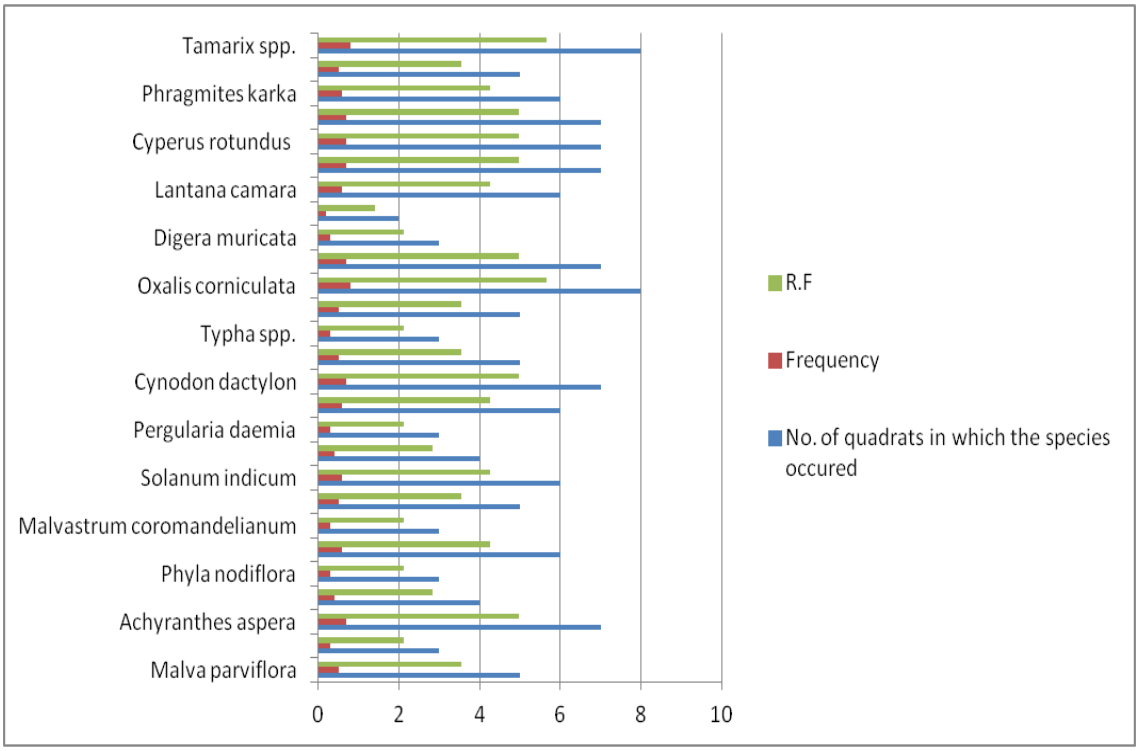


Fig. No. 50 : Bar Graph Showing Representation Of Various Herb/Shrub Species At ITO Site



b) FAUNA

List of Birds

The following birds were sighted during the study period.

Table No. 23 : List Of Birds

S. No.	Species	Scientific Name
1.	Shikra	*Accipiter badius*
2.	Yellow Wagtail	*Motacilla flalva*
3.	Redwattled Lapwing	*Vanellus indicus*
4.	Blackwinged Stilt	*Himantopus himantopus*
5.	Great Cormorant	*Phalacrocorax carbo*
6.	Jungle Babbler	*Turdoides striatus*
7.	Rose-ringed Parakeet	*Psittacula krameri*
8.	Purple Sunbird	*Cinnyris asiaticus*
9.	Asian Koel	*Eudynamys scolopacea*
10.	Indian Robin	*Saxicoloides fulicatus*
11.	Brown Rockchat	*Cercomela fusca*
12.	Red-vented Bulbul	*Pycnonotus cafer*
13.	House Sparrow	*Passer domesticus*
14.	Whitebreasted Waterhen	*Amaurornis phoenicurus*
15.	Oriental Magpie Robin	*Copsychus saularis*
16.	Common Myna	*Acridotheres tristis*
17.	Common Hoope	*Upopa epops*
18.	Rock Pegion	*Columba livia*
19.	White-throated Kingfisher	*Halcyon smyrmensis*
20.	Painted Stork	*Mycteria leucocephala*
21.	Brown-headed Gull	*Larus brunnicephalus*
22.	White-throated Kingfisher	*Halcyon smyrmensis*
23.	Eurasian Collared Dove	*Streptopelia decaocto*
24.	Cattle Egret	*Bubulcus ibis*
25.	White Wagtail	*Motacilla alba*
26.	Long-tailed Shrike	*Lanius schach*
27.	Great Egret	*Ardea alba*
28.	Black Kite	*Milvus migrans*
29.	Green Bee-eater	*Merops orientalis*
30.	Little Cormorant	*Phalacrocorax niger*
31.	House Crow	*Corvus splendens*
32.	Spotted Dove	*Streptopalia chinensis*
33.	Brownheaded Barbet	*Megalaima zeylanica*
34.	Black Drongo	*Dicrurus macrocercus*
35.	Barn Swallow	*Hirundo rustica*
36.	Jungle Crow	*Corvus macrorhyncos*

Fig. No. 51 : Flock Of Blue Rock Pegions At ITO Floodplain Area [Date: 13/10/2014]



Fig. No. 52 : Intermediate Egret At ITO Floodplain Area [Date: 05/02/2015]



Fig. No. 53 : Assassin Bug Preying On Honey Bee On Tamarix Plant And Housefly Ready To Take Upon At ITO Flood Plain Area [Date: 16/09/2014]



Fig. No. 54 : Wasp Feeding On The Flowers Of Tamarix Plant At ITO Flood Plain Area [Date: 13/10/2014]



Fig. No. 55 : Weevil Insect Collected From Waterbody At Krishan Kunj Area Across Yamuna River At ITO [Date: 28/10/2014]



Fig. No. 56 : Water Strider Insect Collected From Waterbody At Krishan Kunj Area At ITO [Date: 28/10/2014]

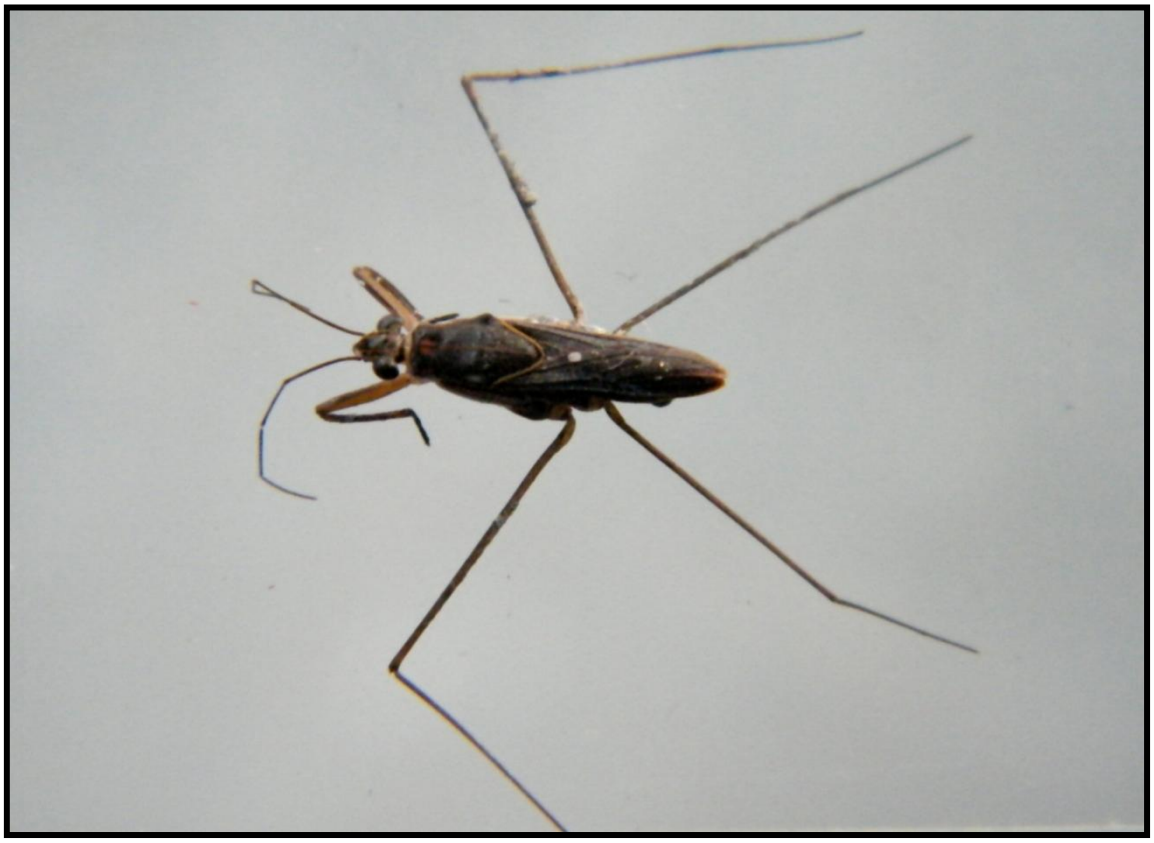


Fig. No. 57 : Shrimps Collected From A Waterbody At Krishan Kunj Near ITO [Date: 28/10/2014]



c) WATER QUALITY

55. 0 Water quality data of three seasons is devided into months July-Sept, 2014; Oct-Dec, 2014; Jan-Feb, 2015, for the convenience of analysis.

Table No. 21 : Water Quality At ITO

S.No.	Parameter	Recorded Value [16/09/14]	Recorded Value [16/10/14]	Recorded Value [05/02/15]
1.	Dissolved Oxygen (D.O.) [in %/ppm]	7/0.56	15.2/1.24	13.1/0.7
2.	pH	6.3	6.7	5.1
3.	Electrical Conductivity (in μs)	1040	1170	1540
4.	Total Dissolved Solids (TDS) [mg/L]	510	580	760
5.	Turbidity	200	100	150
6.	Temperature [˚C]	36.6	36.6	31.5
7.	Phosphate [mg/L]	>5	>5	>5
8.	Nitrate [mg/L]	1-2	1-2	2

Fig. No. 58 : Graph Showing Variation DO, pH, Phosphate And Nitrate Levels

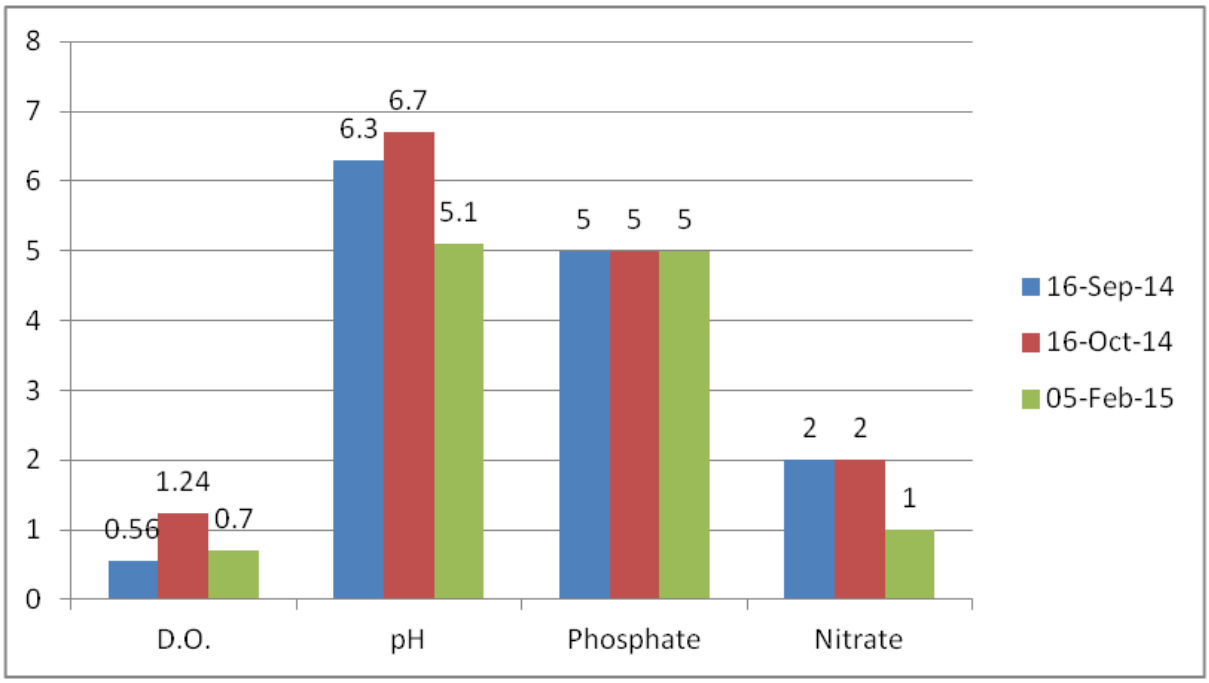
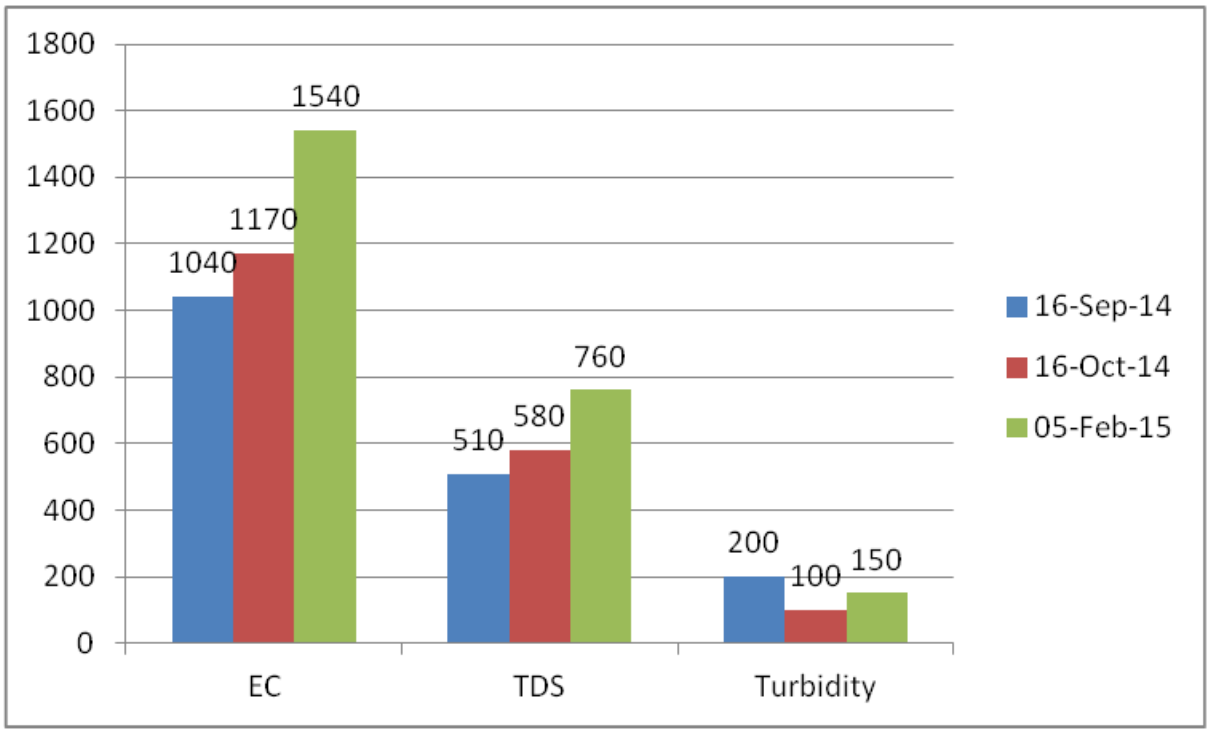


Fig. No. 59 : Graph Showing Variation of EC, TDS And Turbidity Levels



Map No. 8 : Yamuna River And Floodplains At Mayur Vihar Area



STUDY SITE 4 : MAYUR VIHAR AREA

56. 0 The floodplain area and the River is accessible from a narrow road [known as Nangli area road] – in front of Mayur Vihar-I metro station located on Noida Link Road. It passes through some nurseries and leads to Nangli village area. The characteristic vegetation comprises of Saccharum, Phragmites, Ricinus, Ipomoea etc. Religious ceremonies, fishing, agriculture, grazing, harvesting of reeds and grasses, are important human activities observed at the site. Accessibility to River bank, location of the site to downstream of ITO barrage and upstream of Okhla barrage were important factors to select it as study site after ITO study site.

57. 0 Recognised as Ghat, the area is frequented by local people for various religious ceremonies. Many large statues were observed lying on flood plain area as well as immersed in water.

58. 0 There is little riparian vegetation. Most of the flood plain area is under agriculture leaving no space for riparian vegetation. The vegetation comprises of some scarce patches of Phragmites, Ipomoea, Alligator weed, Saccharum. The agriculture fields are extended until the levees. Cultivation of seasonal vegetables are preferred over cereals due to market demand from the Mayur Vihar and Noida areas both which are in developing course over the last some years.

59. 0 Water quality is poor and intermittent patches of Water Hyacinth were observed. Despite poor quality of water, several species of dragonflies and other insects were seen. Some anglers fishing with rods were observed near toll road leading to Maharani Bagh.

Fig. No. 60 : Yamuna River At Mayur Vihar Ghat Near Mayur Vihar Metro Station (Looking North) [Date: 25/09/2014]



Fig. No. 61 : Lord Ganesh Statue Lying Unattended At Mayur Vihar Ghat [Date: 25/09/2014]



Fig. No. 62 : Levees Are Devoid Of Riparian Vegetation At Mayur Vihar Ghat Area [Date: 25/09/2014]



a) FLORA

The flora-trees, herbs and shrubs observed at Yamuna flood plains of ITO area are listed below:

Table No. 22 : List Of Trees

S.No.	Species	Common Name	Family
1.	*Prosopis juliflora*	Vilaiti Keekar	Fabaceae
2.	*Phoenix sylvestris*	Wild Date Palm	Arecaceae
3.	*Mangifera indica*	Mango	Anacardiaceae
4.	*Morus alba*	White Mulberry	Moraceae
5.	*Ficus religiosa*	Peepal	Moraceae
6.	*Ailanthus excelsa*	Maharukh/Mahaneem	Simaroubaceae
7.	*Ficus virens*	Pilkhan	Moraceae
8.	*Acacia nilotica*	Babool/Kikar	Fabaceae
9.	*Dalbergia sissoo*	Shisham	Fabaceae
10.	*Leucaena leucocephala*	Subabool	Fabaceae
11.	*Ziziphus mummularia*	Ber	Rhamnaceae
12.	*Albizzia lebbeck*	Siris	Fabaceae

Table No. 23 : List Of Herbs/Shrubs

S.No.	Species	Common Name	Family
1.	*Parthenium hysterophorus*	Congress Grass	Asteraceae
2.	*Cyperus rotundus*	Nut Grass	Cyperaceae
3.	*Coccinia Grandis*	Ivy Gourd	Cucurbitaceae
4.	*Chenopodium album*	Lamb's Quarter	Chenopodiaceae
5.	*Ricinus communis*	Castor Oil Plant	Euphorbiaceae
6.	*Sacharum spontaneum*	Kaans	Poaceae
7.	*Oxalis corniculata*	Creeping Woodsorrel	Oxalidaceae
8.	*Solanum indicum*	Common Indian Nightshade	Solanaceae
9.	*Dhatura innoxia*	Safed dhatura	Solanaceae
10.	*Cucumis melo*	Kharbuza, Musk melon	Cucurbitatceae
11.	*Ageratum conyzoides*	Goat Weed	Asteraceae
12.	*Cynodon dactylon*	Bermuda Grass	Poaceae
13.	*Setaria viridis*	Green Bristle Grass	Poaceae
14.	*Malva parviflora*	Cheese Weed	Malvaceae
15.	*Ipomea aquatica*	Water Spinach	Convolvulaceae
16.	*Achyranthes aspera*	Chirchita	Amaranthaceae

Fig. No. 63 : Kaans [*Sacharum spontaneum*] At Mayur Vihar Flood Plain Area [Date: 25/09/2014]



Fig. No. 64 : Flower Of *Cucumis melo* At Mayur Vihar Flood Plain Area [Date: 25/09/2014]



Frequency

Given below is the frequency of occurrence of each species.

Table No. 24 : Frequency Table For Trees

S. No.	Species	Frequency	Relative Frequency
1.	*Prosopis juliflora*	0.6	8.33
2.	*Phoenix sylvestris*	0.8	11.11
3.	*Mangifera indica*	0.6	8.33
4.	*Morus alba*	0.8	11.11
5.	*Ficus religiosa*	0.4	5.56
6.	*Ailanthus excelsa*	0.2	2.78
7.	*Ficus virens*	0.4	5.56
8.	*Acacia nilotica*	0.6	8.33
9.	*Dalbergia sissoo*	0.8	11.11
10.	*Leucaena leucocephala*	0.6	8.33
11.	*Ziziphus mummularia*	0.8	11.11
12.	*Albizzia lebbeck*	0.6	8.33
	Total	7.2	100

Table No. 25 : Frequency Table For Herbs/Shrubs

S. No.	Species	Frequency	Relative Frequency
1.	*Parthenium hysterophorus*	0.7	7.61
2.	*Cyperus rotundus*	0.8	8.70
3.	*Coccinia Grandis*	0.3	3.26
4.	*Chenopodium album*	0.6	6.52
5.	*Ricinus communis*	0.5	5.43
6.	*Sacharum spontaneum*	0.4	4.35
7.	*Oxalis corniculata*	0.8	8.70
8.	*Solanum indicum*	0.7	7.61
9.	*Dhatura innoxia*	0.6	6.52
10.	*Cucumis melo*	0.2	2.17
11.	*Ageratum conyzoides*	0.5	5.43
12.	*Cynodon dactylon*	0.9	9.78
13,	*Setaria viridis*	0.7	7.61
14.	*Malva parviflora*	0.6	6.52
15.	*Ipomea aquatica*	0.3	3.26
16.	*Achyranthes aspera*	0.6	6.52
	Total	9.2	100

Fig. No. 65 : Bar Graph Showing The Representation Of Various Tree Species At Mayur Vihar Site

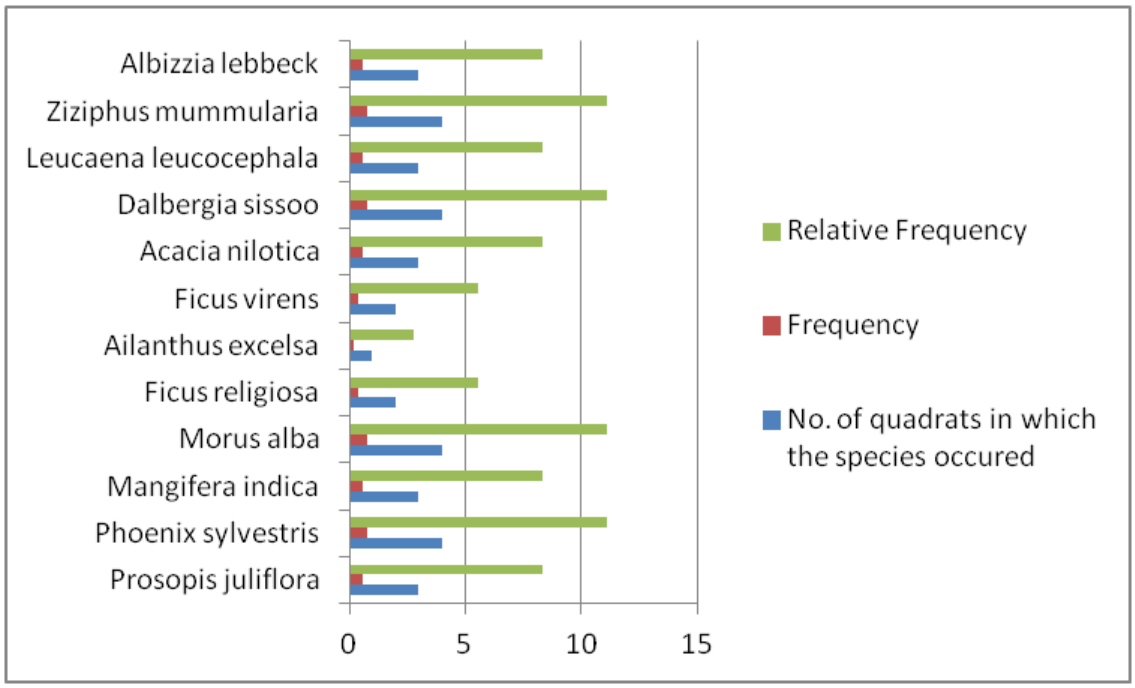
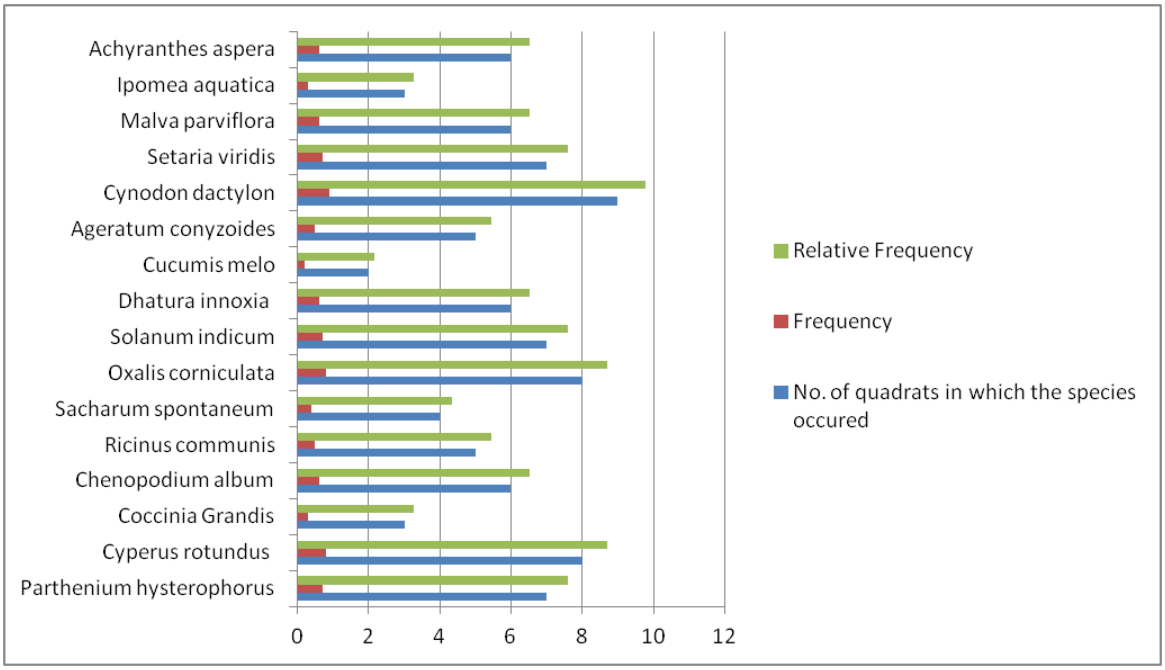


Fig. No. 66 : Bar Graph Showing The Representation Of Various Herb/Shrub Species At Mayur Vihar Site



b) FAUNA

60. 0 As per information conveyed by local people and living nearby Nangli area several snakes species have been sighted nearby agricultural fields. Indian Jackal (*Canis aureus indicus*) locally known as Geedhar roam the area during evenings. Other faunal species sighted at different times during the survey includes Indian Palm Squirrel (*Funambulus palmarum*), Indian Bush Rat (*Golunda ellioti*), Indian Grey Moongose (*Herpestes edwardsii*), Garden Lizard (*Calotes versicolor*), Indian Jackal (*Canis aureus indicus*). Presence of Indian Monitor Lizard (*Varanus bengalensis*), could not be ascertained. Insects species observed during the surveys belonged to the group Grasshoppers and Crickets (Order: Orthoptera), Stick insects and Leaf insects (Order: Phasmatodea), Butterflies and Moths (Order: Lepidoptera), Dragonflies and Damselflies (Order : Odonata).

List of Birds

The following birds were sighted at Mayur Vihar flood plain area during the study period.

Table No. 26 : List Of Birds

S. No.	Species	Scientific Name
1.	Oriental Magpie Robin	*Copsychus saularis*
2.	Yellow Wagtail	*Motacilla flalva*
3.	Redwattled Lapwing	*Vanellus indicus*
4.	Blackwinged Stilt	*Himantopus himantopus*
5.	Great Cormorant	*Phalacrocorax carbo*

6.	Jungle Babbler	*Turdoides striatus*
7.	Spotted Dove	*Streptopalia chinensis*
8.	Oriental Darter	*Phalacrocorax carbo*
9.	Green Bee-eater	*Merops orientalis*
10.	Indian Robin	*Saxicoloides fulicatus*
11.	Brown Rockchat	*Cercomela fusca*
12.	Red-vented Bulbul	*Pycnonotus cafer*
13.	House Sparrow	*Passer domesticus*
14.	House Crow	*Corvus splendens*
15.	Oriental Magpie Robin	*Copsychus saularis*
16.	Common Myna	*Acridotheres tristis*
17.	Black Kite	*Milvus migrans*
18.	Rock Pegion	*Columba livia*
19.	White-throated Kingfisher	*Halcyon smyrmensis*
20.	Painted Stork	*Mycteria leucocephala*
21.	Common Hoope	*Upopa epops*
22.	Spotted Dove	*Streptopalia chinensis*
23.	White Wagtail	*Motacilla alba*
24.	Green Bee-eater	*Merops orientalis*
25.	Black Drongo	*Dicrurus macrocercus*

Fig. No. 67 : Rock Pigeon In Agriculture Fields At Mayur Vihar Ghat [Date: 01/10/14]



Fig. No. 68 : Red-Wattled Lapwing Near Water Hyacinth Patch At Mayur Vihar Ghat [Date: 01/10/14]



Fig. No. 69 : Dragonfly At Mayur Vihar Yamuna Flood Plains [Date: 25/09/2014]



Fig. No. 70 : Butterfly At Yamuna Flood Plain Area [Date: 25/09/2014]



Fig. No. 71 : Dragonfly At Mayur Vihar Yamuna Flood Plains [Date: 01/10/14]



c) WATER QUALITY

61. 0 Water quality data of three seasons is devided into months July-Sept, 2014; Oct-Dec, 2014; Jan-Feb, 2015, for the convenience of analysis.

Table No. 27 : Water Quality At Mayur Vihar

S.No.	Parameter	Recorded Value [25/09/14]	Recorded Value [01/11/14]	Recorded Value [05/02/15]
1.	Dissolved Oxygen (D.O.) [in %/ppm]	3.4/0.29	2.3/0.21	4.9/0.4
2.	pH	7.6	6.6	6.9
3.	Electrical Conductivity (in µs)	1310	1102	1540
4.	Total Dissolved Solids (TDS) [mg/L]	640	439	790
5.	Turbidity	100	75	150
6.	Temperature [°C]	30.9	30.9	32
7.	Phosphate [mg/L]	>5	>5	>5
8.	Nitrate [mg/L]	1	1	2

Fig. No. 72 : Graph Showing Variation DO, pH, Phosphate And Nitrate Levels

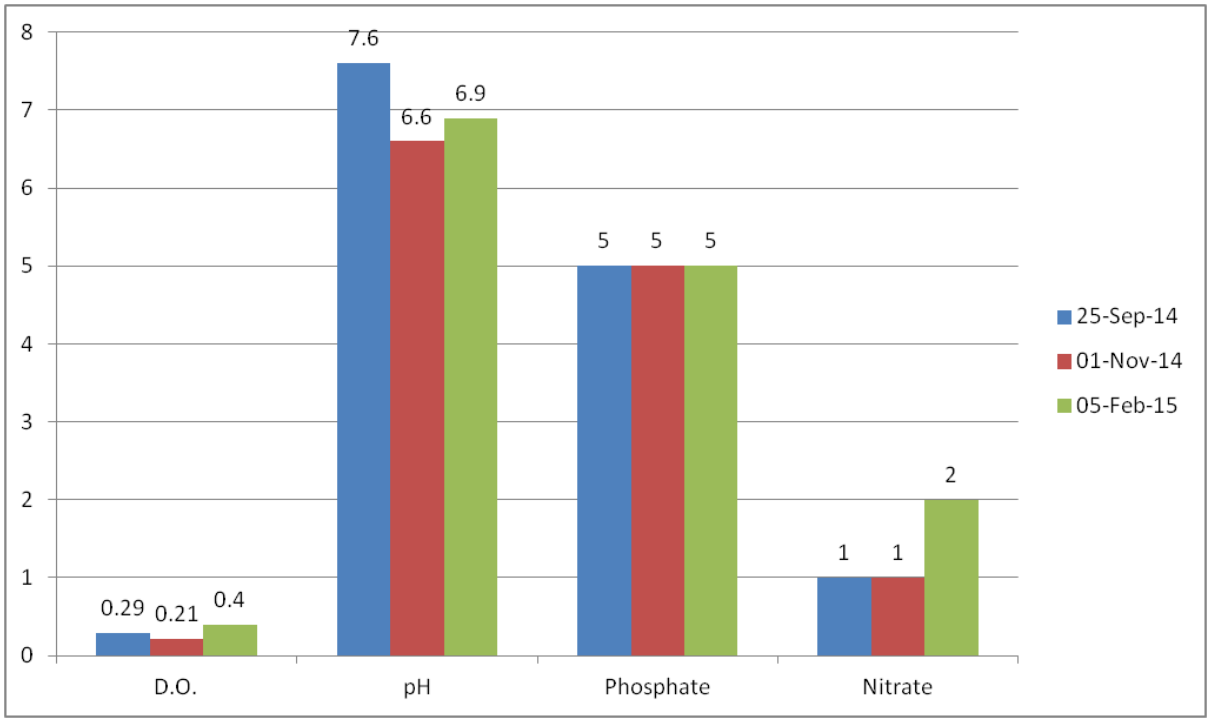
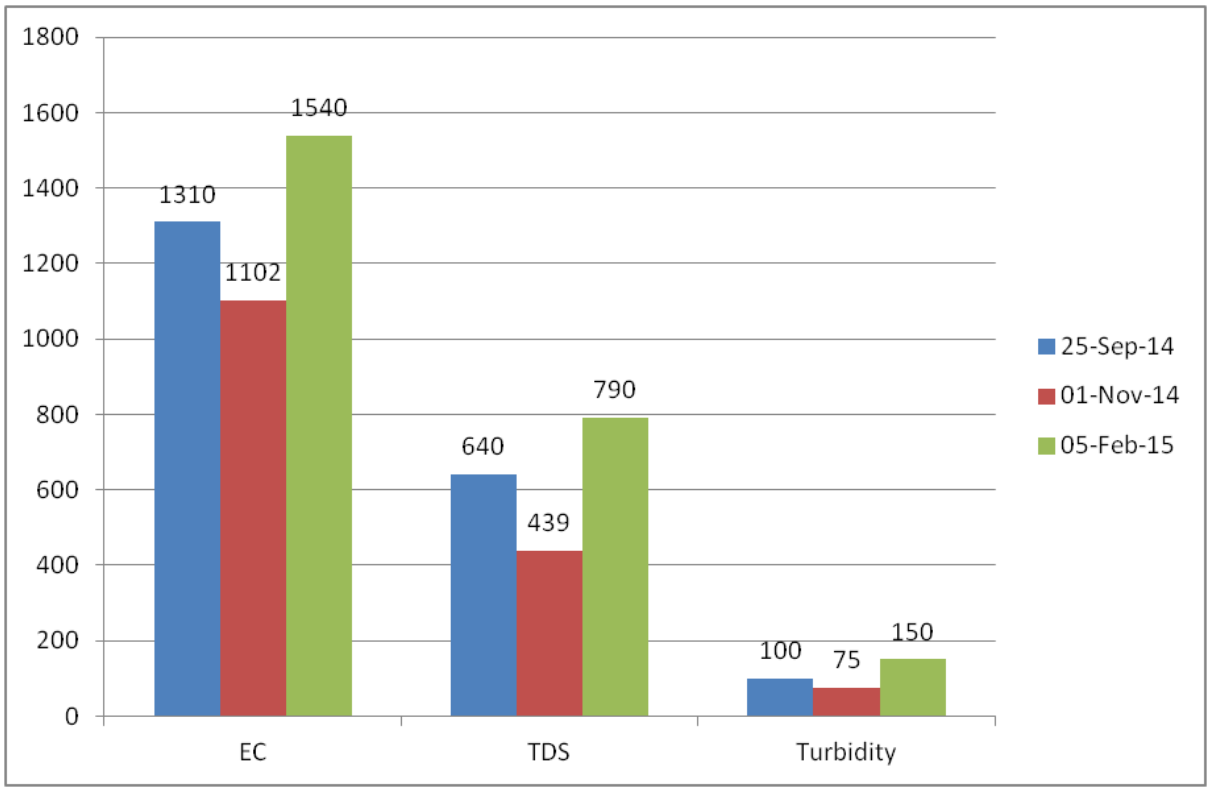


Fig. No. 73 : Graph Showing Variation Of EC, TDS And Turbidity Levels



Map No. 9 : Map of Yamuna River and its Flood plains at Okhla Area



STUDY SITE 5 : OKHLA AREA

62. 0 The Okhla site is accessible from different locations such as Okhla Sailing Club road, Batla House, from the Okhla Bird Sanctuary Gate located on Amrapali marg leading to NOIDA and from Abul Fazal road leading to Kalindi Kunj. The characteristic vegetation comprises of Acacia, Arundo, Saccharum, Phragmites, Ipomoea, Ricinus, etc. Fishing, small scale agriculture, grazing, harvesting of reeds and grasses, are important human activities observed at the site. Location of the site near Okhla barrage, wide River channel and water impoundment, presence of Okhla Bird Sanctuary and hence comparatively rich biodiversity were important factors to select it as study site downstream to Mayur vihar site.

63. 0 The flood plains of Yamuna at Okhla area are spread from Canal Colony to Kalindi Kunj [seen from Abul Fazal Road] and from Hindon Cut Canal to Okhla Bird Sanctuary across the River. Riparian vegetation is scarce on the Abul Fazal side with several spurs of 100 to 300 meters covered with Phragmites, Saccharum, Ricinus communis, Dhatura, Ipomoea, Goat Weed, Achyranthes aspera etc. The flood plain area is protected from trespassers with high iron bars parallel to the road till Kalindi Kunj.

64. 0 On the other side, Okhla Bird Sanctuary, along with a hook shaped bund, harbours rich vegetation and micro-faunal diversity. Intermittent patches of Typha, Phragmites, Giant Cane, Arundo donax, Saccharum were observed. The road on left afflux bund teems with several species of trees and shrubs and provides good habitat for birds. Water quality is poor with many stagnant and floating patches of Water Hyacinth. Waterbirds such as Purple Swamphen, Oriental Darter, Blackwinged Stilt, Kingfisher, Cormorants, Storks, Egrets were seen frequently during the winter season.

65. 0 Considered as one of the best sites for fishing in the past, Okhla is now visited by a few anglers from nearby areas. Fishing with dragnets or cast nets was not observed during the survey. Water logged in some depressions at the end of left afflux bund area is covered with duckweed. *Pistia stratiotes* [Jalkumbhi] was also observed at some places.

Fig. No. 74 : View Of Yamuna River From Okhla Bird Sanctuary [Date: 01/07/2014]



Fig. No. 75 : Yamuna As Seen From Sailing Club, Okhla [Date:23/05/2014]



Fig. No. 76 : Yamuna Floodplain At Dhobhi Ghat Near Jamia Nagar, Okhla [Date:23/05/2014]



Fig. No. 77 : Yamuna River And Its Floodplain Area As Seen From Toll Road. Dhobhi Ghat Area Is Visible In The Backdrop [Date: 27/08/2014]



a) FLORA

The flora-trees, herbs and shrubs observed at Jagatpur area are listed below:

Table No. 28 : List Of Trees

S.No.	Species	Common Name	Family
1.	*Cassia fistula*	Amaltas	Fabaceae
2.	*Acacia nilotica*	Babool/Kikar	Fabaceae
3.	*Dalbergia sissoo*	Shisham	Fabaceae
4.	*Ficus religiosa*	Peepal	Moraceae
5.	*Ziziphus mummularia*	Ber	Rhamnaceae
6.	*Albizzia lebbeck*	Siris	Fabaceae
7.	*Acacia auriculiformis*	Earpod Wattle	Fabaceae
8.	*Morus alba*	White Mulberry	Moraceae
9.	*Ailanthus excelsa*	Maharukh/Mahaneem	Simaroubaceae
10.	*Prosopis juliflora*	Vilaiti Keekar	Fabaceae
11.	*Phoenix sylvestris*	Wild Date Palm	Arecaceae
12.	*Mangifera indica*	Mango	Anacardiaceae
13.	*Ficus virens*	Pilkhan	Moraceae
14.	*Psidium Guavajava*	Guava	Myrtaceae
15.	*Leucaena leucocephala*	Subabool	Fabaceae
16.	*Eucalyptus spp.*	Safeda	Myrtaceae
17.	*Morus alba*	White Mulberry	Moraceae
18.	*Melia azedarach*	Bakain	Meliaceae
19.	*Syzygium cumini*	Jamun	Myrtaceae
20.	*Haplophragma adenophyllum*	Katsagon	Bignoniaceae
21.	*Delonix regia*	Gulmohar	Fabaceae
22.	*Pithecellobium dulce*	Jungle Jalebi	Fabaceae
23.	*Acacia modesta*	Phulai	Fabaceae
24.	*Grevillea robusta*	Silky oak	Proteaceae
25.	*Bergera Koinigii*	Kadi patta	Rutaceae
26.	*Azadirachta indica*	Neem	Meliaceae
27.	*Senna siamea*	Kassod	Fabaceae
28.	*Aegle marmilos*	Bel	Rutaceae
29.	*Butea monosperma*	Dhak	Fabaceae
30.	*Bahunia purpurea*	Kaniar	Leguminosae

Table No. 29 : List Of Shrubs/Herbs

S.No.	Species	Common Name	Family
1.	*Phragmites Karka*	Common Reed	Poaceae
2.	*Phyla nodiflora*	Frog Fruit	Verbenaceae
3.	*Ricinus communis*	Castor Oil Plant	Euphorbiaceae
4.	*Leucas chephalotes*	Gubbha	Lamiaceae
5.	*Mazus pumilus*	Asian Mazus, Japanese Mazus	Scrophulariaceae
6.	*Alternanthera philoxeroides*	Alligator Weed	Amaranthaceae
7.	*Malvastrum coromandelianum*	False Mallow	Malvaceae
8.	*Abutilon indicum*	Country Mallow	Malvaceae
9.	*Solanum indicum*	Common Indian Nightshade	Solanaceae
10.	*Dhatura innoxia*	Safed dhatura	Solanaceae
11.	*Pergularia daemia*	Pergularia	Asclepiadaceae
12.	*Ageratum conyzoides*	Goat Weed	Asteraceae
13.	*Cynodon dactylon*	Bermuda Grass	Poaceae
14.	*Setaria viridis*	Green Bristle Grass	Poaceae
15	*Sacharum spontaneum*	Kaans	Poaceae
16.	*Digera muricata*	False Amaranth, Lesua	Amaranthaceae
17.	*Cucumis melo*	Kharbuza, Musk melon	Cucurbitatceae
18.	*Stellaria media*	Chickweed	Caryophyllaceae
19.	*Coccinia Grandis*	Ivy Gourd	Cucurbitaceae
20.	*Chenopodium album*	Lamb's Quarter	Chenopodiaceae
21.	*Lantana camara*	Common Lanatana/Wild Sage	Verbenaceae
22.	*Parthenium hysterophorus*	Congress Grass	Asteraceae
23.	*Cyperus rotundus*	Nut Grass	Cyperaceae
24.	*Hibiscus hirtus*	Lesser White Mallow	Malvaceae
25.	*Typha spp.*	Elephant Grass	Typhaceae
26.	*Tridax procumbens*	Coat Buttons	Compositeae
27.	*Malva parviflora*	Cheese Weed	Malvaceae
28.	*Ipomea aquatica*	Water Spinach	Convolvulaceae
29.	*Achyranthes aspera*	Chirchita	Amaranthaceae
30.	*Arundo donax*	Giant Cane	Poaceae

Fig. No. 78 : Typha Spp. Inside Okhla Bird Sanctuary [Date: 20/08/2014]



Fig. No. 79 : Flower Of Coat Button Plant (*Tridax procumbens*) At Okhla Bird Sanctuary [Date: 20/08/2014]



Fig. No. 80 : Ivy Gourd [*Coccina grandis*] Inside Okhla Bird Sanctuary [Date: 01/07/2014]



Fig. No. 81 : Vegetation Communities At Yamuna Floodplains Of Okhla Bird Sanctuary [Date: 20/08/2014]



Fig. No. 82 : Duckweed Collected From Yamuna At Okhla Bird Sanctuary [Date: 20/08/2014]



Frequency

Table No. 30 : Frequency Table For Trees

S. No.	Species	Frequency	Relative Frequency
1.	*Cassia fistula*	0.3	2.5
2.	*Acacia nilotica*	0.7	5.83
3.	*Dalbergia sissoo*	0.8	6.67
4.	*Ficus religiosa*	0.5	4.17
5.	*Zizyphus mummularia*	0.5	4.17
6.	*Albizzia lebbeck*	0.4	3.33
7.	*Acacia auriculiformis*	0.3	2.50
8.	*Morus alba*	0.6	5.00
9.	*Ailanthus excelsa*	0.2	1.67
10.	*Prosopis juliflora*	0.3	2.50
11.	*Phoenix sylvestris*	0.5	4.17
12.	*Mangifera indica*	0.2	1.67
13.	*Ficus virens*	0.2	1.67
14.	*Psidium Guavajava*	0.3	2.50
15.	*Leucaena leucocephala*	0.5	4.17
16.	*Eucalyptus spp.*	0.7	5.83
17.	*Morus alba*	0.6	5.00
18.	*Melia azedarach*	0.7	5.83

19.	*Syzygium cumini*	0.4	3.33
20	*Haplophragma adenophyllum*	0.3	2.50
21.	*Delonix regia*	0.2	1.67
22.	*Pithecellobium dulce*	0.4	3.33
23.	*Acacia modesta*	0.2	1.67
24.	*Grevillea robusta*	0.2	1.67
25.	*Bergera Koinigii*	0.4	3.33
26.	*Azadirachta indica*	0.6	5.00
27.	*Senna siamea*	0.4	3.33
28.	*Aegle marmilos*	0.2	1.67
29.	*Butea monosperma*	0.3	2.50
30.	*Bahunia purpurea*	0.1	0.83
	Total	**12**	**100**

Table No. 31 : Frequency Table For Herbs/Shrubs

S. No.	Species	Frequency	Relative Frequency
1.	*Phragmites Karka*	0.4	3.10
2.	*Phyla nodiflora*	0.5	3.88
3.	*Ricinus communis*	0.4	3.10
4.	*Leucas chephalotes*	0.2	1.55
5.	*Mazus pumilus*	0.2	1.55
6.	*Alternanthera philoxeroides*	0.7	5.43
7.	*Malvastrum coromandelianum*	0.2	1.55
8.	*Abutilon indicum*	0.6	4.65
9.	*Solanum indicum*	0.4	3.10
10.	*Dhatura innoxia*	0.3	2.33
11.	*Pergularia daemia*	0.2	1.55
12.	*Ageratum conyzoides*	0.7	5.43
13.	*Cynodon dactylon*	0.9	6.98
14.	*Setaria viridis*	0.7	5.43
15.	*Sacharum spontaneum*	0.4	3.10
16.	*Digera muricata*	0.3	2.33
17.	*Cucumis melo*	0.2	1.55
18.	*Stellaria media*	0.6	4.65
19.	*Coccinia Grandis*	0.2	1.55
20.	*Chenopodium album*	0.8	6.20
21.	*Lantana camara*	0.5	3.88
22.	*Parthenium hysterophorus*	0.7	5.43
23.	*Cyperus rotundus*	0.3	2.33
24.	*Hibiscus hirtus*	0.3	2.33
25.	*Typha spp.*	0.4	3.10
26.	*Tridax procumbens*	0.3	2.33

27.	*Malva parviflora*	0.2	1.55
28.	*Ipomea aquatica*	0.4	3.10
29.	*Achyranthes aspera*	0.6	4.65
30.	*Arundo donax*	0.3	2.33
	Total	**12.9**	**100**

Fig. No. 83 : Bar Graph Showing The Representation Of Various Tree Species At Okhla

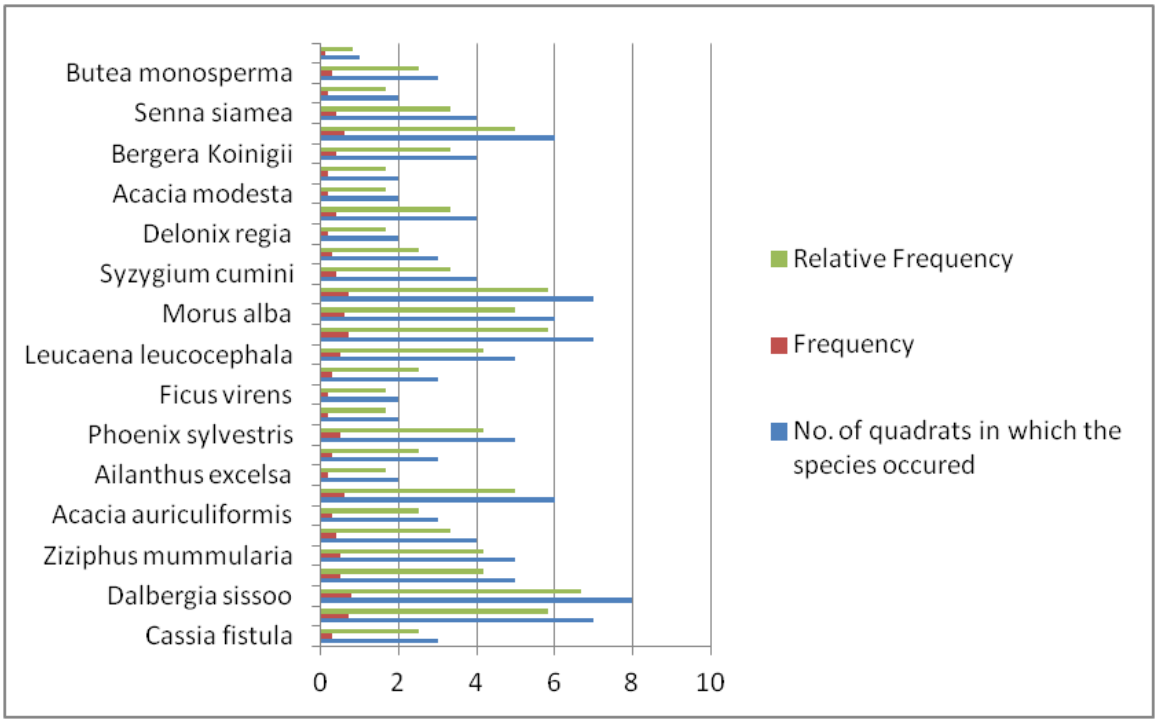
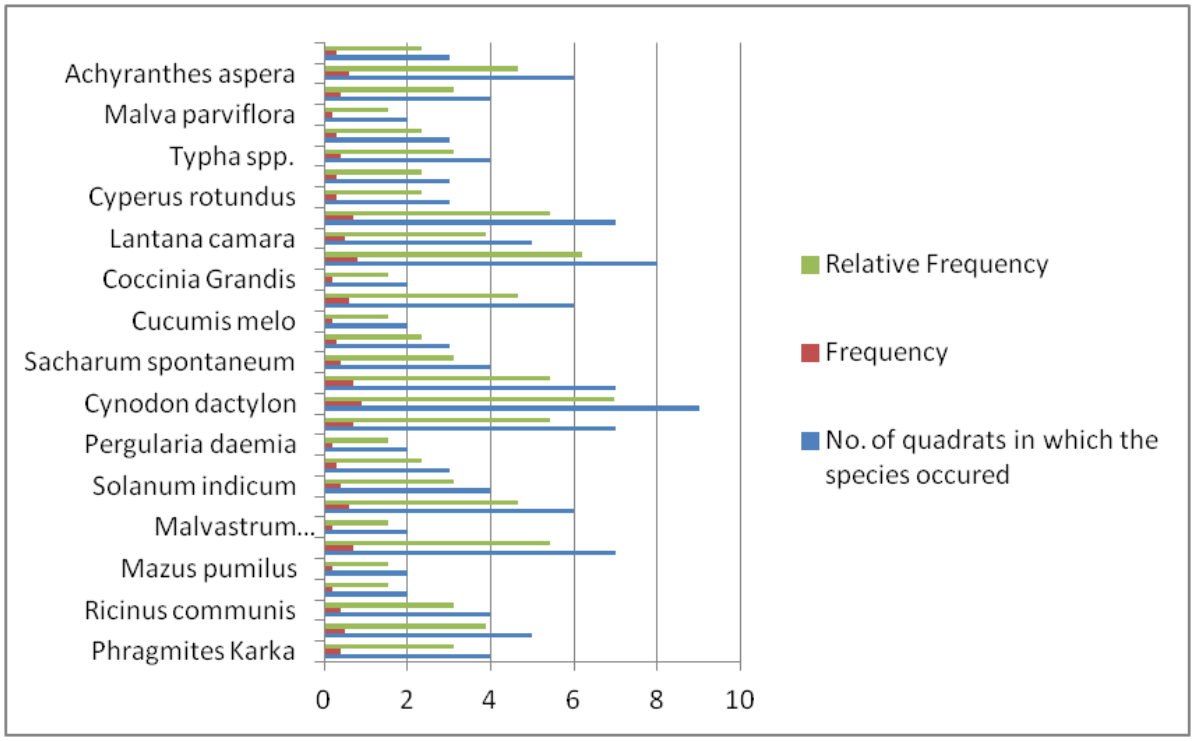


Fig. No. 84 : Bar Graph Showing The Representation Of Various Herb/Shrub Species At Okhla



b) FAUNA

66. 0 Nilgai (Boselaphus tragocamelus), Indian Palm Squirrel (Funambulus palmarum), Indian Grey Moongose (Herpestes edwardsii), Garden Lizard (Calotes versicolor) were sighted during surveys at Yamuna flood plains. Indian Monitor Lizard (Varanus bengalensis) and Indian Jackal (Canis aureus indicus) are known to present and roam inside Okhla Bird Sanctuary area according to local people. Many insect species were also sighted during the study period. Most common were Dragonflies and Damselflies (Order: Odonata). Grasshoppers and Crickets (Order: Orthoptera), Stick insects and Leaf insects (Order: Phasmatodea), Butterflies and Moths (Order: Lepidoptera).

List of Birds

The following birds were sighted at Yamuna flood plains of Okhla during the study period.

Table No. 32 : List Of Birds

S. No.	Species	Scientific Name
1.	Red-vented Bulbul	*Pycnonotus cafer*
2.	Oriental Magpie Robin	*Copsychus saularis*
3.	Shikra	*Accipiter badius*
4.	Common Hoope	*Upopa epops*
5.	Rock Pegion	*Columba livia*
6.	Jungle Babbler	*Turdoides striatus*
7.	Rose-ringed Parakeet	*Psittacula krameri*

8.	Green Bee-eater	*Merops orientalis*
9.	Asian Koel	*Eudynamys scolopacea*
10.	Indian Robin	*Saxicoloides fulicatus*
11.	Brown Rockchat	*Cercomela fusca*
12.	Purple Sunbird	*Cinnyris asiaticus*
13.	House Sparrow	*Passer domesticus*
14.	Black Kite	*Milvus migrans*
15.	Common Myna	*Acridotheres tristis*
16.	Barn Swallow	*Hirundo rustica*
17.	Painted Stork	*Mycteria leucocephala*
18.	Common Myna	*Acridotheres tristis*
19.	Great Cormorant	*Phalacrocorax carbo*
20.	Little Cormorant	*Phalacrocorax niger*
21.	Cattle Egret	*Bubulcus ibis*
22.	Great Egret	*Ardea alba*
23.	Purple Swamphen	*Porphyrio Porphyrio*
24.	White-throated Kingfisher	*Halcyon smyrmensis*
25.	Purple Heron	*Ardea purpurea*
26.	Grey Heron	*Ardea cinerea*
27.	Eurasian Collared Dove	*Streptopelia decaocto*
28.	White-browed Wagtail	*Motacilla maderaspatensis*
29.	Redwattled Lapwing	*Vanellus indicus*
30.	Whitebreasted Waterhen	*Amaurornis phoenicurus*
31.	Blackwinged Stilt	*Himantopus himantopus*
32.	Oriental Darter	*Phalacrocorax carbo*
33.	Asian Pied Starling	*Sturnus contra*
34.	Common Coot	*Fulika atra*

Fig. No. 85 : Asian Pied Starling [*Sturnus contra*] On Water Hyacinth Patch At Okhla Bird Sanctuary [Date: 01/07/2014]



Fig. No. 86 : Oriental Darter [*Phalacrocorax carbo*] And Water Hyacinth In Backdrop [20/08/2014]



Fig. No. 87 : Grasshopper At Okhla Bund Near Kalindi Kunj [Date: 01/07/2014]



Fig. No. 88 : Truebug On The Leaf Of Chenopodium Album Okhla Bund Near Kalindi Kunj [Date: 01/07/2014]



Fig. No. 89 : Damselfly Coromandel Marsh Dart [*Ceriagron coromandelianum*] At Okhla Bird Sanctuary [Date: 01/07/2014]



Fig. No. 90 : Indian Bull Frog [*Hoplobatrachus tigerinus*] At Yamuna -Near DND Flyway [Date: 27/08/2014]



Fig. No. 91 : Cyclops Collected From Okhla [Date: 01/09/2014]

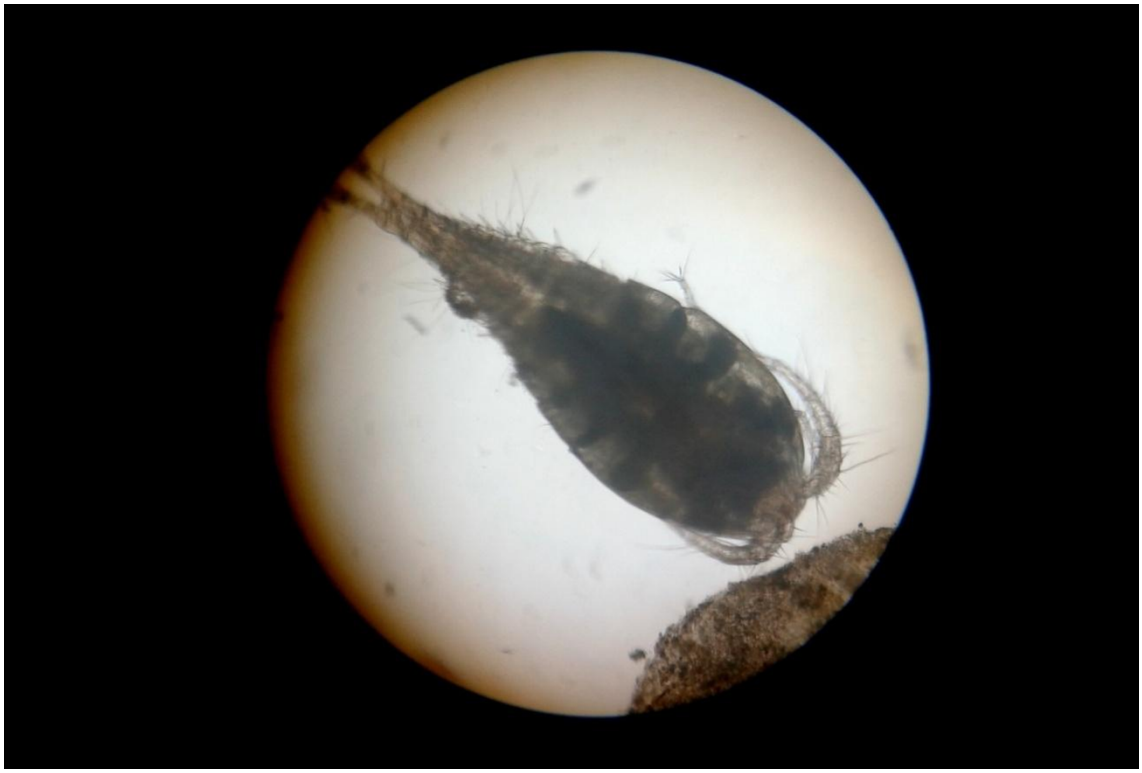
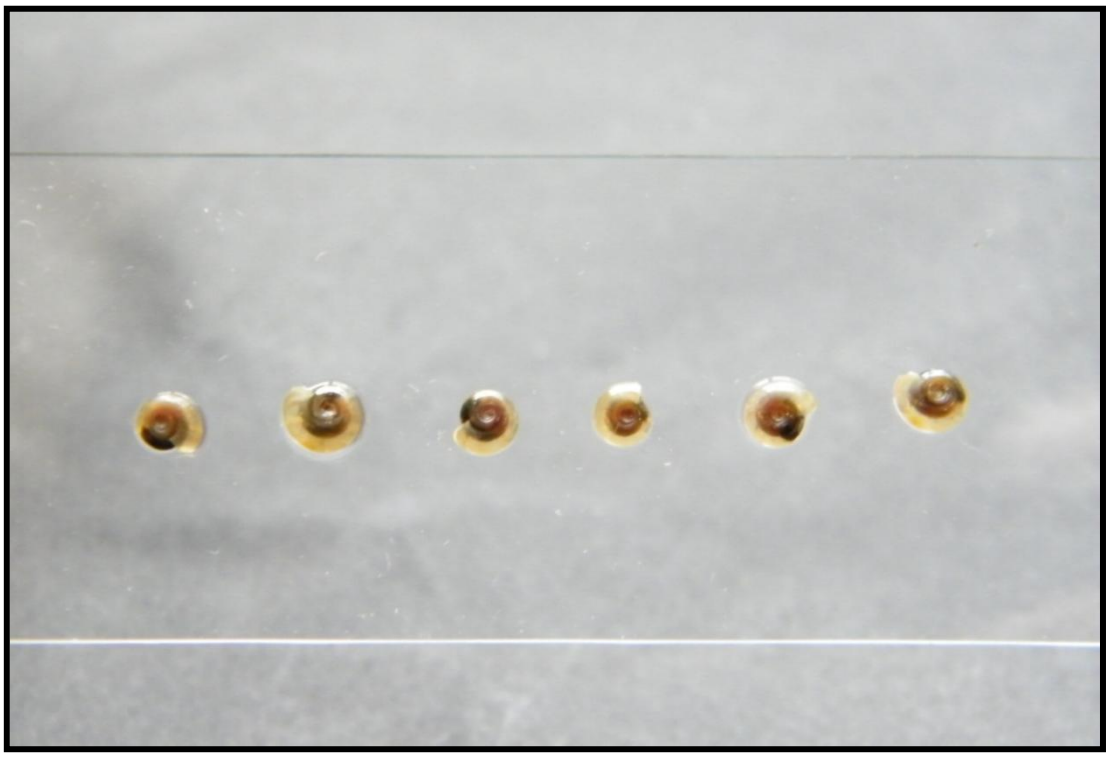


Fig. No. 92 : Insects Collected From Yamuna Waters At Okhla [Date: 01/09/2014]



Fig. No. 93 : Rams Horn Snails Collected From Yamuna Waters At Okhla [Date: 01/09/2014]



c) WATER QUALITY

67. 0 Water quality data of three seasons is devided into months July-Sept, 2014; Oct-Dec, 2014; Jan-Feb, 2015, for the convenience of analysis.

Table No. 33 : Water Quality At Okhla

S.No.	Parameter	Recorded Value [27/08/14]	Recorded Value [28/11/14]	Recorded Value [23/01/15]
1.	Dissolved Oxygen (D.O.) [in %/ppm]	6/0.5	3.5/0.30	5.2/0.4
2.	pH	5.2	4.9	5.3
3.	Electrical Conductivity (in μs)	1048	1310	1630
4.	Total Dissolved Solids (TDS) [mg/L]	560	640	790
5.	Turbidity	150	100	150
6.	Temperature [˚C]	33.9	30.9	33.5
7.	Phosphate [mg/L]	>5	>5	>5
8.	Nitrate [mg/L]	1-2	1	2

Fig. No. 94 : Graph Showing Variation of DO, pH, Phosphate and Nitrate Levels

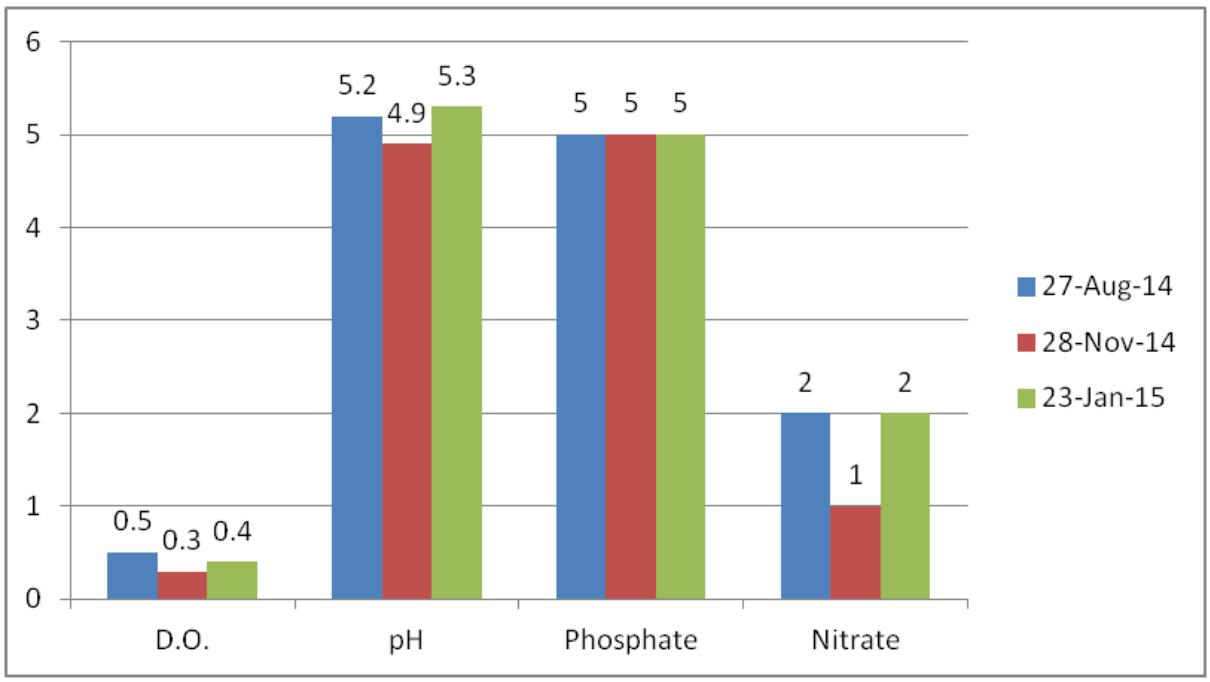
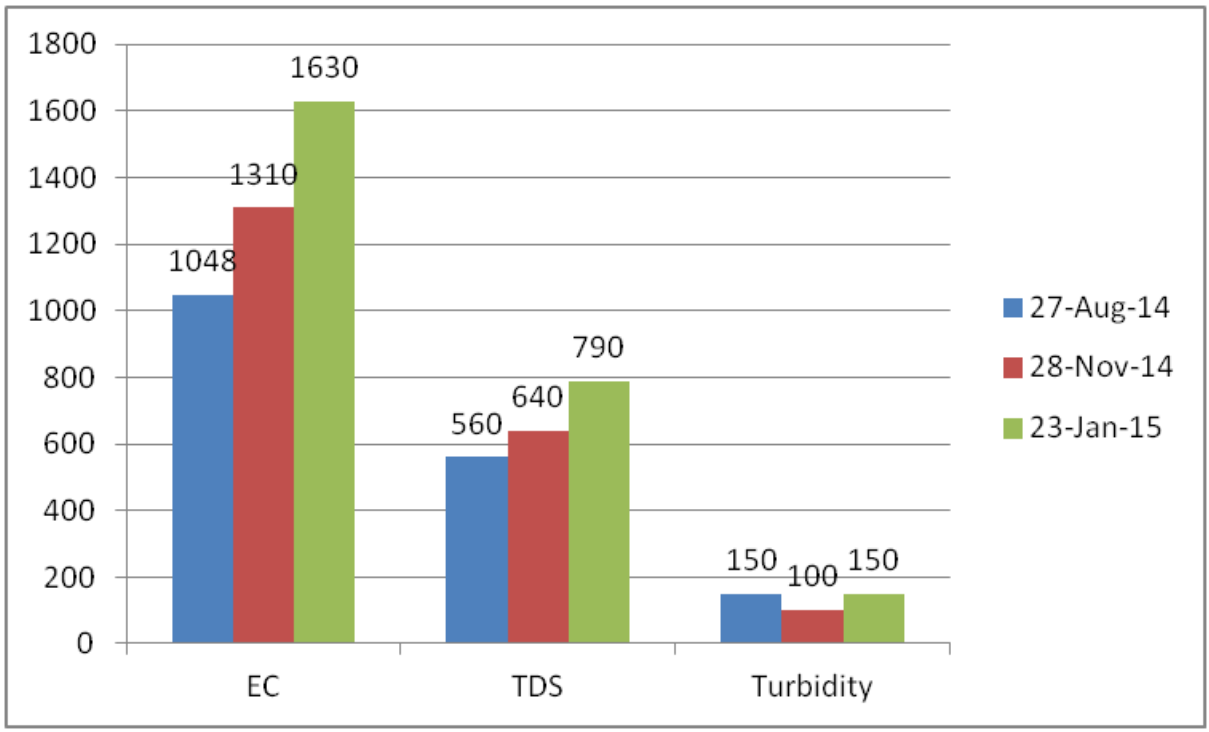


Fig. No. 95 : Graph Showing Variation Of EC, TDS And Turbidity Levels



FISH SURVEY AND DIVERSITY

68. 0 A baseline survey was conducted to assess current fish diversity present in Yamuna River in NCT Delhi. Survey was conducted in two phases viz. Wazirabad to ITO Barrage to cover downstream area in the first phase and Wazirabad to Palla to cover upstream area in the second phase.

69. 0 During phase 1, cast net was thrown at sites: Kursia Ghat, Jamuna Bazaar, Gandhi Nagar, Geeta Colony opposite SDM office (or Kishankunj site), ITO Barrage. Most of the attempts were void indicating absence of fish as quality of water degrades towards downstream. The presence of *Clarias gariepinus* [African Catfish] locally known as Manghur was ascertained at Geeta Colony site opposite SDM office by fisherman. Seven specimens varying in size were collected. The specimens were measured using a standard measurement scale.

Table No. 34 : Body Measurement Of The Seven Specimens Of Manghur Collected From Yamuna At Geeta Colony

	Standard Measurement (In Inch)						
Specimen No. [*Clarias gariepinus*]	Standard Length	Total Length	Head Length	Snout Length	Jaw Length	Pectoral Fin	Pelvic Fin
Specimen 1	24	27	4	1.5	2	2.5	2.5
Specimen 2	21	24	4	1	1.5	2.5	2.25
Specimen 3	24	27	4	1	1.5	3	2
Specimen 4	25	28	4.5	1.5	1.75	3	3
Specimen 5	24	28	4.5	1.5	2	3.5	2.25
Specimen 6	18.5	21	3	1.25	1.5	2	1.75
Specimen 7	19	22	4	1.25	1	2.5	2

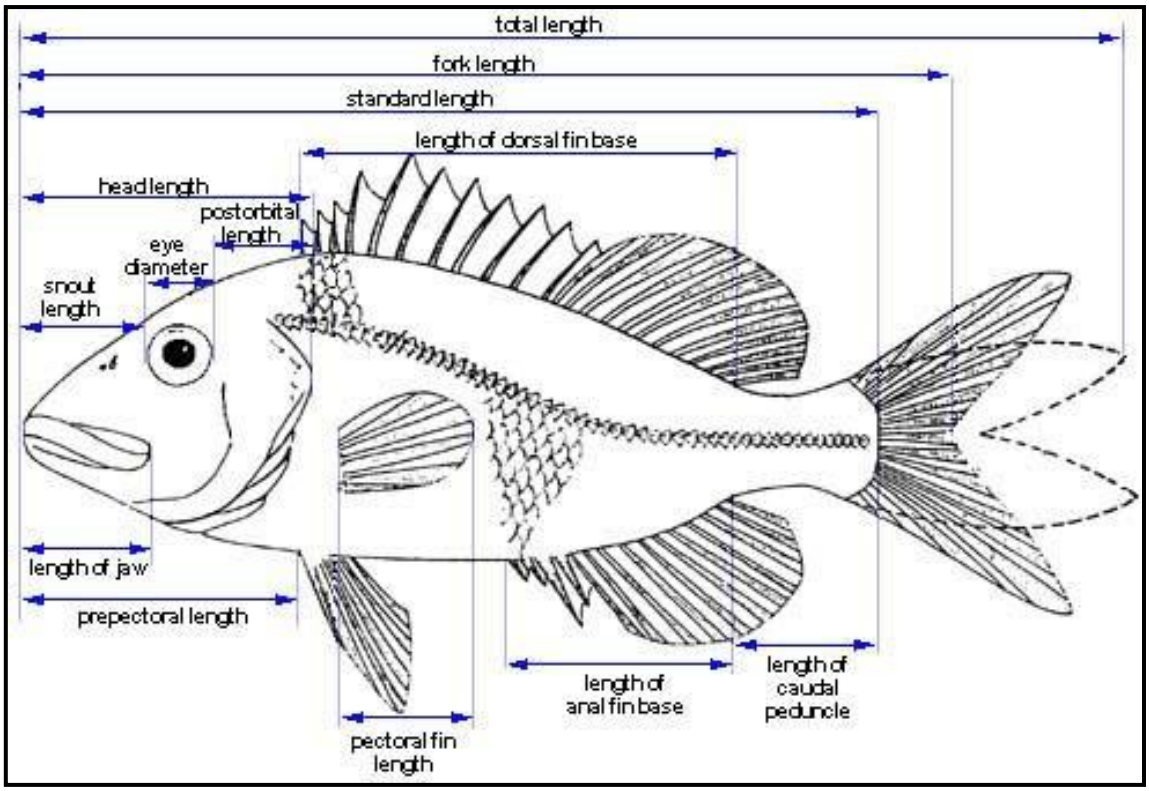
70. 0 The weight of the above specimen varied between 3-5 kg approimately. Clarias gariepinus [Burchell, 1822] belongs to family Clariidae and attains maximum total length of 170 cm and maximum weight of 60 Kg. [Froese and Pauly, 2015][16]. The species has wide distribution across the globe and is considered least concern [LC][17]. It prefers variety of habitats varied from shallow and swampy areas with a soft muddy substrate and calmer water to fast flowing Rivers and in rapids and are widely tolerant of extreme environmental

[16] Froese, R. and D. Pauly. Editors. 2015.FishBase. World Wide Web electronic publication. www.fishbase.org, (02/2015)

[17] IUCN Red List [Freyhof, J. 2014. Clarias gariepinus. The IUCN Red List of Threatened Species. Version 2014.3. <www.iucnredlist.org>. Downloaded on 17 April 2015.

conditions18. On local scale, fish movements are effected by changing gradients of resource availability such as shelter or food, or abiotic conditions, such as salinity, current velocity or dissolved oxygen. Local movements associated with ontogeny are a major feature of the life histories of many freshwater, estuarine, and marine fish worldwide[19].

Fig. No. 96 : Diagram Illustrating Standard Measurements Of A Bony Fish
[Source: Florida Museum Of Natural History]



[18] *Clarias gariepinus* (Burchell, 1822). Fisheries and Aquaculture Department, FAO [Retrieved on 15th Feb, 2015]
[19] Winemiller K.O. & Jepsen D.B. (1998) Effects of seasonality and fish movement on tropical River food webs. *Journal of Fish Biology* 53 (Supplement A), 267–296 Article No. jb980832

Fig. No. 97 : African Catfish [*Clarias gariepinus*] Collected From Yamuna At Geeta Colony Area [Date: 08/12/2014]



71. 0 During the second phase, cast net was deployed at several sites from Palla to Wazirabad. Several individuals of Common Carp (*Cyprinus carpio*) and Tilapia (*Oreochromis mossambicus)* were caught. Species of fish such as Tiger Fish, and Glass Fish were also seen with fisherman at Jagatpur Bund near Wazirabad. Common carp belongs to family Cyprinidae and attains a maximum length of 120 cm varying mostly between 25-36 cm at maturity stage; and maximum weight reaches 40.1 kg. The colour of the body of Common Carp varies from gray through silver to bronze with a yellowish or reddish belly. Common carp has one long dorsal fin, which possesses 2–3 hard, and 17–22 soft rays. The first (largest) hard ray is sharp and is serrated on its posterior margin. Additional morphological characteristics include 2–3 anal spines, 5–6 anal rays and 36–37 vertebrae [Froese and Pauly, 2015][20]. *Oreochromis mossambicus* [Tilapia] belongs to family Cichlidae and attains a maximum length of 39.0 cm and maximum weight of 1.1 kg. [Froese and Pauly, 2015]. Species name of other fish such as Tiger and Glass Fish observed with fisherman could not be ascertained.

72. 0 In a recent study[21] National Bureau of Fish Genetic Resources, Lucknow (2014) reports that there are 63 fish species present in its waters, which belonged to eight orders, 18 families, 39 genuses. The local fish species were grouped as Indian major carps (Catla catla, Labeo rohita and Cirrhinus mrigala) among others. The alien invasive fish species were identified as *Cyprinus carpio Var. communis, C. carpio var. specularis* among others.

[20] Froese, R. & Pauly, D. (eds.). 2015. FishBase. World Wide Web electronic publication, version (02/2015)

[21] Neetu Chandra Sharma, Alien species displacing local fish in the Yamuna, Mail Online India [13 October 2014], Retrieved from http://www.dailymail.co.uk/indiahome/indianews/article-2791511/alien-species-displacing-local-fish-yamuna.html on 16th December, 2014

Table No. 35 : List of Local and Invasive Species of Fish

S.No.	Local Fish Species
1.	*Catla catla* (Katla)
2.	*Labeo rohita* (Rohu)
3.	*Cirrhinus mrigala* (Mrigal)
4.	*Wallagu attu* (Malli)
5.	*Sperata spp.*
6.	*Clupesoma garua* (Bacha)
7.	*Rita Rita* (Rita, Khagga Cheki)

S.No	Invasive Alien Species
1.	*Cyprinus carpio var. communis* (Common Carp)
2.	*Cyprinus carpio var. specularis* (Common Carp)
3.	*Carassius auratus* (Gold Fish)
4.	*Oreochromis niloticus* (Tilapia)
5.	*Oreochromis mossambicus* (Tilapia)
6.	*Clarias gariepinus* (Cat Fish)
7.	*Aristichthys nobilis* (Bighead Carp)
8.	*Hypopthalmichth* (Silver Carp)
9.	*Ctenopahyn godon idella* (Grass Carp)
10.	*Gambusia affinis* (Western Mosquitofish)

73. 0 During the survey we observed that the fish catch was exteremly low. Standard method for assessing diversity and frequency of fish species and richness is Catch Per Unit Effort (CPUE) - it is an indirect measure of the abundance of a target species. In Phase I (Wazirabad to ITO - the polluted stretch) of survey the the CPUE at Kursia Ghat, Jamuna Bazaar, Gandhi Nagar and ITO Barrage was zero. At Geeta Colony only one species was captured - *Clarias gariepinus* with a CPUE of 0.2. Upstream, near Palla, *Cyprinus carpio* was captured - CPUE 0.03; at Jhangola *Cyprinus carpio* was captured with a CPUE of 0.03 and at Jagatpur bandh *Oreochromis mossambicus* was captured with CPUE of 0.03.

Fig. No. 98 : Common Carp [*Cyprinus carpio*] At Wazirabad Barrage [Date: 08/12/2014]



Fig. No. 99 : Tilapia [*Oreochromis mossambicus*] At Wazirabad Barrage [Date: 08/12/2014]



Fig. No. 100 : Tiger Fish From Yamuna At Jagatpur Bund Near Wazirabad [Date: 18/12/2014]

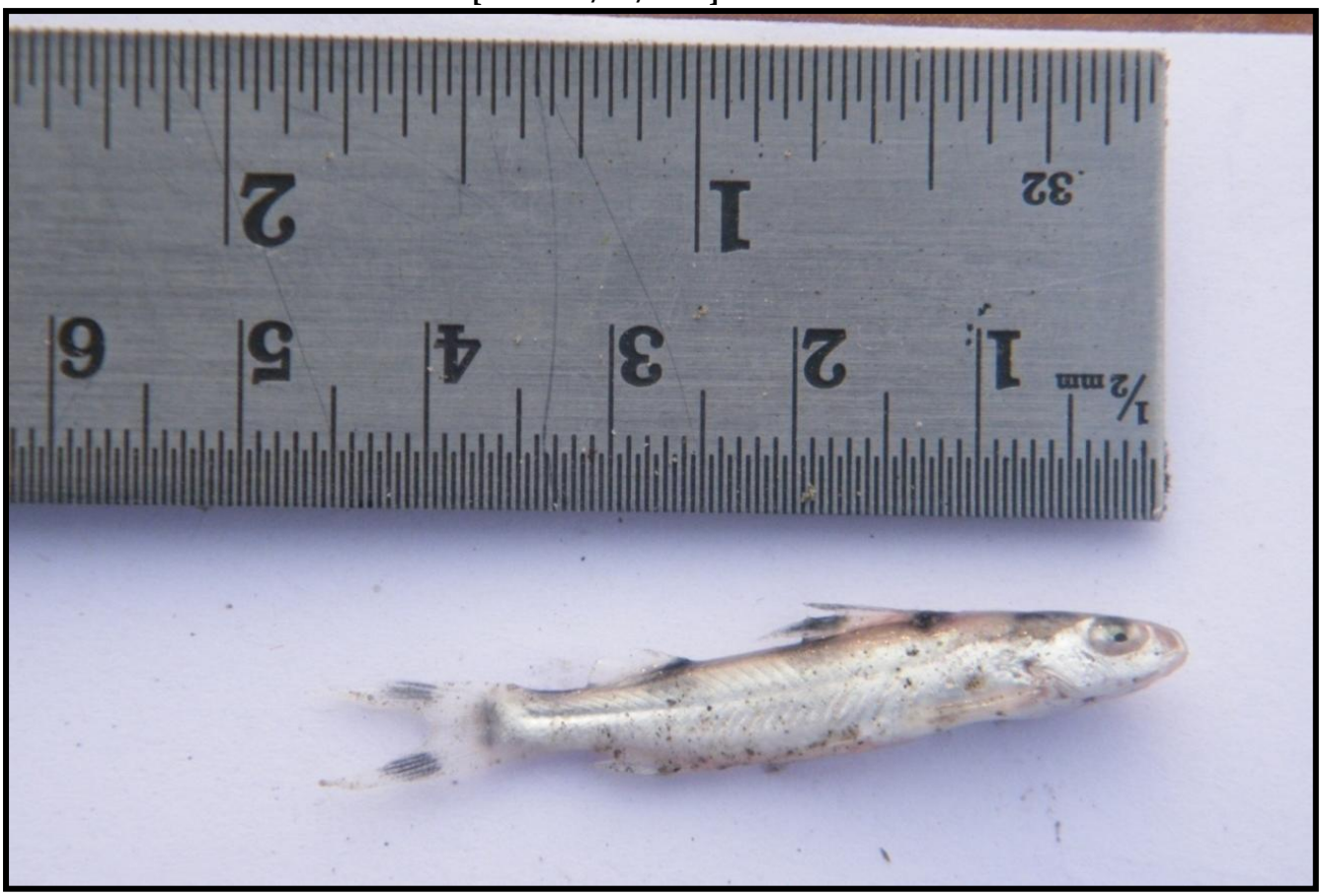


Fig. No. 101 : Glass Fish From Yamuna At Jagatpur Bund Near Wazirabad [Date: 18/12/2014]

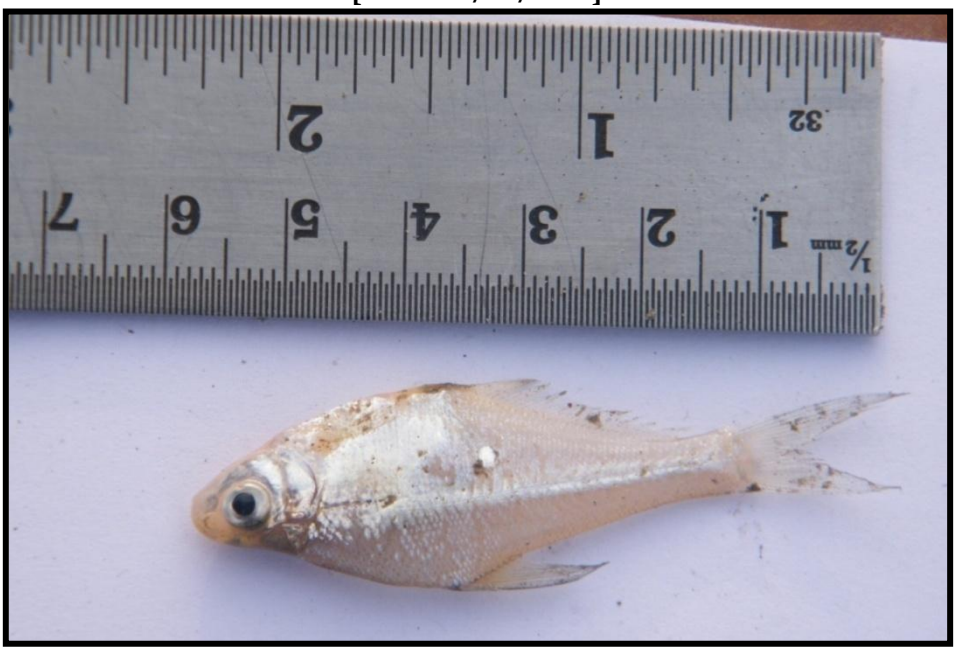


Fig. No. 102 : Tilapia [*Oreochromis mossambicus*] From Yamuna, Jagatpur Bund Near Wazirabad [Date: 18/12/2014]



Fig. No. 103 : Juvenile Eel Collected From Pond Krishan Kunj Near ITO [28/10/2014]



Socio - Ecological Observations

Fig. No. 104 : Sand Beds of Yamuna From Wazirabad To Palla Area Are Linked With Livelihoods Of Hundreds Of Fisherman And Local People [Date: 18/12/2014]



Fig. No. 105 : Fisherman Drying Their Fishing Nets On Flood Plains Of Jhangola Area Of Yamuna River [Date: 18/12/2014]



Fig. No. 106 : A Locally Made Fishing Net Showcases The Traditional Fishing Technique Used By Fishermen Near Jhangola Area Of River Yamuna In Delhi [Date: 18/12/2014]



Fig. No. 107 : Fishermen With A Dragnet And Holding Catfish Species At Jagatpur Bund Near Wazirabad [Date: 07/07/2014]



Fig. No. 108 : A Fisherman Casting His Fishing Net Near Wazirabad Barrage [Date:08/12/2014]



Fig. No. 109 : A Fisherman Holding His Catch -Catfish Near Wazirabad Barrage [Date : 08/12/2014]



Fig. No. 110 : A Locally Made Structure By Garbage Collectors At Yamuna Flood Plain Near ITO Area [Date: 08/12/2014]

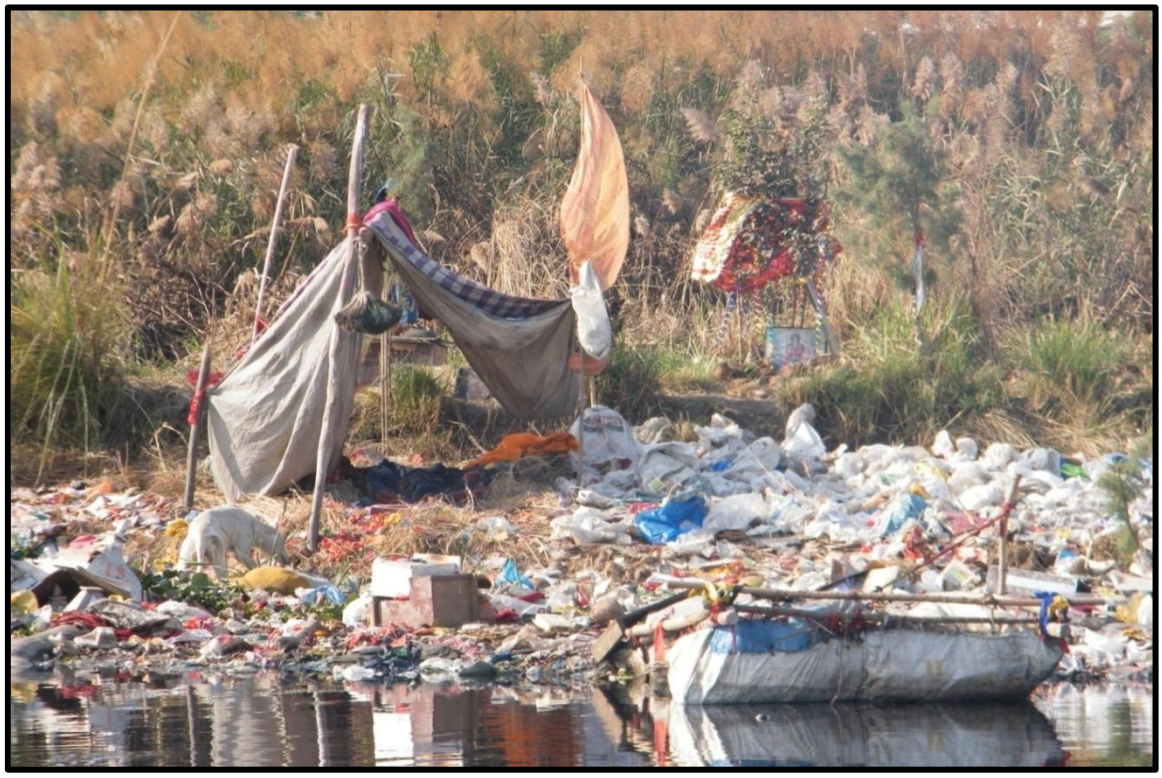


Fig. No. 111 : Obstruction Made By Using A Rope To Collect Garbage By Garbage Collectors Near Qudsia Ghat [Date : 08/12/2014]



Fig. No. 112 : A Child Collecting Waste From The River Near Geeta Colony
[Date : 08/12/2014]



Fig. No. 113 : Statue Installed By Worshippers Near Wazirabad Barrage
[Date : 08/12/2014]



Fig. No. 114 : Watermelons Grown On The Flood Plains Of Yamuna At Jagatpur Bund [Date : 08/12/2014]



Fig. No. 115 : Local People Feeding Seagulls Near Temple Of Jagatpur Village [Date : 04/02/2015]



Local Narratives of the River

Narrative : 1

74. 0 In our times, Jamuna river used to flow with full course and local inhabitants often come for fishing. The catch was very productive at that time. The fishing license provided by Fisheries Dept. would cost cheaper in our times recalls Rahim while angling near toll road which goes towards Maharani Bagh from Mayur Vihar. Now a days the fish variety as well as quality has reduced to a greater extent with a few varieties remaining such as Tilapia (*Oreochromis spp.*), Carp (*Cyprinus carpio*), Maanghur (*Clarias gariepinus*) etc. He has mastered the art of recognising the fish presence through different sounds and activities in water. The catch results depend on the presence of fish in waters on any particular day.

Fig. No. 116 : Rahim narrating the Yamuna's past while angling near toll road Mayur Vihar



Narrative : 2

75. 0 Gaffar Ali, a local who resides nearby Wazirabad often comes for fishing. According to him, the upstream waters still fetch him comparatively healthy fish varieties. Delving back into his memories, he recalls how they were connected with the River during their childhood. "The River was an integral part of our life. We would come for fishing with our locally made fishing rods and if not fishing, we would play around the stream whole day. The flood plains were more like forest areas with large no. of trees and wild bushes. With time they got converted into agricultural fields"

Fig. No. 117 : Gaffar Ali Showing His Catch Common Carp While Fishing At Yamuna Bank Near Wazirabad



Narrative : 3

76. 0 Chanderpal who rows boats for various rescue operations has seen every nook and corner of Yamuna in Delhi-NCR region. "No wonder Yamuna in Delhi is just a drain with lots of sewage being discharged from the capital. I enjoy boating in Yamuna during monsoons when quality gets improved with increased flow of water," says Chanderpal. He can recognise many of the fish species and their activities.

Fig. No. 118 : Chanderpal Rowing Motorboat While Surveying The Yamuna River Near Old Yamuna Railway Bridge



Narrative : 4

77. 0 Mr. B.P Upadhyay, Incharge, Fisheries Extension Office shared his experiences and provided historical insights of River Yamuna in Delhi. According to him, fishing was the most sought after leisure activity and hobby of many people in Delhi. Okhla was the most favourite spot and fishing passes were as cheap as Rs 1. "There were many local varieties of fish such as Rohu, Singhi, Saul, Gonch Kalbons etc but today you rarely find one of them" says Updhyay. 'At present if you go for fishing, you would end up mostly three species, which have dominated the water ecosystem of Yamuna in Delhi. They are African Manghur (*Clarias gariepinus*), Tilapia (*Oreochromis mossambicus*), and Common Carp (*Cyprinus carpio var. communis*). In our times, water was much cleaner and the River used to flow with full course,' he added.

Narrative : 5

78. 0 Chhote Lal, a local at Mayur Vihar Ghat recalls the earlier condition and life at flood plains of Yamuna in Delhi. He narrated with excitement how local boats were used to take people from across the River. Fishing was the most preferred activity at that time. Wazirabad, Nigambodh Ghat, Qudsia Bagh, Okhla were some identified and popular sites. Pointing to the water quality of Yamuna, he said with a mischievous smile, "In our times swimming in Yamuna was more preferred by me and my friends over taking bath at home". Entire Yamuna was a rural landscape with forests, agriculture fields, farmers, livestock, boats, vegetable vendors. Everything has changed with the passage of time.

Discussion

The present study provides the following major insights:

Riparian vegetation:

79. 0 Floodplain areas at some sites have very little vegetation cover or are devoid of riparian vegetation which forms an essential part of a River ecosystem. Sites such as Mayur Vihar ghat, Gandhi Nagar Pushta, parts of landscape near ITO and much part of the flooplains beyond Wazirabad upto Palla and Jhangola area open landscapes with agriculture fields touching the bank of the River.

80. 0 In another observation, the riparian vegetation was found to exhibit stratification at some sites such as near ITO ghat and Okhla i.e species differ in height and strata was readily recognised at flood plain areas. Owing to fewer disturbances, the vegetation communities get full opportunity to thrive and the stratification is clearly visible. This phenomenon is mentioned above in the landscape observations of ITO Ghat section of the report. Flood plain areas, which are devoid of riparian vegetation or have intermittent vegetation cover, should be restored. Riparian vegetation on the edges preferably upto 50 meters is recommended. Riparian vegetation helps support biodiversity by providing food and forage to many aquatic and terrestrial birds, insects, butterflies and various other living organisms. Species of plants characteristic to Yamuna flood plains such as Typha, Phragmites, Tamarix, Giant Cane, Saccharum are recommended for restoration initiatives.

Floodplains:

81. 0 At present, there is limited flood plain area left for inundation due to ever-increasing encroachments. River floodplains are areas for ground water recharge. Appreciation of floodplain area as a vital component of a River ecosystem by public as well as govt. authorities is important. Floodplain wetlands and ponds play a significant role as breeding and spawning grounds of Riverine fish species and their restocking into the system. Therefore, it should be understood that small waterbodies formed in depressions along the Yamuna are integral part of the River. As per observations, migratory birds such as Red-crested pochards, Bar-headed geese etc. were seen foraging in such waterbodies during most of the visits to Jagatpur Bund. Painted storks, Oriental darter, Little Grebe etc were the resident birds frequenting the River and its floodplains. Such small water bodies retain sufficient food throughout the year and exhibit comparatively better water quality. Seasonal flood pulses[22] ensures ecosystem integrity by providing habitats for species to survive unfavorable conditions. Morover, the trees and emergent macrophytes offer nesting sites and a certain degree of protection. Many nests were observed on the trees along the Wazirabad road that leads to Jagatpur village, Yamuna Biodiversity Park (phase-2) and Jagatpur bund road that leads to the River. Map No. 10 shows the locations of the observed nesting sites.

82. 0 Disposal of idols/ statues and remnants of religious ceremonies [generally thrown in polybags] on floodplains especially at ghats is a major solid waste pollution source. Pragmatic solutions are required to change people's attitude towards River by suggesting doable alternatives.

83. 0 Documentation of floodplain's socio-ecological systems and livelihoods should be carried out which would enable scientists and policy makers to understand the complex River systems in urban landscapes. The findings would eventually help in making inclusive conservation action plans.

[22] Flood pulse: The pricipal driving force responsible for the existence of the major biota in the River flood plain systems. Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood plain concept in the River-flood plain systems, p. 110-127. *In* D.P. Dodge [ed.] Proceedings of the International Large River Symposium. Can. Spec. Publ. Fish. Aquatic. Sci. 106

Map No. 10 : Map Showing Trees With Nest Along The Wazirabad Road
[Basemap Source : Here Maps]



Fig. No. 119 : Tree with Several Nests On The Wazirabad Road Leading To Jagatpur Village



Fig. No. 120 : Tree With Nests Of Weaver Bird On Jagatpur Bund Road



Map No. 11 : Showing Waterbodies Formed As A Result Of Depression Along Yamuna River in NCT Delhi



Biodiversity/Species

84. 0 While species inventorisation on the above-mentioned sites gives preliminary record of species and communities, a comparison with the earlier records mentioned in the Gazetteers of 1883-4, 1912, and 1976, indicate high level of habitat fragmentation on the Yamuna floodplains. Most of the floodplain area has now been converted to agricultural lands and the local people now consider any sort of wild riparian vegetation useless. They either cut it or burn the entire tracts before the sowing season starts.

85. 0 In one observation, it was noticed while huge patches of water hyacinth indicates higher degree of pollution, they are observed to be good habitats for microfauna such as insects and thus acts as foraging grounds for many birds. Several aquatic plant species other than water hyacinth were also observed during field surveys especially in small waterbodies formed due to depressions such as Marsilea *quadrifolia* [Four Leaf Clover] and *Potamogeton sp.* [Pondweed] at water body of Yamuna biodiversity park phase-2, which has recently been carved, of Yamuna flood plains near Jagatpur village. *Hydrilla verticillata* [Hydrilla] was observed thriving in the waterbody located at Krishan kunj area on left bank near ITO. *Pistia stratiotes* [Jalkumbhi] was observed in one depression in Okhla Bird Sanctuary near the weir bund. These submerged and free floating aquatic species were not observed in Yamuna water elsewhere except small waterbodies on flood plains. Absence of aquatic vegetation is another indication of the deteriorating condition of the River. High population and diversity of water birds observed at Okhla and Jagatpur bund area utpo Palla shows supportive habitat

conditions in terms of food availability, openness of water body and presence of shelter plants and vegetation cover.

Fig. No. 121 : *Marsilea quadrifolia* And *Potamaogeton sp.* At Waterbody Of Yamuna Biodiversity Park Phase-2 [Date : 04/02/2015]



Fig. No. 122 : *Marsilea quadrifolia* and *Potamaogeton* sp. At Waterbody Of Yamuna Biodiversity Park Phase-2 [Date : 04/02/2015]

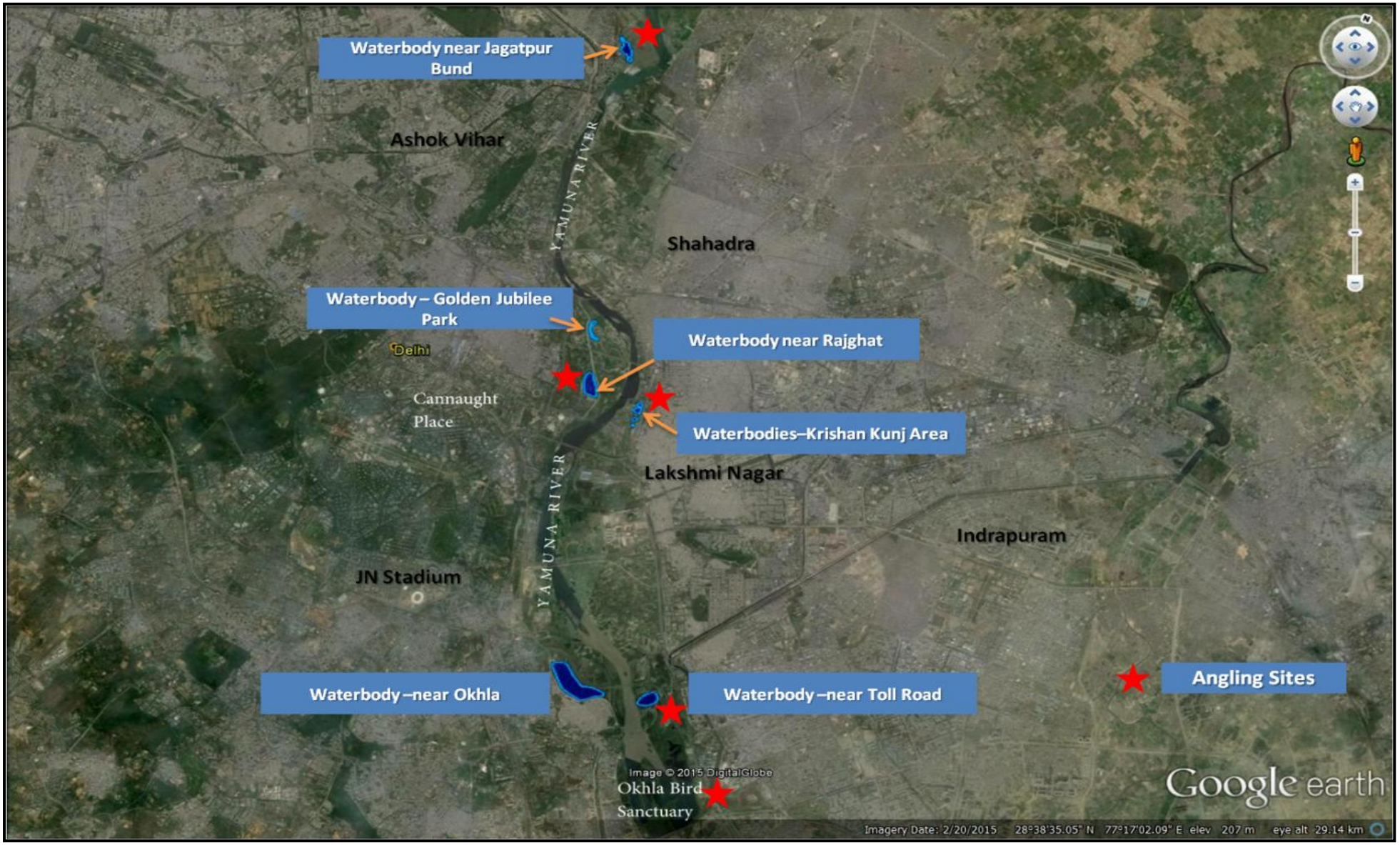


Fig. No. 123 : Hydrilla Verticillata Collected From Waterbody Located Floodplain Krishan Kunj Area Near ITO [Date : 29/10/2014]



86. 0 In case of fish diversity, Gazetteer of India, (Delhi) 1976 mentions 65 species of fish belonging to different families[Refer to Annexure-II]. Species common to waters of Yamuna in Delhi today are hardy and tolerant varities which are capable of thriving well in polluted waters. Of them, three most common species are African Manghur (*Clarias gariepinus*), Tilapia (*Oreochromis mossambicus*), Common Carp (*Cyprinus carpio*). This indicates how change in overall River ecosystem changed the species profile over time. Decreased fish diversity has also affected the livelihoods of fisherman who have been partially dependent on their daily catch as their source of income. Fishing was a popular sport once especially at Okhla and Wazirabad. Meenakshi Dhawale notes in 'Narratives of the Environment of Delhi'[2] [2010] that professional fishermen even could earn a decent amount by teaching amateurs how to fish and that Okhla was once known as angler's paradise. At present times, as per field observations and through informal discussions, it was found that fishermen now prefer the area upstream of Wazirabad barrage for fishing activities. Several different methods of fishing and locations can be seen if one traverses Yamuna River upstream from Wazirabad barrage towards Palla. Local anglers fishing with rods prefer small water bodies located on the both banks of the River. Some specific sites preferred by anglers today are shown in the map below:

Map No. 12 : Map Showing Some Popular Angling Sites On The Banks Of Yamuna River In NCT Delhi

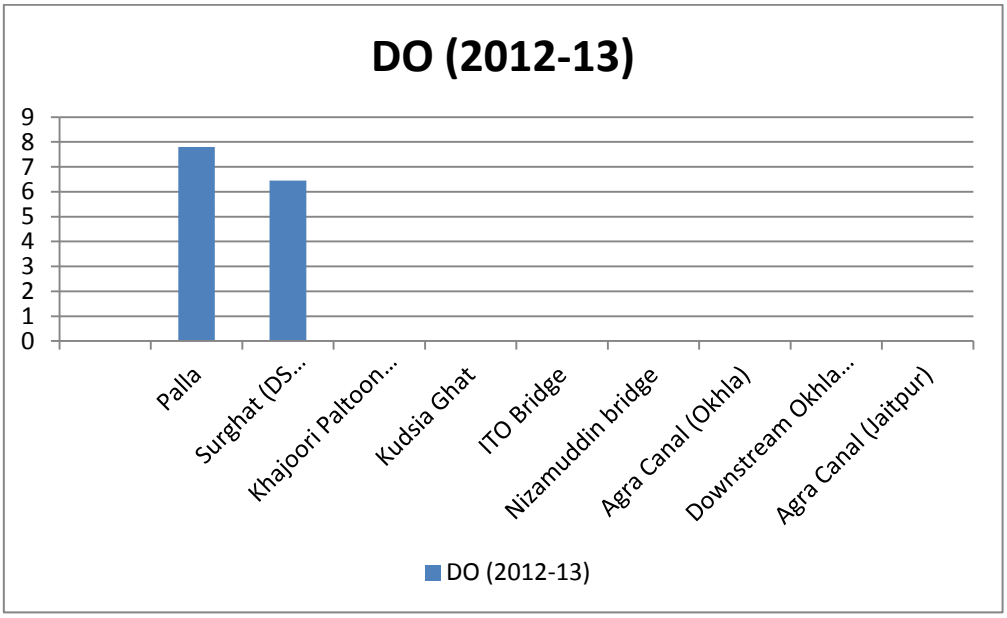


Impacts of Pollution

87. 0 Yamuna in Delhi is known to be one of the most polluted Rivers in the world. The Energy Resouce Institute (TERI) in 2008-9 observed that the levels of nickel (Ni), manganese (Mn), and lead (Pb) in Yamuna water were found to be higher than the international aquatic water quality criteria for fresh water; two hotspots for soil contamination were identified around Wazirabad and at Okhla barrage. The report also found that vegetables grown in the flood plains of the Yamuna show higher levels of heavy metals contamination than those cultivated in rural areas, thus acting as the entry point for toxic metals into the human food chain. Bio-monitoring of vulnerable population such as women and children revealed significantly higher levels of heavy metals (Hg, Cr, Pb) in urine and blood samples were measured in urban than rural unexposed participants. In the Yamuna bank area, 23% of sampled children had blood lead levels above the 10 µg/dl, a widely accepted guideline the limit above which adverse health effects have been noted. The likelihood of high blood lead level is eight times when exposed to Yamuna bank area as compared to rural areas[23].

88. 0 Delhi Pollution Control Committee (DPCC) monitors water qaulity in River Yamuna. Based on reports published by them it was observed that Dissolved oxygen (DO) is in the range of 6.4mg/L to 8.8 mg/L upstream of Wazirabad barrage and nil downstream of it (ref. Fig 117 and 118 below). Similarly, Biological Oxygen Demand and Chemical Oxygen Demand show an increasing trend as the River progresses through Delhi. These parameters indicate very high levels of pollution in the River downstream (refer Fig.s 124, 125, 126 & 127 below) of Wazirabad barrage where all the freshwater is impounded and the River is rendered a mere sewage conduit thereafter.

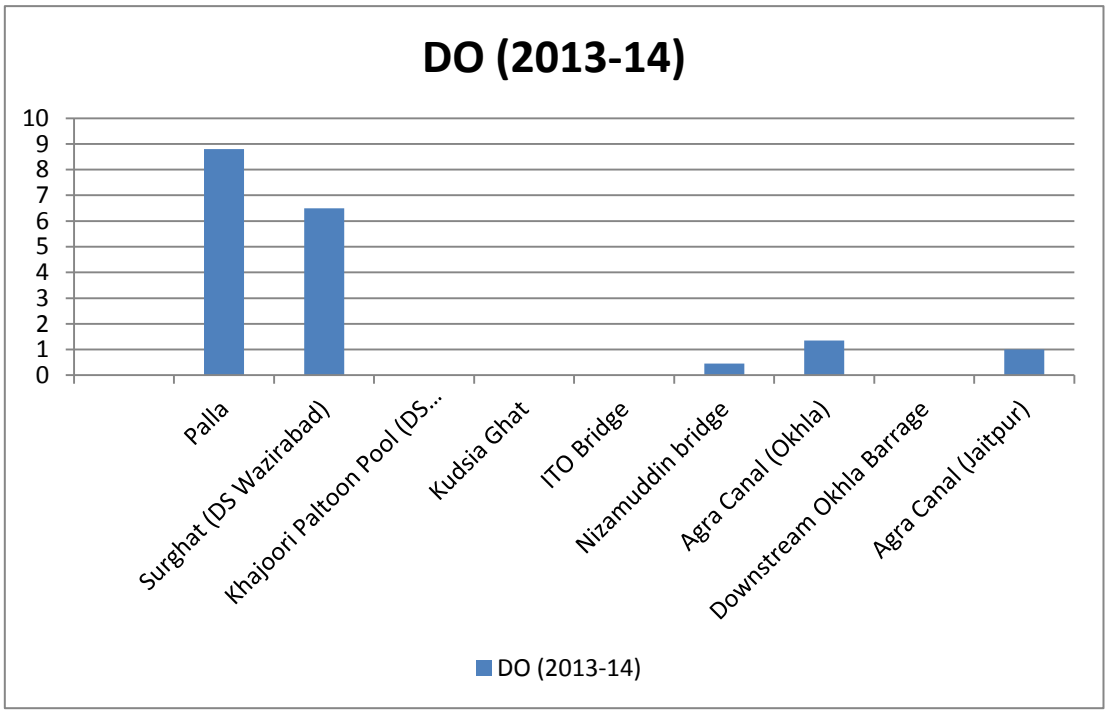
Fig. No. 124 :Average DO Levels In Yamuna In Jan 2012-Dec 2013



[23] Yamuna, The Poisned River by The Energy & Resource Institue[2012]

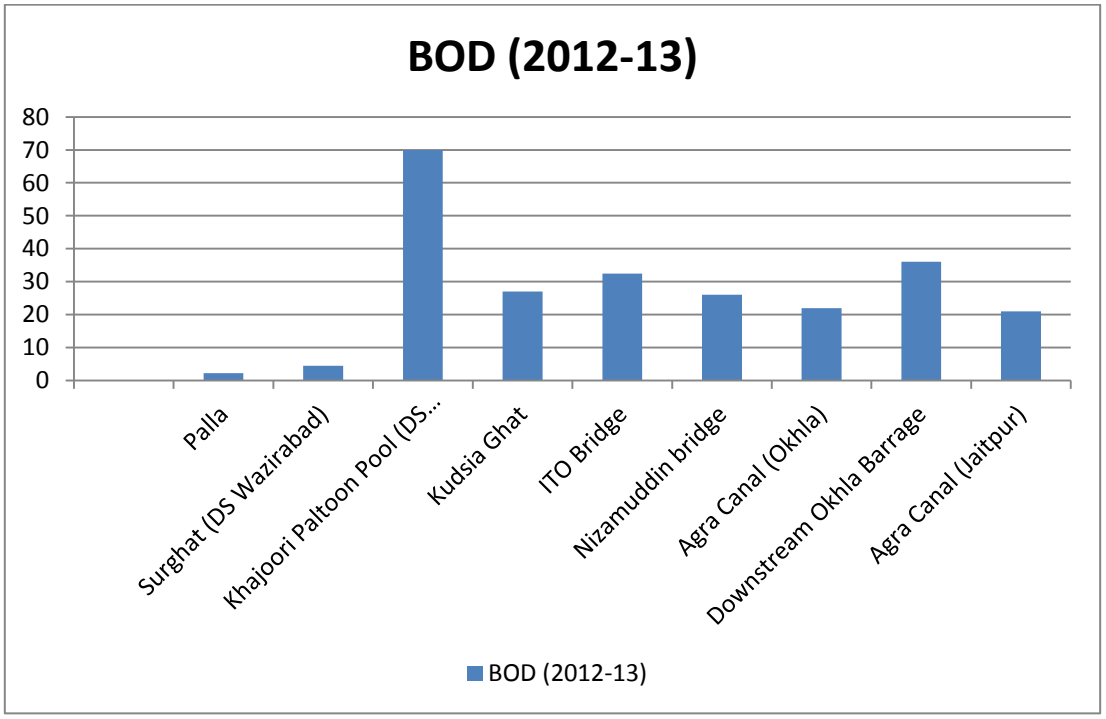
Source:DPCC

Fig. No. 125 : Average DO Levels In Yamuna In Jan 2013-Dec 2014



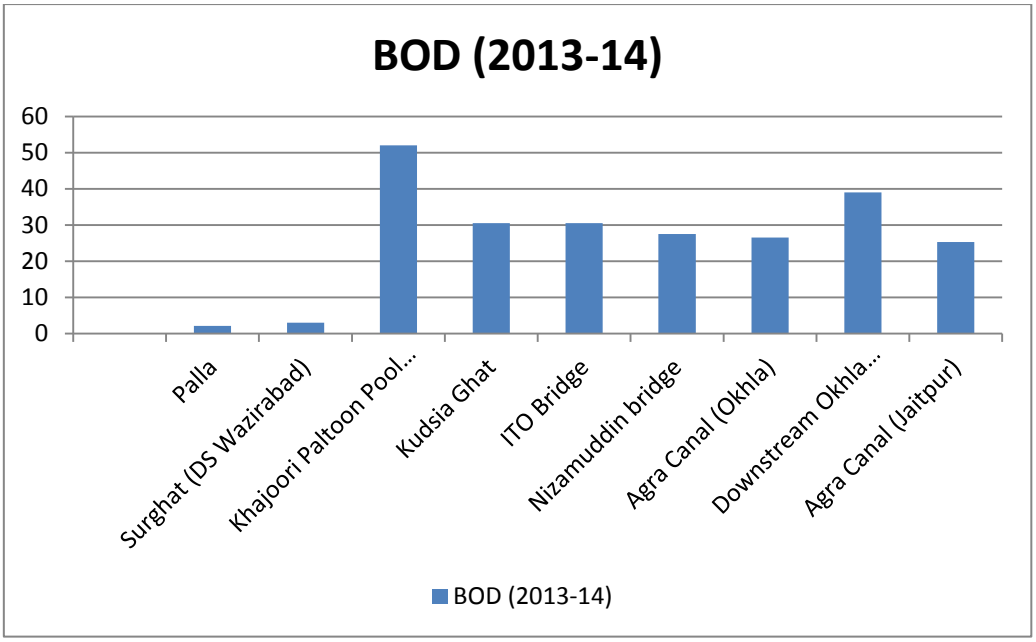
Source : DPCC

Fig. No. 126 : Average BOD Levels In Yamuna In Jan 2012-Dec 2013



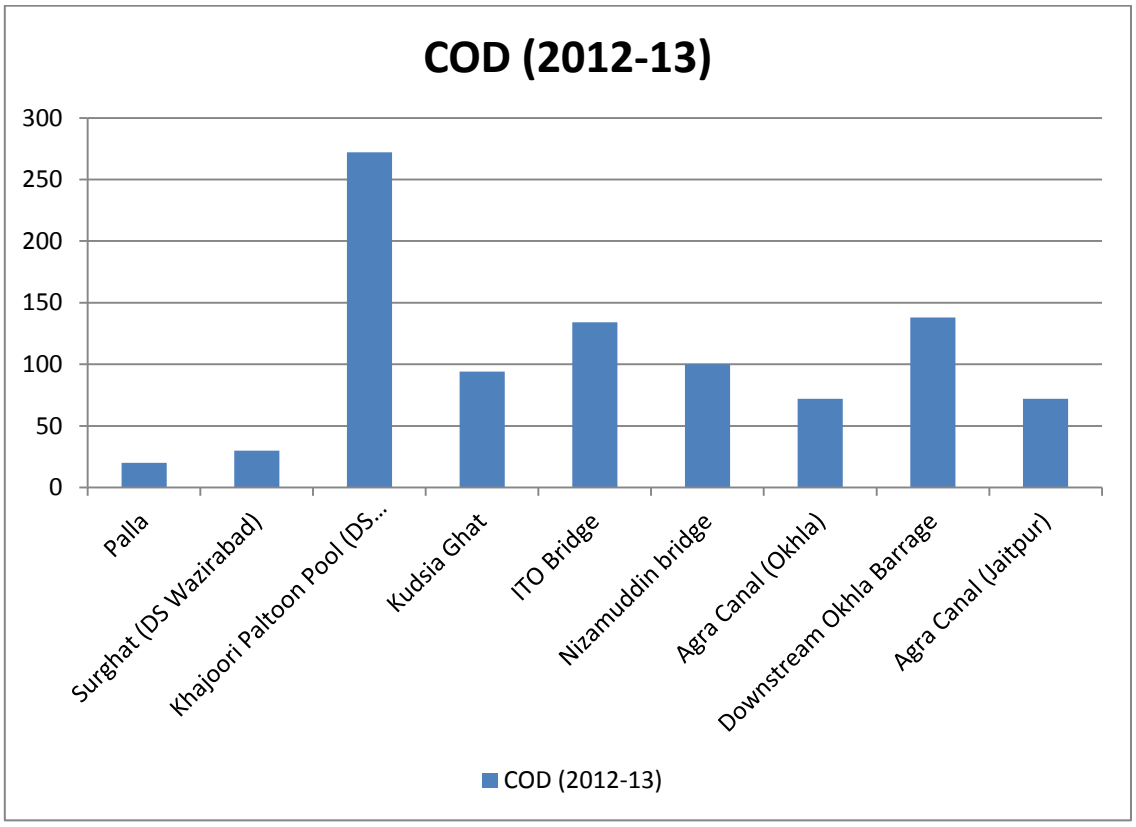
Source : DPCC

Fig. No. 127 : Average BOD Levels In Yamuna In Jan 2013-Dec 2014



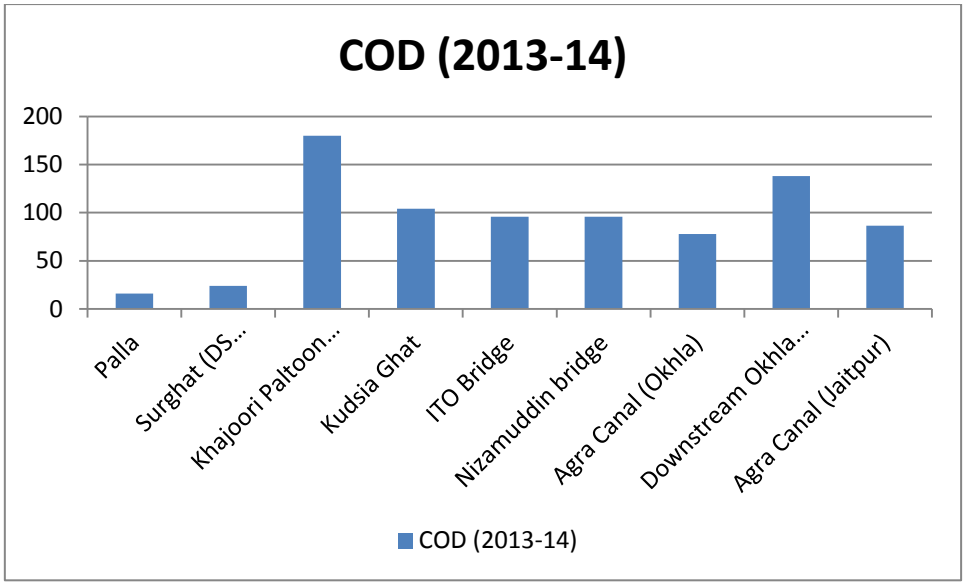
Source : DPCC

Fig. No. 128 : Average COD Levels In Yamuna In Jan 2012-Dec 2013



Source : DPCC

Fig. No. 129 : Average COD Levels In Yamuna In Jan 2013-Dec 2014



Source : DPCC

ANNEXURE –I

List of local fish species mentioned in Delhi Gazetteer, 1976

S.No.	Zoological Name	Species Authority	Family	Local Name
1.	*Labeo rohita*	Hamilton	Cyprinidae	Roho
2.	*Labeo galbasu*	Hamilton	Cyprinidae	Kalbons
3.	*Labeo gonius*	Hamilton	Cyprinidae	Kurchia
4.	*Labeo dro*	Hamilton	Cyprinidae	Chilwa
5.	*Labeo pangusia*	Hamilton	Cyprinidae	----------
6.	*Cirrhina mrigala*	Hamilton	Cyprinidae	Mrigal Narain
7.	*Cirrhina reba*	Hamilton	Cyprinidae	Rala, Suni
8.	*Catla catla*	Hamilton	Cyprinidae	Katla
9.	*Barbus (tor) tor*	Hamilton	Cyprinidae	Mahasee, Raja
10.	*Puntius sarana*	Hamilton	Cyprinidae	Punti
11.	*Puntius cochonius*	Hamilton	Cyprinidae	Punti
12.	*Puntius sophore*	Hamilton	Cyprinidae	Bhur, Punti
13.	*Puntius ticto*	Hamilton	Cyprinidae	Punti
14.	*Puntius punjabensis*	Day	Cyprinidae	----------
15.	*Crossocheilus latius punjabensis*	Mukerji	Cyprinidae	----------
16.	*Garra gotyle*	Gray	Cyprinidae	----------
17.	*Ambypharyngodon mola*	Hamilton	Cyprinidae	Miluwa
18.	*Aspidoparia morar*	Hamilton	Cyprinidae	Morak
19.	*Barilius vagra*	Hamilton	Cyprinidae	----------
20.	*Rohtee gotio*	Hamilton	Cyprinidae	Chanda
21.	*Esonius danricus*	Hamilton	Cyprinidae Subfamily: Rasborinae	Mola
22.	*Chela bacaila*	Hamilton	Cyprinidae Subfamily: Abramdidinae	Chela
23.	*Laubuca atpar*	Hamilton	Cyprinidae Subfamily: Abramdidinae	----------
24.	*Psilorhynchus balifora*	Hamilton	Cyprinidae Subfamily: Psilorhynchini	----------
25.	*Psilorhynchus corica*	Hamilton	Cobitidas	----------
26.	*Nemachilus mintanus*	Me Clell	Cobitidas	----------
27.	*Nemachilus zonatus*	Me Clell	Cobitidas	----------
28.	*Botia lobachata*	Chaudhuri	Cobitidas Subfamily: Botini	----------
29.	*Wallao attu*	Block and Schneider	Siluridae	Malli
30.	*Ompak bimaculatus*	Bloch	Siluridae	Pabda
31.	*Ailia coila*	Hamilton	Siluridae	Basmati
32.	*Mystys (osteobaqrus) seenghala*	Sykes	Bagridae	Singhiwa
33.	*Mystus (mystus) carasius*	Hamilton	Bagridae	Teengra
34.	*Mystus (mystus) teengra*	Hamilton	Bagridae	Teengra

35.	*Mystus (mystus) acr*	Hamilton	Bagridae	Teengra
36.	*Rita rita*	Hamilton	Bagridae	Rita, Khagga cheqi
37.	*Eutropichtys bacha*	Hamilton	Schilbedias	Bacha
38.	*Silonia silondia*	Hamilton	Schilbedias	Siland
39.	*Clupisoma garua*	Hamilton	Schilbedias	Bacha
40.	*Heteropneustes follilis*	Bloch	Saccobranchidae	Singri
41.	*Bagarius bagarius*	Hamilton	Sisoridae	Gonch
42.	*Gagata cenia*	Hamilton	Sisoridae	----------
43.	*Nangra punctate*	Day	Sisoridae	----------
44.	*Glyptotaorax lelcbitta*	Hamilton	Sisoridae	----------
45.	*Sisor rhabdophorus*	Hamilton	Sisoridae	----------
46.	*Channa punctatus*	Bloch	Ophiocephalidas (Ophicaphalidae)	Souli
47.	*Channa striatus*	Bloch	Ophiocephalidas (Ophicaphalidae)	Soula, Souli
48.	*Channa marulius*	Hamilton	Ophiocephalidas (Ophicaphalidae)	Shai
49.	*Channa galbua*	Hamilton	Ophiocephalidas (Ophicaphalidae)	Shouli
50.	*Glossogobius sp.*	Hamilton	Gobndas	Bhilus
51.	*Ambassia nama*	Hamilton	Centrogmidae (Ambassidae)	Chanda
52.	*Ambassia ranga*	Hamilton	Centrogmidae (Ambassidae)	Chanda
53.	*Colisa fasciatus*	Bloch and Schneider	Anabantidae	Kharda
54.	*Mugil corsula*	Hamilton	Muglidae	Andwari
55.	*Mugil cascasis*	Hamilton	Muglidae	
56.	*Mastacembelus armatus*	Laccpede	Mastacembelidae	Bam
57.	*Bhynchobdella aculeata*	Bloch	Mastacembelidae	Giluwa
58.	*Notopterus chitala*	Hamilton	Notopteridae	Chitalm, pari
59.	*Notopterus notopterus*	Pallas	Notopteridae	Pholecmo
60.	*Gadusia chapra*		Clupeidae Subfamily: Elupini	Chital, pari
61.	*Zenentodon cancila*	Hamilton	Belonidae (Xeinentodontidae)	Chaoch-wali
62.	*Amphipnous luchia*	Hamilton	Amphipnoidae	Bam

Imported Varieties

1.	*Hilsa hilsa*	Hamilton	Clupeidae	Hish, Hilsa
2.	*Clarias batractus*	Linnaeus	Clariidae	Macr
3.	*Nandus nandus*	Hamilton	Nandidae	
4.	*Eleutheronema tetradectylus*	Shaw	Polynemidae	Salmin
5.	*Pampus argenteus*	Euphrasen	Stromateidae	Pomfret
6.	*Scomber microlepidotus*	Ruppell	Scombridae	Mackorel
7.	*Lates calcarifer*	Bloch	Latidae	Bhotki
8.	*Cynoglossus*	------	Cynoglossidae	Chepti

ANNEXURE-II

Table No. 1.1: Communities of Flood Plain & Okhla Bird Sanctuary

S. no.	Dominant species	Associate Species	Lower stratum species
1.	*Saccharum spontaneum*	*Typha angustifolia, Saccharum bengalense*	*Rannunculus sceleratus, Rorippa nasturtum-aquaticum, Paspalum distichum, Polygonum hydropiper, Pyla nodiflora*
2.	*Saccharum bengalense*	*Typha angustifolia*	*Chenopodium ambrosioides, Alternanthera philoxeroides, Rannunculus sceleratus, Cirsium arvense, Phyla nodiflora*
3.	*Typha angustifolia*	*Typha elephantina, Dactyloctenium aegyptium*	*Polygonum hydropiper, P. Barbatum, Rannunculus sceleratus, Cyperus bulbosus*
4.	*Typha elephantina*	*Typha angustifolia*	*Cyperus kyllingia, Comelina bengalensis, Rannunculus sceoleratus,Rannunculus sceleratus, Rorippa nasturtium-aquaticum*
5.	*Phragmites Karka and Arundo donax*	*Typha angustifolia, Typha elephantina*	*Chenopodium ambrosioides , Rorippa nasturtium-aquaticum, Cirsium arvense, Alternenthera philoxeroides, A. sessilis*
6.	*Alternenthera spp*	*Paspalum distichum*	*Cyperus conpressus, Ipomea fistulosa, Polygonum hydropiper*
7.	*Ipomea fistulosa, I. Aquatica*		*Polygonum hydropiper, Cyprus kyllinga*

Source: Manral et. al., 2012

ANNEXURE-III

List Of Yamuna River Embankments Under The Control Of Irrigation And Flood Control Dept

S. No.	Name of Embankment	Length (in Mtrs.)	Top level of the Bund(in Mtrs.)	Max Water Level in 1978 (in Mtrs.)	Max Water Level in 1988(in Mtrs.)	Max Water Level 1995(in Mtrs.)
1.	a)Rural Marginal Embankment (R.M.E) from Palla to Wazirabad	18360	216.200 at Palla 214.40 at Jhangola	212.35 211.75	213.27 211.75	212.80 211.60
	b) Jagatpur Bund	4388	211.00 at RD 210 M	----	208.97	209.30
2.	Yamuna Bazar Bund	600	209.120	----	----	----
3.	Yamuna Bazar Wall	1100	Min. R.L. OF 280.50 m at RD 0 m to RD 1100 M with opening platform	----	----	----
4.	Mughal Bund	2700	208.44 at RD 1800 m; 208.45 at RD 2700 m	----	----	----
5.	Power House Bund	2300	207.14	----	----	
6.	Left Marginal Bund (L.M. Bund)	6700	208.44 at RD 550 m; 208.24 at RD 4578 m; 207.42 at RD 6700m	----	----	----
7.	Rural Marginal	3550	203.80 at RD 0 m	201.4a at	200.87	200.15

	Embankment (RME) Madanpur Khadar		202.13 at RD 3500 m	RD 3000m 200.87 AT RD 3500 m		at RD 180 199.62 at RD 3500m
8.	Left Marginal Bund (L.M. Bund)	5750	210.00	208.20	----	----
9.	Shahadra Marginal Bund (S.M. Bund)	11900	209.00		207.00	----

Source: Flood Control Order of 2014, Irrigation and Flood Control Dept., Govt. of Delhi

ANNEXURE- IV

The Central Pollution Control Board has classified water resources of the country according to their uses for setting water quality objectives for different water bodies. The classification system is as follows:

S.No.	Designated Best Use	Class	Criteria
1	Drinking water source without conventional treatment but after disinfections	A	1) Total coliform organisms MPN/100mL shall be 50 or less. 2) pH between 6.5 and 8.5 3) Dissolved oxygen 6 mg/l or more 4) Biochemical oxygen demand 2 mg/l or Less
2	Outdoor bathing (organised)	B	1) Total coliform organisms MPN/100ml shall be 500 or less 2) pH between 6.5 and 8.5 3) Dissolved oxygen 5 mg/l or more
3	Drinking water source with conventional treatment followed by disinfection	C	1) Total coliform organisms MPN/ 100ml shall be 5000 or less 2) pH between 6 and 9 3) Dissolved oxygen 4 mg/l or more 4) Biochemical oxygen demand 3 mg/l or Less
4	Propagation of wild life, fisheries	D	1) pH between 6.5 and 8.5 2) Dissolved oxygen 4 mg/l or more 3) Free ammonia (as N) 1.2 mg/l or less
5	Irrigation, industrial cooling, controlled waste disposal	E	1) pH between 6.0 and 8.5 2) Electrical conductivity less than 2250 micro mhos/cm 3) Sodium absorption ratio less than 26 4) Boron less than 2mg/l

Source: Polluted River Stretches in India: Criteria and Status, Central Pollution Control Board (CP

ANNEXURE V

Landuse Pattern in River Yamuna Catchment

Yamuna basin has about 60% cultivable land but only 52% is under cultivation. Only 12.5% of the basin is forest land largely distributed in the states of Uttarakhand, Himachal Pradesh and Madhya Pradesh.

Table 6.1 : State-wise Landuse pattern in Yamuna basin

State	Area (% of total catchment)	Land use pattern			Land Actually cultivated %	Land under habitation %
		Non-arable %	Forest land %	Cultivable land %		
Himachal Pradesh	1.6	25.0	59.4	15.6	14.2	1.5
Haryana	6.1	18.1	2.4	79.5	59.9	3.6
NCT - Delhi	**0.4**	**51.0**	**1.0**	**48.0**	**46.5**	**43.7**
Uttarakhand	1.1	5.0	22.0	23.0	14.3	1.6
Uttar Pradesh	20.4	14.5	3.9	81.1	68.0	5.1
Rajasthan	29.8	40.8	8.8	50.4	43.9	2.2
Madhya Pradesh	40.6	26.0	18.0	56	50.7	1.8
Total	100.0	27.5	12.5	60.0	51.9	2.9

Source: Comprehensive plan of flood control for Ganga sub-basin and tributary River System, Ganga Flood Control Committee, Ministry of Water Resources, Govt. of India

ANNEXURE VI

Narratives Of The Environment Of Delhi [An Extract]

Meenakshi Dhawale, INTACH[2010]

Yamuna was omnipotent in determining Delhi's history. Traces of the earliest civilizations in Delhi were found along the river. Yamuna bestowed upon Delhi one of the richest agricultural tracts of northern India. These tracts form a strategic corridor between the plains of Punjab and those of Ganga-Yamuna basin. The fertile alluvium soil of Yamuna supported the early stages of urbanisation.

In his book '*The Seven Cities of Delhi*' (1906), GR Hearn, Captain in the Royal Engineers Associate, asks: "What were the reasons which induced the monarchs (of Delhi) to build new cities, instead of being content with the walls of the first extended, if necessary, to contain a larger population? Answer to this he found in a native proverb. "Three things make a city- *Daria, Badal, Badshah*". That is to say, a river, rain-bearing clouds or an emperor (who can enforce his wishes). Two of these three emphasise the necessity for water, without large quantities of which life in a hot country would soon become unendurable. The storage of rainwater in tanks may prove sufficient for ordinary purposes, but the river comes first in the estimation of the Hindu because it is sacred…..All the great cities of Hindustan are situated on the banks of a river; Muttra, Kanauj…it is therefore suggested that it was found necessary to move the cities of Delhi to the north-east, to follow the river, which once flowed not so very far from Old Delhi, but has gradually set further and further east-a process which is going on today, the extent of which has been considerable, even during the last century…..whatever influence the *daria* had on the shifting of the cities of Delhi, there has certainly been a great change in the climatic conditions so that the wells in Old Delhi, have almost dried up, the tanks and reservoirs are never now filled and it would be impossible for a large population to exist within the walls. The Hindi proverb thus is justified; and it was the vagaries of the river, and the failure of the clouds to pour down their waters, rather than the caprice of emperors, which have been the causes of the construction of so many cities, where one would have otherwise sufficed.

Yamuna is believed to have once flowed into the Saraswati, eulogised as the foremost of all rivers in the ancient hymns of the *Rig Veda*. The *Varaha Purana* say that the river was in decline 3,700 years ago, around the time of the Mahabharata; the great sage Manu talks of the Saraswati disappearing into the sands near Sirsa, Rajasthan. Saraswati has been identified by many scholars during the past century as the present dry bed of the Ghaggar along the northern margin of the Thar Desert in Haryana and Rajasthan. In 1996 Indian remote sensing satellites found evidence of groundwater sanctuaries below the Sarasvati's supposed bed. The tectonic movements initially pushed up the old Aravalli hills, cutting off the headwaters of the Saraswati. Betrayed by its two snow fed sources, the Sarasvati was left with the waters of petty streams rising in the puny Shivaliks. Forced eastward the Sarasvati was then progressively robbed of its water: first by the Yamuna, then by the Satluj- both rivers, along with the Tons, were once a part of its massive expanse. A branch of the Chambal cut northward in a channel deeper than the Sarasvati, finally beheading the great river. This new channel became the Yamuna, which migrated eastward. Satluj migrated westward. A geological paroxysm in the Aravallis pushed Satluj into a U-turn at Ropar, Punjab, forcing a complete abandonment of the Sarasvati, sending it into the arms of the Indus. Over time, Yamuna also preferred to chart a more and more easterly course, eventually abandoning the Saraswati and joining up with the system of the Ganga. The Sarasvati's demise indicates how dramatic tectonic movements can change the face of a society. There seems to be archaeological evidence to this movement: the total absence of late Harappan settlements in area of the Saraswati is in sharp contrast to the dramatic increase in habitations in the plains of Harayana and western Uttar Pradesh. There is also a remarkable scarcity of Harappan sites around what are today's Yamuna and Satluj. This is again in sharp contrast to the archaeological gold mines turning up in the dry channels of Punjab, Rajasthan and Sindh in Pakistan.

Aided by tectonic movements Yamuna continued to slither and change its course temperamentally, abandoning its meanders into marshes and lakes on its way east. New studies suggest that the Yamuna once flowed through the hills south of Delhi. It seems to have abandoned its hilly route around 4000 years ago, gradually moving eastwards through the plains area till it settled into its present course.

The remains of at least six palaeo-channels (old channels or courses) of Yamuna have been identified in the Delhi area. While a major palaeo-channel has been located in west/north-west Delhi coinciding in the main with Mungeshpur Drain, several palaeo-channels have been located in and adjacent to the Yamuna flood plains. Traces of old courses of the river can be seen in various lakes such as the Najafgarh, Surajkund and Barkhal lakes. Studies of the palaeo-channels have shown that the migration of the river ranged over about 100 km. in the north and west Delhi region to 40 km. in the south.

While changing its course the river also determined the soil character of the territory. While migrating east the river abandoned its fluvial deposits. The earliest deposits now constitute the bangar tracts while the more recent are characterised as old khaddar.

The Gazetteer states: "The drainage channel called the Budhi Nala, which comes down under the very doors of Sunipat, would seem by the conformation of the country to have been the old bed of the Jamna, and this is supported by strong and general tradition. The course of the Budhi marks off the division of the country into Khadar and Bangar" .This channel can now be identified as Drain No.6.

It may at any rate be considered certain that the river once flowed beneath the walls of Sunipat, and down south by Narela, to somewhere near Azadpur on the Grand Trunk Road near Delhi, where, beginning to feel the influence of the hills, it must have turned sharply to the east. Below Delhi its course seems to have been in the same way immediately east of the Bangar bank. This in the immediate vicinity of the city abuts almost directly on the stream where it now runs. But then the old river would seem to have taken again a more westerly course than the present- to have passed close by the ancient village of Tilpat: then turning again south-east along a nala still visible, to have rounded closely the high bank on, which the Khadar-Bangar villages in this part mostly stand.

Migration of Yamuna has been important in determining the history of ancient settlements in Delhi regions. While many Stone Age sites have been found in the hilly stretches that were once traversed by it, several ancient mounds mark settlements that grew up along the older courses of the river. There are interesting observations in history that indicate the gradual shift of the river. We have a legend that says a Hindu King built the first storey of Kutb Minar in order to enable his daughter to daily see the river without the trouble of taking a fatiguing journey". Turkman Shah, the saint, is said to have lived and to have been buried on the banks of the river as was Empress Riziyat in 1240. The graves of both are near the Turkman Gate, far from the river, as it now flows. Mubarik Shah founded his incomplete city on the bank, and was buried within it. This tomb is not far from a ravine, which starts between the Ajmere and Turkman gates of the modern city, and looks extremely like an old bend of the river. Then again "the ravine which runs near the walls of the enclosure of Roshan Chiragh Delhi, may be part of an old channel- a theory which is to some extent borne out by the fact that the walls of Old Delhi, where they cross the Kutb Road, appear to follow an old river-bank". When Babur entered Delhi, he camped besides the river Yamuna directly opposite Tughluqabad.

The Turks and the Rajputs before them, found their strongholds on the Ridge. The hills gave them a natural line of defense. It also ensured that fertile soil of Delhi plain was utilised fully for agriculture without any interruptions from urban settlements. The citadel shifted from the hills to the river for the first time in the reign of Firoze Shah Tughluq. Later Humayun and Shahjahan also established Dinpanah and Shahjahanabad on the banks of Yamuna in Delhi.

Imperial cities express the power and grandeur of court. The river *au fond* the palace multiplied the aesthetics of the court. Riverside palaces also benefited from the fresh cool breezes from the east called poorvai. Situated on the right bank of Yamuna, these forts are believed to made full use of the river as a natural defense, though the river's meandering course is too unpredictable to lend itself strategically for

the needs of fortification. Moats had to be stretched around the circumference of the fort to meet defense necessities. Firozabad, Dinpanah and Shahjahanabad flourished mainly during peaceful times.

Proximity of the river from the fort however did ensure a reliable escape route. In 1787, Prince Jahandar Bakht, eldest son of Shah Alam II, jumped from Shah Burj next to Water gate to escape an attempt on his life. Those were the years of Maratha ascendancy and also the time when Ghulam Qadir Rohilla attacked the fort. Jahandar Bakht swam across the river and made his way to Lucknow where he tried to enlist the help of the Nawab of Awadh and Lord Cornwallis to free the Mughal throne from the control of the Marathas and Rohillas who made Shah Alam II a virtual prisoner in the Red Fort. It is also said that when the British were about to recapture Delhi from the sepoys during the Mutiny of 1857, Bahadur Shah Zafar was advised to escape from the River Gate, cross the Yamuna and then reach the Punjab by the way of Saharanpur, from where he could make his way to Iran via Baluchistan in disguise and eventually reach Arabia and Mecca.

The gazetteer states "It (river) passes close under the Fort at Delhi, and it must always have rounded the eastern point of the rocky 'Ridge' at Wazirabad. But in the northern part of the district it appears formerly to have had a course much to the west of what it holds at present."[24] The river substantially moved away from the Fort in 1857. In 1858 only the floods reached the fort. GR Hearn writes in 1906: "Nowadays the Jumna alters its course very slightly indeed: it is turned to the east by the fort of Salimgarh, and by the modern city, built on ground which centuries ago was at a much lower level, and not safe from flood"

The decision to shift the British India capital from Calcutta to Delhi was followed by the plans to create a new centre as a proclamation of power, deliberate and distinguished from the anarchy of Shahjahanabad. A site was selected north of Shahjahanabad where the grand Coronation Memorial was held in 1912. That same year floods submerged the intended site creating in its wake marshes and pools of stagnant water, which bred mosquitoes. The New Delhi as we know stands aloft the Raisina hills.

The river influenced the fate of the city and the life style of its people as well. Yamuna to a large extent determined the socio-economic, cultural and religious patterns of life in the city.

The territories under Khadar (Riverain Zone) were flood prone but most fertile and hosted various agricultural activities. These tracts were known as Sailab or Dhari and saw cultivation of various cereals and fruits according to seasons. These fields were rich with fluvial soils that the river deposited alongside its banks. Flood irrigation was also practiced in the Najafgarh tract. Canals which received no flood water were used for the Kharif cultivation of jowar, bajra and cotton. Areas which got submerged were cultivated for the rabi crop. "As young boys we spent a lot of time at ghats under the clouds of the clear afternoon skies reflecting on the waters of the river, beyond which extended vast expanse of green farms across Qudsia bagh interrupted only occasionally by small hutments or grain stacks" narrates Mr Ravi Mehra in a poetic trance and then with a mischievous smile he adds "sometimes we would cross the river to steal Kakdis and other vegetable".

Mr. Javed Akhtar works in the administration of the Crescent School at Ghata Masjid, but his heart lies in farming. "Character of soil determines growth pattern of crops" he says thoughtfully. "Crops that were grown here had the distinction of Delhi's '*ab-o-hawa*'. Fruits grown in the orchards and fields had the taste of Yamuna. Just three decades back, the air of early winter mornings used to be filled with cries of vegetable sellers, declaring "*jamna par ki matar le lo*" (peas from the fields of trans-Yamuna). "My mother used to make soft chappatis stuffed with these sweet peas for my school lunch" nostalgia engulfs Mr. Mathur. Summer thirst was quenched with the sweetness of melons, cucumbers and kakdis grown in the fields on the banks of the river.

Mr. Javed Akhtar remarks "Melons available in Delhi were like the *Lukhnavi Kharbuza*. The sweetness of these melons depended upon the prevailing air. Water melons with lines on them have only recently come in the market (some even call them Disco Kharbuza). The earlier ones were greener and devoid of these

[24] Gazetteer 1883

lines. They were also much larger and heavier. In fact it was popularly believed that bigger the size more sweet the melon will be". A farmer from Dalupura informed me that earlier the melon crop gave fruits only once in the season and had few fruits one each crop but these fruits weighed between 15-20 Kgs. "The new seeds however give greater yield with smaller fruits". On Friday or Sundays Professor Dehlvi and his friends would meet up on the fields across the left bank of the river and enjoy *falez* or melons. "Some would buy melons for home. Then they would take a dip in the river and come back home".

"People would ritually go to *ghats* early morning to buy fresh vegetables and fruits (also flowers for *puja*), for the day" reflects Mr. Kishen Mohan Gundhi. However, produce of these field were taken to different mandis like Shahdara and Shakarpur from where it was taken to wholesale markets of walled city.

River water was important for even garden plants. Sydney Percy Lancaster reflects his concern in '*Garden Chat*' where he writes, 'Throughout the summer we had anxiously waited for a good monsoon but its failure caused us a great deal of worry and anxiety about our plants, most of which suffered much at the nursery. The water of the Jumna fell so low that it was impossible to maintain the full supply of unfiltered water' .

As a physical feature Yamuna divided the rural landscape on its left bank from the urban life on the right. Before and post monsoons bridges of boats were in use. This bridge was made of airtight barrels tied together. Tongas and bullock carts could easily cross this bridge. In the absence of any permanent pedestrian bridge, the interdependence between rural and urban economy was sustained by a system of ferries and flat boats that carried people, livestock, grains, vegetables, milk and milk products, etc.

"The Jamna forms the eastern boundary of the Delhi district throughout, and is navigable for the whole of its course". "During the cold weather the river is fordable almost anywhere, but at other seasons people have to cross by the ferries". Punjab Famine Report of 1879 lists the mooring places of the ferries on the river and distances between them. It mentions the following stations across the river- Maniarpur Baghpat, Dahisra, Burari, Wazirabad, Okhla, Jaitpur, Kiraoli, Mahabatpur, Kabulpur Khadar, Majhaoli, Shajahanpur, Chhansa. Gazetteer of 1883 observes that "….there is a small wood depot at Garhi Mehndipur, below Mamiarpur, and corn is sometimes brought down the river from Bigah, a large village in the north of Delhi, to Sunipat; but there is little else worth speaking of in the way of river trade". The Gazetteer also tells us that "For a period between 1875 and 1880 there were in average 10,302 ferries plying". It seems that navigation on Yamuna was restricted to areas in the vicinity of Delhi. It would however be no surprise if once upon a time the river was used for long distance trade.

"Delhi grew up in its present locale as a trading centre with a broad navigable river adding is dimensions for the conveyance of goods". Some rumours mention the dispatch of cargo by boats to Delhi carrying a load of as much as 100 tons from as far away as Calcutta for example Mohammad Sheikh has heard of large boats which were called 'Sulfa' plying Yamuna. Commodore Sinha tells me that boats were employed by the Mogul army from Delhi for transferring supplies for the Bengal conquest. The maps of 1907 and some old paintings indicate that a small tributary of Yamuna used to cross through the Water Gate of Red fort. This gate was used to carry a royal entourage to Agra on boats.

In fact till as late as 1971, Yamuna was extensively traversed by ferries. The existing ferry boats plied in five different areas, which were under the control of the MCD- Sungrarpur (18 Kms from Kashmere Gate), Burari (13 Kms), Wazirabad (2 Kms), Okhla (16 Kms) and Jaitpur (22 Kms). The ferry boats at Wazirabad transported villagers and their merchandise throughout the year. In Jaitpur and other places the boats could not ply when there is heavy rainfall as also in winter when the river water dries up. The public ferry at Sungrarpur helped movement of villagers not merely of the neighbouring villages but also of Uttar Pradesh. Milk vendors and dealers in sugars and *gur* from the latter region were frequent users of this ferry and carried their merchandise with them. The length of the waterway traversed by the ferries was about a kilometre and the average number of passengers per day varies from 100 to 200. The ferries were put to yearly auction. In the financial year 1970-1971, it brought to the coffers of the Municipal Corporations a sum of Rs 4,015.

Mr. Kirat Singh remembers that around the river near old fort lived people who were called 'malleha'. Their livelihood depended upon taking people across the river on their boats. "Some of them actually used to live on their boats. These boats carried bullock carts across the river". "The boats or kashtis took us on the other side for one anna", Prof. Dehlvi tells me. The street called Ballimaran in Chandni Chowk was named after large wooden oars used for pushing the boat across the river. The ballimars used to live on this street.

However, slowly yet steadily ferries as a mode of transport declined. A dramatic change is noticed by the Gazetteer of 1976, "…..as a waterway the river has ceased to be of any consequence. Its changing course, insufficient water in summer time and connecting bridges have made transport by boats, barges and steam launches obsolete. The few public ferries on the Yamuna are probably the only survivals of a mode of transport which has passed into oblivion". Cost of maintaining navigation on these water networks might be another cause of decline; "The Agra Canal is navigable, and boats ply regularly up and down it; but from the official report of the Executive Engineer in charge it appears unlikely that the income from navigation tolls will ever be equal to the interest of the additional capital required to make the canal navigable". "….the ferries are under the management of the District Board which pays to Government a lump-sum of Rs.4, 500 per annum. The additional incidental costs of management amount to Rs.772 per annum".

Boating however remained a favourite pastime especially at Okhla. When Commander Sinha first visited Delhi in 1946, he had been taken for a picnic to Okhla on the banks of Yamuna. "Okhla was very popular among Delhiwalas for picnics". The head works of Agra canal, established by the British, was also situated here. Canal Bungalows were rented for picnics. For recreation many residents would go to Okhla with their personal boats. In her article, Shalini Saran narrates about her life in Nizamuddin before 1979 and talks about a Mr. Gawk who would load his boat every Sunday on to his car and to go to Okhla on a fishing expedition. Boats could however be hired on an hourly basis.

Boating was quite popular even in Okhla Sailing Club, where according to Commander Sinha, there were 35-40 boats. The club also held annual regattas. "Small islands would emerge in unpredictable places every summer in the river; they ensured new challenges even for seasoned Delhi sailors of the Club".

Colleges like St. Stephens and Hindu had their own boat clubs. During his college days, Prof. Diwjen Kalia, along with his friend Arwind Sachdeva, would row a boat themselves from Wazirabad to Qudsia Bagh or all the way to Okhla. Going upstream however was quite difficult for them. Sometimes boatmen from eastern UP came to Delhi, recalls Mr.Vijay Kapoor, to recite Ramayan on boats. On rare occasions Mr. Virender Jain would take his family opposite the clock tower at ghats for boating. During summers, he recalls the water was shallow and muddy. In late 60s Mr. Ray remembers taking a motor boat from Okhla to Old Fort and getting down at University. In those days there was only one bridge – the old Jamna Bridge.

Mr. Mohammad Sheikh inherited the skill of boat making from his father. He lives in Okhla where I met him near the Sailing Club. Some of their best boats were made of wood from Sheesham tree. "You can keep these boats in water for ever and they would not rot, but now because of pollution even good new boats don't last too long", he complains. With the increase in pollution levels and pungent smell, Okhla also lost its charm with people. Boat makers suffered great losses and were forced to find new vocations.

Along the river there were many fishermen village. The river catered to a variety of fishes which ensured good income in market. "Yamuna is divided into the Delhi area and the Okhla area" explains Mr. GS Malhotra of the Fisheries Department. "Licenses were acquired depending upon the nature of activity i.e. whether one was fishing with an angle or a net. Annual license was acquired from the Fisheries department for commercial fishing using. License for fishing using net is given only to the contractors" he elaborates. Angling was popular past time among people and was pursued by paying for a license on hourly basis. "License could be found at Old Okhla office which almost resembled shacks across the bus stand at Okhla headwaters. The license gave you the right to fish in Okhla and water in the canal" mentions Mr Rajan Ray. He also recalls that in early 1960s, a permit for fishing was priced at Rs1 "if we stayed on the bank" and Rs2 "if we wanted to fish on the jetties (or "thokars") across on the other bank".

Reportedly fishing was quieter and better on the other side". There were some dhabas and Dak Bunglow. The Bunglow was surrounded by Gulmohar trees, mango trees, etc. Ex-patriots from different embassies also came here to fish.

The Okhla area consists of the Barrage which was once known as the Anglers Paradise. "At Okhla only angling is allowed" adds Mr. Malhotra. According to Mr Kirat Singh fishing was popular in Okhla because the barrage created a sort of a waterfall which would have a deeper pool in which it would be easier to catch the fishes than in the flowing river. GS Malhotra elaborates that "the ladder near the weir is called the reserve notch and fishes are aplenty there".

Professional fishermen could earn a decent wage by teaching the amateurs how to fish. As an adolescent Mr. Rajan Ray would travel on his bicycle from Jungpura to Okhla to fish. The canal had great fish fields on both the sides. The shikari community around these areas earned there living by fishing and purchased annual fishing license. Old fishermen from Jama Masjid area would come often to fish here. "Professional shikaris (guides) could be hired to show the sahib's the ropes. They could find bait for them for one rupee". His guide was a person called Nanku at Old Agra Canal.

Mr. Ray recalls that the tackle comprised of bamboo rods and a talcum powder can on which the line was wrapped or a fairly basic reel. Small fish called chilua were used as bait. "Nobody we saw had casting reels". The equipment could not be hired but be bought in Jama Masjid or at Bharat Bhandar, a shop in Gole Market. "Okhla offered sport for real anglers and one saw a lot of Delhi's keen anglers out there with expensive tackle with fibre glass rods and spinning reels". Dwijen Kalia narrates that when he was in seventh grade he and his friends went to Okhla on their cycles and were amused to see fishing techniques employed there. For example, somebody had attached a small ghungroo to an angling rod that could immediately bring to notice a struggling fish caught in its bait. In another instance he saw a man almost dragged into water by an escaping fish. The man incurred many painful bruises. But with the help of few others he took control the fish which would have 'weighed nothing less than 40 Kg'. Mr. Ray had also heard something similar. He remembers that once a big *Goonch* took their line and sank to the bottom. According to the locals the same fish had been landed a few years earlier by leaving a large piece of meat on an equally large sized hook tied with a nylon rope to a lamp post on the Rs2 jetty overnight. The next morning it took four people to pull the fish in and the lamp post got bent in the ensuing struggle. Since the lamp post was still bent when they saw it so perhaps the story was true. Near Wazirabad Bridge, yet another ingenious technique was employed for fishing. Some experts would jumped into the water and swam to the middle, where the river was shallow. With much agility they would catch those fishes which were trapped in the sandbanks and shallow waters. Mr Ravi Mehra recalls that during summers many fishes would jump out of the water just before the monsoons. They would flutter for a while on the ghats and die. Perhaps this happened because of change of temperature of the water in the river.

"To fish for *Bachua* we waited until the floodgates were lowered during monsoons and then cast out for in the fast running water. This fish was rarely more than 1-2 lbs in weight but offered a great sport while taking chilua and running for the wild waters. If you took half a dozen in the day you had done very well indeed". "Silund fishing was a finely practised art. You threaded a single chilua through the head and cast out from the end of the pier reeling in slowly, (there were no spoons or artificial lures in those days) while moving in an anti-clockwise direction shoulder to shoulder with others. As you reached the tip of the pier you reeled in and went back to start all over again. If someone got into a fish everyone else pulled their lines in whilst the hooked fish was played in and landed to much praise. The fish were silver in colour, had no scales and ran 30 lbs plus on some occasions. The line could not be broken and with so many bodies behind and on each side one had to be sure of the accuracy of one's cast otherwise the hook could be embedded in a sensitive part of the neighbours anatomy". "The hot summer days meant sitting on the cement benches in front of the restaurant and fishing for carp. This was different from anything we had done. The hooks were of a different shape, being more rounded, and came tied together with a silky thread in pairs. Bait was worms carefully threaded onto the hook or atta (wheat dough) or moss. Below the hooks was about 12" of ordinary thread attached to a stone for weight. About 3-5' above the hooks was a peacock quill float. This whole caboodle would be flung over the railing and the line slowly reeled in until it was tight and the float visible as a bobbing piece of white in the water. If a fish was feeding or sucking the bait (as carp are bottom feeders) we were told the float would begin to twitch or slowly sink.

That was the moment to strike, too early or too late and you lost the bait. In any case if there was atta it needed to be checked every 10 minutes or so because it would wash off. On a hot summers day the bright light reflecting off the water would lead to drowsiness until the some watchful instructor would shout 'maro, maro' (strike, strike)".

They would sometimes cycle as far as Ballabhgarh and fish along the way. The best grounds were beyond Palwal at Chajunagar. Because of the weir gates here there was a fall at Chajunagar. One could walk across the beach over the gates if the water gates if the water was not high. Alirjheel 3-4 miles from Okhla to Sarita Vihar there were old tombs (which he cannot find anymore). The water of this entire stretch was gorgeous.

One could find different fishes in different seasons because of migration and breeding. Cold water fish-Silund would come and one could find at least 4 to 5 fishes whole year. They were big in size and the shikaris would hunt them. Gooch was considered a prized catch. They could grow to 200-250 lbs and they chew up the bait without getting caught.

Even gangetic Dolphins were found at Okhla in a shoal of 4-5 fishes. Murral and sol were caught a lot in Agra Canal. At tokkar one could fish for a small fish called bachchua. It was a great feat for a beginner to catch even 3-4 of these fast fishes. Tortoises were found in plenty but they were considered a nuisance since they would eat the bait. Fishermen would drag them along the bank, turn them upside down and piling them on top of each other. Mr. Kirat Singh tells me that some people belonging to North-east India also caught tortoise. When the water course was low these tortoises would sun bath themselves on the islands that would create in the river.

The avifauna was so plentiful that the Gazetteer of 1912 describes that on the various water bodies and the Yamuna one only had to 'hold straight' to bring down the birds. Licenses were issued to shoot ducks behind Old Fort, recalls Mr. Ray. Fishing was also done at Wazirabad and WJC. Many also came to these grounds to shoot Partridges and other birds. Partridge hunting was gradually banned but no ban was imposed on fishing. This activity gradually declined with the increase in water pollution of the river. At Okhla however state jurisdiction of the weir (or *darisi* in Hindi) came under controversy. When the sluice gates are closed the area behind it stores water and makes it a reservoir. In 1992 this reservoir near Okhla was declared as Bird Sanctuary. Therefore all the activity in this region was prohibited including fishing. However G.S. Malhotra argues that in reality it is not a true reservoir. If the sluice gates were to be opened then the water will resume its natural flow.

Today fishes caught upstream at Wazirabad (especially above the barrage) are considered much better than those found down stream. On my visit to Wazirabad I made two observations. First the community of fishermen that are found much often along the banks are the recent immigrants from Bihar or Bengal. This was similar to my findings in Pakshi Vihar where there is in fact a whole settlement of immigrants from Bihar who either till the small farms near by or catch fish in mornings and late evenings. There is also a Bengali Club that pays them for their services. I found this to be an interesting social change. Secondly, I realized that my over excitement on discovering a small shrimp drying near a hut of a fisherman, was unfounded. Many fishes I was told were cultured in the river. The fisherman told me that he got many seeds for these fishes from the Barafwala. Mr. Malhotra however informed me that culturing Magur which is a carnivorous fish is banned.

Among the various other competitive sports in Delhi like wrestling, archery, kite flying, etc., swimming was greatly popular too. Swimming was considered a great accomplishment especially in Yamuna because of the fear of *magars* (crocodiles). Along the river mushroomed *akharas* or local gymnasiums. Many of the *akharas* also operated swimming schools. The Jungla Singh Tairak Sangh (Jungla Singh swimming association) at one time had more than 5000 members on its rolls. These *akharas* operated under the traditions of guru and *shagird*. Teams were also patronized by the elites of the city. The competitions were a matter of prestige and the elites were responsible for their teams. At the end of the course at the Zenat-ul-masajid (Daryaganj) they would recite their prayers.

Swimming in the river was not a pastime for the men alone, we hear that Mughal princesses too were fond of it, and of boating. Moonlight picnics were arranged on the waterfront; bathing on hot summer nights was a pleasure. Water for moat at Red Fort was controlled at a point near River Gate or Water Gate. The River Gate is incidentally also known as Mumtaz Mahal or Chota Rang Mahal. It was here that the Mughal princesses had their apartments, which were a part of the imperial seraglio, also known as the *Choti Baithak*. It is to the south of Rang Mahal, from the latticed windows of which the ladies of the harem watched animal fights held during the day. At night the mahal was the centre of song and dance and drinking sessions. The inmates of the seraglio used the River Gate to reach the Yamuna. A huge old wooden door can still be seen at the side of Rang Mahal. This was the entrance which was closed after the royal ladies had descended the staircase and reached the waterfront. Eunuchs with drawn scimitars guarded the two gates, while several of their kind accompanied the ladies, who either bathed on the banks or went in boats from which they jumped into the water. There were romantic escapades too, though most of the eunuchs were faithful retainers who had to guard the imperial ladies at the cost of their lives. There was a staircase which descended to the river bank. The princesses and their ladies-in-waiting used it for their leisurely swims and secret assignations. "When one thinks of the riverside games the princesses must have played, one does get the feeling that the Mughals led a full life".

The emperor and his entourage also went down the staircase when they wanted to enjoy the river breeze. Akbar used to have boats tied in the Yamuna at Agra if he felt like sleeping out on the river on some nights. Shah Jahan and his successors did the same, both at Agra and Delhi. But the begums had to be told in advance so that the men's plans did not clash with those of the *zenana*.

The elites of the walled city continued with the traditions of organising soirée long after the demise of the Mughal court, with equal panache. Professor Dehlvi remembers reading anecdotes about parties organised by *nawabs* on flat boats called *bajrā*. They had comfortable sitting arrangements and enough space to allow for dance and musical performances. These performances would take place mostly during bright moonlit nights. To create the ambience these boats were lit with camphor (kafori) lamps.

The experience of the river, now dead, still lingers in the childhood memories of many old timers. Mr. Ravi Mehra, a 1968 alumnus of Ludlow Castle School, remembers that the river used to flow very near to his school. "We used to bunk classes and escape to the ghats. Oh! What fun it was to splash around in the water, compete at stone throwing, or just lie on the sandy banks discussing gossips and modus operandi of future pranks. During summers the river would develop small islands of dry sandy patches over which we could cross to other side. I couldn't help but picture in my head the adventures of these local Tom Sawyers' and Huckleberry Finns. As a child Mr. Yogesh Bahadur eagerly waited for his cousins from Punjab to visit Delhi and together they would go to Yamuna for a swim. "Jamna was so clean then", he exclaims. Ms. Alvi remembers how her young nephew used to entertain himself by throwing stones into the river. The river had a steady flow without any unpleasant odour.

During monsoons schools would sometimes organise picnics at Qudsia Bagh or Okhla, remembers Dwijen Kalia, where "groups of boys would miss the eyes of teachers and escape near a ghat where the leaders of the group would take their shirts off and jump into water". At Okhla even lifeguards were employed. Mr. Mohammad Sheikh told me that if somebody drowns in the river at old Delhi, the police would inform us at Okhla as soon as possible and we would close the gates of the weir to be able to locate the body and then he went on to narrate few incidences trying to prove the authenticity of a local belief that the river Yamuna never lets a women drown in her waters.

The river was in some or the other way integrated into the daily lives of people of the city. Many Old Delhiwallahs habitually visited the ghats early in the mornings to bathe, to exercise at akhadas, or to get a massage. "We used to go to Qudsia Ghats for taking bath in the river and for tel malish" proclaims Mr. Kishen Mohan Gundhi "from Nigambodh ghats till Nilichatri there were provisions for men and women to take bath separately".

Across the river there were vast expanses of fields that allowed cool eastern winds or *poorvai* to gently sweep the city. It was a fashion amongst the young girls of Shahjahanabad to visit Thandi Sarak on a

phaeton for *tafri* (promenade), remembers Prof. Dehlvi with a smile. The street was called so because of its proximity to the river.

Ms. Tamkin Alvi who used to live in Zakir Nagar in Okhla not far from the river, remembers that in summer evenings the breeze from across Yamuna was very pleasing. Her father regularly went out for evening strolls to enjoy the breeze and the view of the river.

The Okhla Sailing Club would also regularly host night balls. These summer parties were normally held alfresco. "The river created a prefect ambience, we never felt the need for fans or coolers and only the womenfolk complained about the breeze bothering their hairstyles" exclaims Commander Sinha.

It is said that Yamuna was once known as Kalindi, the dark one. She was Sarjuga the daughter of the sun and the sister of Yama, Lord of death. She was so winsome that Sri Krishna's brother Balaram got besotted by her looks. Our ancestors were given to weaving folktales and venerations around the inspiring forces of nature. They also transformed this zeal into idolization through art forms, which symbolized their perception of that force. The goddess Yamuna is depicted along with Ganga in the sculpture of many ancient Indian temples, often flanking their entrance. Ganga, white as the moon, stands on a *matsya* (fish) or *makara* (crocodile). Yamuna is the dark goddess (Kalindi). She stands on a *kachchhapa* (tortoise). The two goddesses sometimes hold a *chamara* (fly whisk) in one hand and a flower in the other. Elsewhere, they may be seen wielding a *purna-kumbha* (jar of plenty). In the Mahabharata, the Yamuna is a sacred river. In the course of their tour of important places of pilgrimage (*tirthas*), Yudhishtra is urged by the sage Lomasha to bathe in the Yamuna, the gateway to Kurukshetra. It is believed that once when the Ganga was in spate, she threw up the *Shastras*, sacred texts of the Hindus, on her banks this site is marked by a temple, known as Nigambodh (Sacred Knowledge) Ghat on the banks of Yamuna, were many now perform the last rites of life.

"Temples are built on the terraces and elbow bends of a river. These terraces are created either due to prolonged siltation and accumulate into a stable block. These deposits are very fertile. Settlements crop next to fertile lands and temples are built in between these settlements" explains Mr. KK Mojumdar of Geography Department, Delhi University. All along the right bank of Yamuna, there are variety of ghats and temples. In the past, these *ghats* and the *akharas* situated near them used to be the centres of social activity in the city. Saints, *pirs* and penitents often visited these *akharas*. Outcastes, orphan and rebels were given shelter and food.

Under Wazirabad masjid there are remains of a staircase which the locals believe was used by Bela the daughter of Prithvi Raj to descend down to Yamuna for her daily prayers. RV Smith writes in his book "Delhi no one knows" that the main part of the Ramlila celebrations then used to be held on the Yamuna bank, with the Mughal emperor looking on from the Red Fort

"On any religious occasion which calls for taking bath in river, for example Ganga snan, baisakhi, marg snan, people would bathe in Yamuna especially if they were unable to visit the ghats of Ganga. Sometimes people would bathe in Yamuna for a whole month, everyday" remembers Mr. Ravi Mehra. A letter of concern sent from the Deputy Commissioner's Office to the Police Authorities observes "*People bath in Jamuna in large number, on Baisakhi and other festivals. I am told that yesterday about 12 people drowned in the river. There were no rescue arrangements*." It is interesting to note that even in the months of April and May the river had water deep enough to cause such havoc on people.

"Water was allowed to pass from Wazirabad before the beginning of any festival in order to clean the river" informs Dwijen Kalia. "But from last 15 years or so most of the festival near the water has shifted towards Wazirabad" adds Mr. Ravi Mehra.

On my visit to Wazirabad barrage with Bhagwandass under the scorching heat of mid May sun, we stopped at a small kiosk for refreshments where I had to explain a group of really curious audience, why I was shunting up and down the bridge and peering over it at intervals. To avoid making a long conversation I told them that I had come to survey the river. Their immediate response was a frustrating query. "Madam why can't they open the gates of the barrage and let the water cleanse the river…..he went

on to narrate that before there used to be so many ceremonies from Basakhi to Kali Pooja for which people used to immerse flowers, idols and
confetti in the river but the next day one could find only a few remnants of the festivities.

Mr. Ravi Mehra recalls that water of the river was very clear and clean without debris, except for the algal growth sometimes along rocky banks. Ms. Tamkeen Alvi remembers that at Okhla the river held flowing water and had no stink, weed or hyacinth. "In summers when the water level recede, workers cleaned the river bed with a crane like machine and removed silt and sand from the banks". In 1964 Commander Sinha participated in the National Regatta hosted by the Okhla sailing club. During the course of the event his yacht capsized and he fell in the water. While struggling to get back on board he accidentally swallowed some water, which he describes tasted like mountain spring.

"The most vivid memory that I have of my childhood is that during monsoons water used to come inside our home. But instead of loosing nerve our elders would smile and say Yamuna has come to our home to bless us". Professor Kalia used to live near Kashmiri Gate and was perhaps in fifth standard. The water, he insists was not sewage. "There was no stink". Water would enter the city after breaking the kucha kinara along the bank and would stay for three four days and then recede. This was a normal part of monsoon life in Delhi. "We knew that such a thing would happen in July or August" he asserts. "During floods", he recalls "water would reach till ISBT and my mother would take us in the evenings to see the '*baad*' from Chandni Chowk". River in full spate was very inviting for those who wished to commit suicide. His mother had spotted a few such desolate souls and tried to talk them out of such ventures. "One girl in fact stayed with us at our home for three months".

"Yamuna used to flow where the present ISBT Ring Road is situated, along the Hanuman Mandir. During floods the water would come till Calcutta Gate which was near the railway bridge called Calcutta Bridge. There is a jat dharamshala just next to it" reports Mr. Mehra manager of an old dharamshala at Kucha Ghasi Ram. Before the *samadhis* of the political leaders were constructed, the floods of Yamuna would leave behind a large wetland which would attract Siberian cranes and many other birds. Many a times the ring road would submerge under water during rainy season especially at Maharani Bagh. Inner ring road was the outer boundary of the city then. In the 1978 floods it was predicted that the Loha Bridge would get washed off.

Delhi District Gazetteer of 1883 informs: "In the floods of the rainy season the river has a considerable breadth swelling in places to several miles, with a maximum depth of some 25 feet. In the cold weather its normal depth is said to be four feet only; the stream is only sufficient to feed the three canals which draw from it …." Floods are systemic to Yamuna, Najafgarh and Sahibi networks.

The Yamuna crossed its danger level (fixed at 204.83m) twenty five times during the last 33 years. Since 1900 Delhi has experienced six major floods in the years 1924, 1947, 1976, 1978, 1988 and 1995. The peak level of Yamuna River was one meter or more above danger level of 207.49m at old Yamuna Rail bridge (2.66m above the danger level) occurred on sixth September 1978. The second record peak of 206.92m was on 27th September 1988.

Dr. SK Ghosh narrates his experience of 1978 floods "at Tajewala the river changed its course and flooded the banks on both sides. First warning from the meteorological department was issued in August and observers were stationed all along the river. They were not sure about the flood. The flood waters normally take two days to come towards Delhi. By 6th September the river was filled to its brim.

The Irrigation and Flood Control Department received warnings on 2 September 1978 that a discharge of level more than 7 lakhs cusecs (maximum level, after which there was no bench mark) had passed through Tajewala. It had rained persistently from 31st August to 2nd Sept. Those installed at the head-works from the Haryana Irrigation Department had to flee away. The heavy discharge had dead bodies and broken tree trunks. A breach had occurred on the right bank of the Drain no.8 which caused the water to flow in the city. The bunds were weak and the embankments got breached. Desperate thinking commenced at higher levels. Some suggested that the railway tracks should be blasted so that the pressure on Trans Yamuna could be reduced. But it was decided otherwise because the fall of debris may cause the

water in the river to rise and may also close any possibilities for escape for the TransYamuna residents. Areas in trans-Yamuna are low lying where in the wake of floods swamps and marshes crop up. It was decided thus to breach the Shah Alam bund and let the Model Town area flood. "The flood water over topped and breached the walls of a pump house at Shah Alam bund. The entire GT road was under water and the entire Alipur Block got inundated. These (marginal) bunds are normally earthen.

The residents were pre warned by the Revenue Department through media and by '*Munadi*'. Wealthy people left their cars at an elevated surface and started motor boating in the lanes. The water filled the entire ground floor. Residents of the villages located on the river bank like Jagat pur, Wazirabad, Gadi mandi, Osman pur, Chauhan patti, Gujran, Sherpur, Sadat pur, etc, had to be evacuated with the help of army boats.

After the floods personnel of Irrigation and Flood control department got busy with raising bund levels, undertaking repair works, etc. RME, LMB and Shahadra Ninor Bund were raised and strengthened, Bhawana escape was diverted and brought along GT road near Wazirpur barrage so that the Alipur sector is not affected. The Public Works Department erected Road Number 50 which acted as an embankment to save the city against flood. Near Jagatpur and Wazirabad villages Left Forward Bund was constructed. Dhaisra bund of Haryana was raised and strengthened by paying money to Haryana government. Drain no. 8 on the right bank of the river was strengthened. Anti-erosion works were taken to safeguard the bunds. During both the floods (77 and 78) Mr. AK Gupta was Assistant Engineer holding charge at Najafgarh Drain and, Wazirabad-Timarpur area. Water was backing up at Najafgarh Drain and these inlets had to be stopped. His team was given the charge to safe guard these inlets. Metcalfe and Qudsia outfall regulators were in their charge.

Delhi Environment Status Report by WWF for Nature-India (1995) observed that since 1978, the flood threat to Delhi has increased. In 1980, a discharge of 2.75 lakh causes at Tajewala resulted in flood level of 212.15 meters at the bund near Palla village in Delhi. In 1988 also Delhi experienced fierce floods. Dr SK Ghosh informs me that due to heavy rains the water stored in the Bakra Nangal dam also flooded, aggravating the situation in Delhi.

According to Mr. AK Gupta, main reasons for this rise of water level is not a part of natural process but release of excess water from Tajewala headworks upstream to the two canals one on left and other on the right bank of the river. Rise in water levels caused over flows in the connecting drains and increase in monsoon related diseases.

During the past few years, flooding due to the city's 18 major drains has also become a common phenomenon. Already under the pressure of the city's effluent discharge, these drains experience reverse flow from the Yamuna during monsoons, as a result they tip their banks, flooding the neighbouring colonies.

A significant phenomenon which has been increasing during recent years is that of local flooding. Urban areas are characterized by a high area under impervious surfaces (Roads, pavements, houses etc). High rates of development along with the resultant loss of natural landscape have led to high surface water run-off rates. This results in flash floods in the low lying areas even after moderate precipitation.

Flood Plain Zoning is phenomenon of demarcation of the areas that is liable to be affected by flood of different magnitudes and frequencies and the regulation of the use of such areas. The flood prone areas of Delhi have been classified into thirteen zones based on flooding risk in relation to incremental rise in the water level of the Yamuna (DDA, 1993). These cover a range from 199m to 212 m level of water in the Yamuna. This zoning map covers part of North Delhi on the West bank of the Yamuna and almost the entire Trans Yamuna Area on the East bank. Besides this, the Delhi Flood Control Order also the NCTD into four Flood Sectors, namely Sectors, namely, Shahadra, Wazirabad - Babrapur, Alipur and Nangloi - Najafgarh sectors. By creating such zones, developmental activities in the different zone of the flood plain are organised in such a manner that the inconvenience and damage due to flood are minimized. This was so far not been implemented.

Occupancy if the flood plains for agricultural, industrial and urban development have always been attractive due the various advantages such as fertile nature of the soil, availability of water and river transport facilities. Consequently, in spite of the risk of damage by flooding, considerable encroachment has taken place in the flood plains in several areas. While it is possible to demarcate the flood zones in such areas and to legally restrict their use, it may not be easy to enforce it in the already developed areas, both on account of likely public opposition and the magnitude of rehabilitation programme that will involve.

Even much after independence, Delhi witnessed its urban development along the western side of the river, placed much higher and less flood prone than the eastern side. Dr. Narayani Gupta insists that many viewed the River as a menace.

Pre-partition, the *bundhs* were not constructed, so during the monsoons, the flood basin used to be submerged under water. Hence, agrarian activities used to be only seasonal. The low-lying areas used to act as a buffer for the overflow of water during the monsoons. These are seasonal low-lying farmlands that remain underwater during the monsoons. At the site level this zone appears to be a large open space, which connects the urban edge of the zone to the river. There are some pockets of temporary hutments, which change in character with the changing season. It was only after the construction of the *bundhs* in 1960's by the Delhi Government Drainage schemes solved the problem of floods the area recovered could easily become habitable.

Raising of embankment or construction of embankment on river Yamuna is one of the flood control measures which may be required for flood control in NCR. Embankment is generally the cheapest, the quickest and most popular methods of flood protection. These embankments are strengthened further by creating spurs and shanks; they jut out perpendicular to the embankment. Spurs and Shanks are a part of River Training Works. They are meant to keep the active flow of the river away from embankments. During floods the flow of the river can erode the masonry works of the embankment causing it to collapse. Spurs impede the flow of the water and tames it along the embankment[25]. Locally they are known as thokkars.

The *kar sevaks* initiated the local citizenry to aid them, in making a bund which is now known as Bela road. These efforts were undertaken to prevent the city from getting flooded during the rains. I was told that this bund was later extended to constitute the present Ring Road. To prevent the Cremation parks (Raj Ghat, etc) from inundating, embankments were erected on its riverfront. After the 1978 floods various embankments were erected at Mukherjee Nagar, Jehangirpuri etc. Real estate value of the low lying areas like Shakarpur, Laxmi Nagar, etc. increased only after the fear of inundation during rains was checked by making embankments along the river.

But there are number of inherent environmental problems. Also they are liable to be breached by over-topping erosion, seepage, leaks and cracks which may result as environmental consequences. Bunds remain earthen for its low cost value, lining it with cement works would be very costly. It is not because of the percolation as it is not affected drastically. And therefore need constant and often expensive maintenance. Embankments are designed to cater for a flood of specified frequency which the general public is normally not aware of and with the sense of security provided, there is likely to be excessive development on the land side of embankment. This may cause serious deposition of silt and debris in the river bed in case of breach of embankment. Also embankments can cause an increase in flood heights up stream, and drainage difficulties in the country side. Secondly, the areas which used to be inundated by the floods and get the benefits of silt laden water are deprived of this due to the construction of embankments. This has direct impact on environment of agriculture field. Where the river channel between the embankments cannot develop adequate velocity for carrying down its silt load, the deposition of silt may lead to rise in the bed level and consequent higher flood heights. There will be impact on existing environment. In such cases they require to be supplemented by training measures

which will induce siltation near banks and erosion of the bed and enable the river to carry its silt load effectively. The silt is also dredged out from river bed mechanically to create velocity and erosion of bed.

Although the unprotected flood prone area is only 1.7% or 25km only towards the south east and about 5% or 74 sq km in the north eastern parts which is protected by earthen embankments every year water level rises in Yamuna above danger level and large population has to be evacuated to the top of the bunds and Delhi highways.

The Yamuna is harvested at the Wazirabad and Chandrawal waterworks. Wells were constructed in Chandrawal village in 1889 to provide Delhi with tap water for the first time. The harvesting of Yamuna began in 1925 with a bund at Waziarbad village across the river. Subsequently, a weir was raised in 1957 just before the point where the Najafgarh drain falls into the Yamuna. This led to a massive cholera epidemic during the 1950s.

Wazirabad Barrage was made in 1959 to supply drinking water to Delhi through two plants. Delhi's water supply came from WYC from Haryana[26].

The ITO barrage was erected to divert water to the Indraprastha Power Station. Thermal Power Stations run on coal which has to be burnt to provide energy. Hot coal after burning has to be cooled. Water diverted from ITO was thus used as a coolant.This process however produced large quantities of ash that was deposited along the open flood plain now known as Nagla machi situated behind Old Fort. Ash deposited here was to be removed every day and taken away by trucks. Government paid for this work. However, this activity could not be maintained efficiently, therefore ash remained deposited there and was continuously blown around with wind.

Mrs. Tamkin Alvi booked their house in Patparganj in 1986. Before its development the area had many sand *tilas* (mounds) through which it was not possible to drive. Therefore they had to park their car at Patparganj depot. Driving across Nizam-ud-din Bridge to reach the construction site was sometimes very difficult, especially during rainy days. "There were days when the visibility would just extend to 5 to10 meters. Anyways driving over it in late hours was quite a scary experience.

Mr. Virender Jain had a cousin living in Daryaganj where they would visit and at nights they would sleep on the terrace. In the mornings their sheet would be covered by ash and dust particles coming from the newly constructed Power Station. They had experienced a similar fate two decades before at Pahari Dheeraj but this time the cause was the chimney of the DCM factory just in the vicinity.

Okhla barrage was created to divert the river water into Agra Canal. When closed the barrage creates an artificial pondage which over the years became habitat of migratory birds. In 1991 the barrage was given the status of a sanctuary. "Bird watchers and hunters frequented the barrage. The barrage occasionally caused excitement when fast flowing water jumped across its gates and sometimes along with the waves fishes were also compelled to follow this acrobatics" remembers Mohammad Sheikh.
As far back as 19th Century the author of Asar us Sanadi complained about the scarce water supply from Yamuna, which according to him had considerably reduced because the water was regularly diverted by the canals (*nahar*). He observed that even the quality of water had suffered.

Although Delhi is situated on the banks of the river Yamuna, it is unable to draw water from the river, as the entire flow of the river is diverted by the Government of Haryana and Uttar Pradesh into their canals upstream of Tajewala under the draft agreement signed in the year 1954 between the Chief Engineer of Punjab and Chief Engineer of Uttar Pradesh, which was primarily an instrument for operation of their canal system.

In 1994, Chief Ministers of the five basin states viz. Uttar Pradesh, Haryana, Rajasthan, Himachal Pradesh and Delhi signed the "Yamuna Water Accord". According to this agreement different share of Yamuna

water was allocated to respective participant states. Haryana got the largest share of about 5.73 BCM, follwed by Uttar Pradesh with 4.032 BCM. 1.119 BCM of water was also diverted to Rajasthan along with 0.378 BCM to Himachal Pradesh. Finally Delhi only was given a miniscule share of 0.724 BCM.

There is hardly any flow downstream of Tajewala except regeneration. Commodore Sinha insists that the water started becoming unpleasant from 1985 onwards. More and more water was being diverted to the Western and Eastern Yamuna Canals for irrigation. Finally by the end of the eighties, no water was being allowed to flow downstream of the barrage at Tajewala, and greater amounts of sewage was being deposited in it (due to rise in population), converting the Yamuna into a dead river for eight months of each year. The Central government at Delhi watched helplessly on, unlike the predecessor British Government, which had expressly barred withdrawals from the river beyond the levels of adequate flow. By 1988 as a result of the untreated sewage disposal the water smelled bad and had lost its flow. The old sewage plants called STP's were of old design and treated only a small part till the secondary stage.

Delhi, therefore, has to depend upon the neighbouring states to meet its drinking water needs. Since 1983, Delhi has been drawing water not only from the Yamuna but also from rivers of Punjab- Ravi, Sutlej and beas- through the Bhakra-Beas storage system; from the Ganga and it tributaries; and from groundwater wells in and around the city. Delhi's water system is, thus, dependent on five rivers, and on the five states through which these rivers flow- Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana and Uttar Pradesh. Delhi's water supply system will work well as long as the rivers on which it depends provide water; the state chief ministers remains docile to Delhi's rulers; and there is no sabotaging of the watercourses. Should any one thing go wrong anywhere, the whole water grid will go haywire.

Presently, the water in Delhi is supplied from three points- Chandrawal and Wazirabad in North Delhi, Haiderpur in West Delhi and Bhagirathi in east Delhi. The Okhla plant in south Delhi had to be closed because the potability of the water became very low. Some 19 drains empty into the river. The water from Murad Nagar Ganga canal was initially meant for the TransYamuna colonies but was transferred to south Delhi. Delhi has been facing acute shortage of water for operation of its water treatment plants at Wazirabad (120MGD) and Chadrawal (90MGD), except during monsoon season. The citizens of Delhi remember the traumatic experiences of the months of April and May 1988, when water level in Wazirabad and Chandrawal fell dangerously low and the two plants had to be closed down. The third was operating at about 20 percent of its capacity. With the rapid growth of population and urbanisation, water demand has increased rapidly and urgent action is called for to get due share of Delhi from river Yamuna itself.

The change in water quality, reduction in flow, control of the river meandering and the extensive cultivation within the floodplain, has led to substantial changes in the vegetation of the *khadar* tract (reference). Mr. Ravi Mehra laments that these days vegetables don't taste like they used to." He retorts "the vast grey expanse of slum and garbage has taken over the green vistas".
Lack of flow in Yamuna also destroyed the eco-systems maintained by the river; economy of many fishing villages has been destroyed, with fishermen migrating to other areas to seek other jobs. The polluted Yamuna water is today no longer used for the gardens and lakes near a *samadhis*. Groundwater is used for this purpose. As the river flows down it gets more and more polluted and covered by water hyacinth, a weed which indicates growing water pollution.

After the *samadhis*, the Rajghat and Indraprastha power stations discharge hundreds of tons of fly-ash and other toxic materials into the river. Large expanse of agricultural farms placed along the river. Open spaces, however, are unstructured and are resultants of the left-over spaces from the settlements having come up legally. Also, these open spaces were conveniently used as dumping grounds for ash that is produced as a by-product of the Thermal Power plant on the zone. Over the years, these 'ash ponds' have been filled with ash, resulted in huge mounds of ash. This whole phenomenon has ensured contamination of not just surface water but also ground water.

Delhi not only needs freshwater but also a system of disposing off the wastes created by about 15 million inhabitants and a number of industries. Some 19 drains from Delhi open into the Yamuna. Waste disposal arrangements in Delhi are extremely poor. City's engineers, instead of laying down sewers, simply

discharge the polluted water into the 19 channels that originate in the Aravalli hills. At one time these channels acted as streams for draining off rainwater, and in the process recharged many wells and *baolis*. However, now these channels carry more industrial pollutants and domestic sewage than rainwater. As a result, on their way to the Yamuna, they pollute all the water bodies.

The most polluted of these is the Najafgarh drain, which is located just about 100m downstream from the Wazirabad pumping station. In between is the Wazirabad weir. Except in winter and the monsoon season, thousands of sand bags are put between the barrage and the drain to avoid contamination of water at the pumping station. The 1982-86 statistics of the Central Pollution Control Board show that the drain discharges on an average 1.028 million cum sewage per day.

At Okhla, the Yamuna is transformed once again into a broad river from a nullah, this is because just before the Okhla barrage, the Hindon cut canal discharges a huge amount of water into the Yamuna to supply water to the Agra canal. Until 1984 south Delhi colonies used to get water from the Okhla water treatment plant. However, cholera and Jaundice epidemics forced the municipal corporation to stop water supplies from Okhla, and to link south Delhi with the Bhagirathi water supply. The old Okhla barrage is no longer functioning due to heavy siltation. The mouth of the Agra canal is full of weeds and water emits a foul smell. A new barrage has been constructed just 3km downstream from the old one. At the barrage, the Yamuna gets diverted into Agra Canal carrying with it the wastes of a mega city. Beyond the barrage, the river itself disappears and only the riverbed exists.

ANNEXURE VII
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