2006

Assessment of Water Pollution and its Impact on Fisheries Resources of Posna Beel, Kalihati, Tangail

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University of Rajshahi

ASSESSMENT OF WATER POLLUTION AND ITS IMPACT ON FISHERIES RESOURCES OF POSNA BEEL, KALIHATI, TANGAIL

A Thesis
Submitted to the Institute of Environmental Science (IES),
Rajshahi University for the Degree
of

**DOCTOR OF PHILOSOPHY
IN
ENVIRONMENTAL SCIENCE**

By

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Rajshahi- 6205
Bangladesh

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June 2006

DEDICATED
TO
MY PARENTS WHO OPENED MY EYES TO THE BOUNTIES OF NATURE

DECLARATION

I do hereby declare that the entire work submitted as thesis for the degree of **Doctor of Philosophy** in the Institute of Environmental science, University of Rajshahi, Bangladesh, is the result of my own investigations.

I further declare that the work embodied in this thesis has not already been submitted in substance for any degree and has not been concurrently submitted as a candidature for any other degree.

11.06.06

Ashraful Alam
(The Candidate)

CERTIFICATE

We have the pleasure to certify that the thesis entitled as **Assessment of Water Pollution and Its Impact on Fisheries Resources of Posna Beel, Kalihati, Tangail** is original research work carried out by Mr. Ashraful Alam for the degree of Doctor of Philosophy in Environmental Science. To the best of our knowledge, this is the researcher's own achievement and not a conjoint work. The thesis or thereof the part of it has not been submitted to any other university for any degree.

We also certify that the research work has been carried out under our direct supervision and the thesis is found satisfactory for submission to the Institute of Environmental Science, University of Rajshahi, Rajshahi, Bangladesh. Moreover, Mr. Ashraful has fulfilled all the requirements according to the rules of Rajshahi University for Ph.D. degree and has made distinct contribution to the field of Environmental Science.

We, therefore, are forwarding the thesis to be submitted for the degree of Doctor of Philosophy to the Institute of Environmental Science (IES). University of Rajshahi.

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ACKNOWLEDGEMENT

At the outset, the author bows down his head to Almighty Allah for giving enormous blessing for successful accomplishment of this research.

The author feels pleasure to express his deepest gratitude, profound appreciation and best regards from the core of his heart to reverend supervisors, Professor Dr. M. Sarwar Jahan, Director, Institute of Environmental Science, University of Rajshahi and Dr. M. Zaman, Professor, Department of Botany, University of Rajshahi for their untiring supervision, endless and dynamic guidance, valuable suggestions and constant encouragement for the successful completion of this research work.

His sincere gratitude and deep appreciation go to Md. Abul Kalam Azad, Assistant Professor, Institute of Environmental Science, University of Rajshahi for his encouragement, corrective advice and providing the laboratory facilities with financial assistance through Posna beel fisheries project.

The author would like to be thankful to all his respectable teachers, secretary, all fellows and office staff of the Institute of Environmental Science (IES) for their direct and indirect help in course of study. He also offers his immense thanks to his batch mate research fellows Mr. Kamrul Ahsan, Mr. Monirul Haque, Mr. Norul Bashar and Mr. Tarekh Rasul for their open discussion and giving valuable suggestions on this research topic.

The author is indebted to Dr. Sabrina Naz, Associate Professor. Department of Botany, University of Rajshahi and Dr. M. Nazrul Islam, Professor, Department of Zoology, University of Rajshahi for their spontaneous cooperation and invaluable suggestions during the research work. He is also indebted to all M. Phil. and Ph. D. fellows of Phycology and Limnology lab, Department of Botany, University of Rajshahi for their kind cooperation, who helped to identify the plankton taxa.

The author wishes to thank Dr. Abu Hanif Sheikh, Chairman, Department of Geography and Environmental studies, Professor Noor Mohammad, Department of Geography and Environmental studies, Dr. M. Mushfiq Ahmed, Professor, Department of Geology and Mining, University of Rajshahi and Dr. M. Amjad Hossain, guest teacher of IES for their affectionate encouragement and keen interest in this research work.

He would like to acknowledge his gratefulness to Mr. Saifur Rahman, Director. Institute of Food, Nutrition and Radiation Biology, Bangladesh Atomic Energy Commission and, P.S.O and S.O of SRDI laboratory, Shampur, Rajshahi for extending all sort of laboratory facilities and their kind help.

The author gratefully acknowledges the Worldfish center and DFID-UK for financial support to carry out the research work, especial thanks to Mr. Golam Mustafa, coordinator, WorldFish center for his valuable suggestion and cooperation throughout the research work.

The author sincerely acknowledges the Center for Natural Resource Studies (CNRS) for providing the seasonal fisheries data and giving valuable materials and information of Posna beel.

He is sincerely thankful to inhabitants of Posna, Sheroil, Kaluha and Monotia Villages for their kind cooperation during the field works.

The author owes to his relatives, friends and members of ARF (R.U) for their good wishes and blessing to furnish the research works gently.

Finally, he expresses his heartiest gratitude to the members of his family, especially his elder brother Md. Abul Kalam Azad and his wife Mrs Dilshad Azad for their inspiration, moral support, and sacrifices.

The Author

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ABBREVIATIONS

Alk	=	Alkalinity	ppm.	=	Parts per million
BOD	=	Biochemical Oxygen Demand	rH_2	=	Oxidation-Reduction Index.
Cl.	=	Chloride	SD	=	Standard Deviation
cm.	=	Centimeter	Sp-1	=	Research spot-1
COD	=	Chemical Oxygen Demand	Sp-2	=	Research spot-2
DO	=	Dissolved Oxygen	Sp-3	=	Research spot-3
Eh.	=	Oxidation-Reduction Potential	Sum.	=	Summer
Fig.	=	Figure	TH	=	Total Hardness
g.	=	Gram	TPA	=	Total plankton abundance
h.	=	Hour	TPPA	=	Total phytoplankton abundance
Ha.	=	Hactre	Trans.	=	Transparency
HYV.	=	High yielding variety	TS	=	Total Solid
Kg.	=	Kilogram	TSP	=	Triple super phosphate
m.	=	Meter	TZPA	=	Total zooplankton abundance
meq	=	Milli Equivalent	u/l	=	Unit per Liter
mg/l	=	Milligram per liter	Win.	=	Winter
ml.	=	Milli liter	yr.	=	Year
mm.	=	Millimeter	%	=	Percentage
Mon.	=	Monsoon	%sat.O_2	=	Percentage of Saturated Oxygen
MP	=	Muriate of potash	µg/g	=	Microgram per gram
mv.	=	Milli volt	^0C	=	Degree Centigrade
nm.	=	Nanno-meter	±	=	Positive /Negative
OM	=	Organic Matter	≤	=	Greater than
P	=	Page	≥	=	Less than
Pl.	=	Plate	*	=	5% level of significance
PM	=	Post monsoon	**	=	1% level of significance
PP	=	Phytoplankton	+	=	Positive
pp.	=	Total printed page			

ABSTRACT

Posna beel is an important perennial waterbody in Kalihati Upazila of Tangail District. The beel area is 121.5 ha in monsoon and 9.0 ha in dry period. The beel is the main source of fish for Pouzan, Balla, Rampur and Elenga Bazars.

A research work for two years was carried out on the water quality, Agro-chemical use, and pesticide residue and beel sediment of Posna beel. From water quality monitoring, it was found that the beel water was very suitable for open water fisheries. The levels of concentration of some water pollutants such as ammonia (0.012-0.076 mg/l) and nitrate (0.15-0.48 mg/l) were very low while the bio-chemical parameters such as BOD_5 (2.70-5.43 mg/l) and COD (5.20-8.15 mg/l) were slightly high. Nitrite was found zero round the year. The values of DO vary from 6.66 mg/l to 9.66 mg/l, which was suitable for fishes and other biota.

According to the field survey, the farmers in the beel area was found to using 113.14 kg urea per acre against the government recommendation level of 87.0 kg per acre. On the other hand, application of TSP, MP and Gypsum were lower than the government recommendation level.

Both the beel water and sediment were free from Organophosphorus and Carbamate pesticides. However, a very trace amount of Organochlorine (DDT, heptachlor and dieldrin) pesticide was found in the beel sediment and water sample, which was negligible in the context of pollution. From the survey on agro-chemical use, it was found that farmers around the Posna beel were not using organochlorine pesticides in HYV Boro field. The presence of a trace amount of Organochlorine pesticides in water and sediment samples may be for the past use of these pesticides for mosquito eradication in this area.

From sediment study, it was found that the Posna beel sediment was rich in nutrient matter. It contains a high amount of organic matter (3.84-6.25 %) and some essential metal compounds such as Iron, Manganese, Copper and Magnesium. Nitrogen was found at medium level, whereas phosphorus level was low.

A total of 47 genera of Phytoplankton was recorded , of which 19 genera belonged to Chlorophyceae, 13 to Cyanophyceae, 10 to Bacillariophyceae, 3 to Euglenophyceae, and 2 to Dinophyceae. Dinophyceae was found to be dominant (57.60%) followed by Chlorophyceae (25.26%), Cyanophyceae (9.02%), Bacillariophyceae (4.09%) and Euglenophyceae (2.09%). The seasonal abundance of Phytoplankton was found to be dominant in winter followed by Post-monsoon, monsoon and summer. Zooplankton comprised of 40 genera of which 13 belonged to Rotifera, 13 to Cladocera and 8 to Copepoda. The Copepoda (37.87%) dominated the Zooplankton population followed by Cladocera (27.37%), Rotifera (20.95%) and Crustacean larvae (7.62%).The Zooplankton abundance was found to be dominant in post-monsoon followed by monsoon, winter and summer. In winter'04, only Dinoflagellates plankton bloom was observed throughout the study period.

The study revealed that the fish diversity of Posna beel was not so rich. A total of 48 species from 33 genera and 16 families were recorded during the study period. The familywise species were: Amphipnoidae 1, Anabantidae 1, Bagridae 4, Belonidae 1, Cyprinidae 16, Centropomidae 3, Channidae 3, Cobitidae 1, Clupeidae 1, Claridae 2, Gobiidae 1, Heteropneustidae 1, Mastacembelidae 3, Notopteridae 1, Osphronemidae 3, Pristolepidae 2, Siluridae 4 and Tetradontidae 1.

Among the fish fauna, *Jat Puti* (*Puntius sophore*), *Kanchan Puti* (*Puntius conchonius*), *Tengra* (*Mystus vitatus*), *Kholisha* (*Colisa fasciatus*) and *Gura Icha* (*Machrobrachium lammarrei*) are very common and *Koi* (*Anabus testudineus*), *Meni* (*Nandus nandus*), *Chanda* (*Chanda baculis*), *Taki* (*Channa punctatus*) and

Shing (*Heteropnuestes fossilis*) were moderately common in Posna beel. Some national endangered fish species like *Napti Koi* and *Dankina* (*Rasbora danicunius*) were found vulnerable level in this beel. However, *Tilo Taki* (*Channa gachua*) was vulnerable and *Potka* (*Tetradon potka*) was common nationally but both were endangered in Posna beel.

The non-fin fisheries resources were Prawn (4 species), Crab (1 species), Mollusca (8 species), Amphibia (1 species) and Reptile (1 species). The presence of a total of 63 fisheries species indicates that the Posna beel was still poor in fisheries diversity.

During the 2-years of study from 2003 to2004, fish harvesting was on the average 1516 kg/month and 283.21 kg/ha/year in the Posna beel. Most of the fish are harvested from November to April. Cypriniformes were dominant group with 35.38% of the total fish catch followed by Perciformes (21.07%), Siluriformes (16.61%) and Channiformes (12.14%). The Ceridian prawns constituted 3.94% of the total catch. The abundance of minor carp fishes was always higher than the major carp in the study area.

The physico-chemical and biological parameters indicate that the beel is eutrophic in nature and fits well with piscicultural practices.

Chapter 1
Introduction

1.1 Water Resources of Bangladesh

Bangladesh is the delta for all the major river systems of the vast catchment area of the Himalayas and the Gangetic plain. The major river systems are the Ganges, the Brahmaputra and the Meghna. Their combined peak flow is nearly 6 million cusecs which drain into the Bay of Bengal (Ali, 1991). These river systems along with their tributaries and distributaries number 230. Of the 230 rivers, 54 are shared with India (Ali, 1994).

The country is very rich in inland capture fish production as an attribution of the geographical characteristics of the deltalic land uniquely set-up by the three majors river systems. During the wet monsoon, various components of this dynamic fluvial system (rivers, haors, baors, beel and flood plain, and estuaries) become interconnected and integrated into a single biological production system providing opportunities to move, breed, feed and grow. According to World Bank (1989) Bangladesh ranks at the top for production of fresh water fishes (4076 kg/sq.km.) and in terms of total production and per capita fish production of about 5.5 kg, it stands third after China and India as the world's largest inland fish producing country. There exist 260 species of finfish belong to 55 families in the inland open-water system of Bangladesh (Rahman, 1989).

The inland water resources of the country occupy an area of 4,42,24157 hectares, which is undoubtedly one of the richest in the world. The open water areas of inland fishery comprises 10,31,563 hectares of rivers, canals and estuaries; 1,14,161 hectares of natural depressions such as the beels and haors; 68,800 hectares of Kaptai lake and 2,832,792 hectares of flood plain which get inundated in the monsoon. The retaining water for 4 to 6 months can be utilized for seasonal fish culture. The close water or culture fishery comprises 241,5000 hectares of ponds, 5,488 hectares of baors and 1,41,353 hectares of brackish water aquaform (Table 1.1) (BBS, 2001).

Table 1.1
Annual Total Catch and Area Productivity's Sectors of Fisheries for July, 2001-June, 2001

Sector of Fisheries	Water Area (Hectare)	Total Catch (Metricton)	Percentage	Catch/Area kg/Hectare
A. Inland Fisheries (I) Capture				
1. River & Estuaries	1,031,563			146
2.Sundarban		12,035		
3. Beels	114,161	74527		
4.Kaptai lake	68,8000	7,051		102
5. Flood lands	2,832,792	445,178		157
Capture Total	**4,047,316**	**688,920**	**38.68 %**	
(II) Culture				
1. Pond & Dictches	241,500	615,825		2550
2. Baors	5,488	3,801		693
3. Shrimp Farm	141,353	93,014		653
Culture Total	388,341	712,640	**40.01 %**	
Inland Total			**78.69 %**	
B. Marine Fisheries				
1. Industrial Fisheries		23,901		
2. Artisanal Fisheries		355,596		
Total Marine			**21.31 %**	
Country Total		**1781,057**	**100 %**	

Source : BBS, 2001.

The country has 480 km. long coastline and approximate 10,00,000 hectares of territorial water resources (Karim, 1978), the country's exclusive economic zone (EEZ) extends 320 km out of the sea from the coastline. Thus the nation's total area of water having fish production potential is very great (Karim, 1978).

1.2 Importance of Fishery Resources of Bangladesh

Fishery is one of the major sub-sectors of agricultural economy in Bangladesh. It plays a dominant role in the socio-culture and economic life of the country by creating job opportunities, meeting nation's protein requirements and earning foreign exchanges.

A great number of people, 1.2 million directly and 11 million people indirectly are engaged in earning their livelihood from fishery (FFYP, 1997-2002).

More than 63% of animal protein comes from fish alone (DOF, 2003). Besides, fish is an excellent source of protein containing all the 10 amino acids in desirable concentrations for human being and available at cheaper rates (Menon, 1991). Fish is not only an important source of protein but also a source of good quantities of fat, vitamins and minerals like calcium, phosphorus etc. the other nutrients essential for human health are also available in fish. It contributes about 6 percent of vitamin A, 2 percent of niacin and 4 percent of Vitamin C (INFS, 1983). According to a local agent reflects the role of fish in the food habit, diet and nutrition of the people, *Mache Bhate Bangali.* i.e Bangali body is made up of fish and rice. Fish and fisheries have been an integral part of the bengali life.

Although the rate of production of fisheries has increased, the per capita fish consumption is decreasing day by day. In 1926-63, the per capita per day fish consumption was 33.0 gm but in 1995, the per capita per day fish consumption fell down to 18.0 gm only against the estimated requirement of 73.0 gm per capita per day (Ahmed and Islam, 1999).

World Bank reported that fish prices increased faster (15.6% per year) than rice prices (10.3% per year) largely, because fish demand increased faster than fish supply (World Bank, 1991). Because of this fact, the present fish production is not yet sufficient to meet the nation's demand. In 1999-2000, the nation produced about 1,661,384 metric tons of fishes of which 1,327,585 (79.91%) metric tons come from inland water and 333,799 (20.09%) metric tons from marine water (BBS, 2001). It is worth mentioning that the contribution of the fishery sector to gross domestic product (GDP) is 5.3% and more than 6% to the export earning of the country (ESB, 2003). By exporting 41482 metric tons of fish and fish products in 2001-2002, the country earned 1637.14 crore taka (ESB, 2003). Accordingly the fish production target in the terminal year (1996 -1997) of the current five year plan is set at 2,07,500 metric tons; 9,34,000 metric tons (fresh) and 2,66,000 metric tons marine fish (FFYP, 1990-1995).

1.3 Water Pollution

Water pollution is a phenomenon characterized by the deterioration of the quality of land water (rivers, land marshes and ground water) or sea water as a result of various human activities and any physical or chemical change in water that can adversely affect organisms. Water pollution is a global problem, affecting both the industrialized and the developing nations. The water pollution problems in the nation, however, are quite different in many respects. Heat, toxic metals, acids, sediment, animal and human wastes, and synthetic organic compounds foul the waterways of developed nations. Human and animal wastes, sediment and pathogenic organisms head the list in the non-industrialized nations.

The term 'water pollution' is referred to the addition to water of an excess of material (or heat) that is harmful to humans, animals, to desirable aquatic life or otherwise causes significant departures from the normal activities of various living communities in or near bodies of water (Trivedi *et al.*, 1997).

In reality, the term water pollution refers to any type of aquatic contamination between two extremes:

1. A highly enriched, over productive biotic community, such as river or lake with nutrients from sewage or fertilizer (cultural eutrophication) or

2. A body of water poisoned by toxic chemicals, which eliminate living organism or even exclude all forms of life.

1.4 Sources of Water Pollution

1.4.1 Degradation of water quality from agricultural sources

Irrigation is not the only essential factor for the production of more food. In addition to that it is necessary to supply plant nutrients (usually some inorganic chemicals in the form of fertilizers) to the fields. The most common of such compounds are Urea, TSP, murate of potash, mercaptans, zinc sulphate, manganese sulphate etc. Almost in every case the fertilizers applied are not in proper time and doses. Again all of the nutrients applied to the fields are not taken up by the crops. The waste water coming out from farmer's fields always carries a major proportion of the applied chemicals and thereby pollute the water reservoirs (Ahmed, 1985).

The magnitude of nitrate and phosphate pollution from leachate and drainage of agricultural land has not yet been evaluated through systematic studies. A maximum concentration of 9 ppm of nitrate in water has been found in some rivers. The location of rivers indicates that drainage from fertilized lands may be the source of this nitrate.

The use of phosphate are fertilizers in agricultural sectors as well as binders in detergents, is the main cause of phosphorus load in surface water. Investigations (Brigitte and Rudolf, 1989) upon municipal wastes and rivers have been done by reducing the amount of phosphorus (mainly as $Na_5P_3O_{10}$) in detergents by statistical methods and time series analysis. Results showed the declination of P-loads in most of the rivers. In the case of small rivers, an increasing tendency of phosphate pollution was observed due to the growing consumption of phosphorus containing fertilizers in agricultural use.

The polluting effect due to pesticides is more dangerous and has the biggest impact on the environment .In Bangladesh pesticides have been being used since 1950s in agriculture and public health (e.g. malaria eradication programme). The country pays millions of dollars to import such chemicals for self-sufficiency in food production. The consumption varies widely in different districts because of the variation in crop production and nature of pest attacks in each area. The maximum amount of pesticides is being utilized in the district of Dhaka (11.66%) followed by Mymensingh (7.29%) in comparison to other districts of the country (Sattar, 1983; Edward, 1981).

Practically it is difficult to prepare a list of all the pesticides being used in Bangladesh. Even after banning a chemical (pesticide) for environmental safety it appears in the market with different label due to lack of suitable methods to identify it. According to Ahmed (1982) Bangladesh has been using 20 insecticides, 18 fungicides, 5 herbicides and 2 rodenticides. They are 2-4-D, AGALLOL, AGROSAN, ALDRIN, ANTHIO BIDRIN, AZODRIN, BAYGON, BAYLETON, BAYTAN, BENLATE, BIDRIN, BORDEAUX, CALIXIN, CARBICRON, CHLOROPICRIN, COPPER OXYCHLORIDE, DIAZINON, DIELDRIN, DIMECRON, DITHANE, DUTER, FERNOXONE, FURADAN, HEPTACHLOR, HOMAI, KARMOX, LEBAYCIDE, MANEB, METASYSTOX, MEVIN, MIXTURE, NOGOS, ORTHOCIDE, PADAN, PERFEKTHION, ZINC PHOSPHATE, RECUMIN, RODOMIL, ROXIN, SUMITHION, TOPSIN, VITAVOX, ZINEB, ZOLONE etc. Here the quality and the side effects of the chemicals are never tested which is very important to register a pesticide in any country. Bangladesh follows its own registration policy and does not use the international system (Ahmed, 1982).

1.4.2 Degradation of water quality from industrial wastes

Pollution due to industrial waste disposal has not come up as a major problem since our country is industrially less developed. Whatever industries we have (fertilizer, sugar, cement, refinery, electroplating units, plastic, textile etc.) are hardly equipped with any pollution control measure. The release of waste effluents into riverine system have given rise to heavy localized pollution hazards and threatens the environment.

The effluent released from pulp and paper processing operations has been a mixture of chemicals used in the digestion of raw wood chips, cellulose fibers, dissolved lignin, pulp and wood preservatives like pentachlorophenol and sodium pentachlorophenate, methyl mercaptans, highly reducing sulphites etc (Safiullah and Mofizuddin 1988, Rashid 1988). The effluent is often dark in colour which lowers the photosynthetic rate of aquatic communities by hindering sunlight penetration into the water column, consume much of the dissolved oxygen (by the wastes) and all these increase biochemical oxygen demand (BOD). Chromium (VI) a species, very poisonous to fish and vertebrates, is coming out with the waste from the tannery industries. The lifetime of the species is, however, limited in aqueous environment as it is readily reduced to chromium (III). Mercury (II) may come out from caustic soda and chlorine industry during washing operations. It is one of the toxic metals producing serious irreversible neurological damage specially when in methyl mercury form (CH_3Hg^1) (Rashid, 1988).

Urea and ammonia are the main pollutants from fertilizer industries (Eunus, 1988 and Hossain, 1988). Ammonia is highly toxic to fishes, a concentration as low as 1-2 ppm in the liquid stream has been found to be lethal (Safiullah and Mofizuddin, 1988). A list of the pollutants in wastewater from some of the industries is given below (Table 1.2).

Table 1.2
Chemical Pollution Characteristics in Waste Water Industries ((Khair, 1988)

Industry	pH of the Wastes	Pollutants in the Wastes
Urea	8	Ammonia, urea, arsenic, chromium.
TSP	-	Fluorine, phosphoric acid.
Cotton textile	7-10	Sodium, organic acids, colouring matters.
Pulp and paper	6.5-8.3	Lignin, lignino sulphate, organic matters, sulphides etc.
Refinery	-	Free oil, emulsified oil, mercaptans, alkali, salts, phenols, soaps, resinous and tarry materials.
Tannery	8	Cr (III), Cr (VI), Ca (II)-salts, enzymatic materials, dyes, oils, ammonium salts, sodium sulphide and sulphonic acid.
Viscose rayon	2.8-4.1	Zinc and polysulphides.
Electroplating	-	Cyanide, heavy metals, ammonia and chloramines.
Caustic Soda and chlorine	-	Mercury, chlorine.
Pesticides	-	Colouring matters, oxalic acid, heavy metals like Pb, Zn, Cu etc.
Suger	-	Carbohydrate, sugar, waxy materials.

1.4.3 Degradation of water quality from domestic sources

Generally the impurities from domestic wastes get diluted and join with the water in ponds and rivers. The waste materials are largely organic and oxidized by bacterial decomposition to nitrates, phosphates, carbondioxide etc (Faso *et al.* 1988). This type of decomposition needs the use of dissolved oxygen and places an oxygen demand on the system.

The pollution also arises significantly due to the domestic use (bathing, washing utensils, clothes etc.) of water by the people. Even the clothes of the sick persons are also washed here. Almost in all places, people are used to relieve themselves on the bank of the rivers. In many places people construct open-hanged latrines on the pond usually at the corner. According to the literature (Rahim *et al.* 1985) special bacteria (such as coliform FC, faecal streptococci FS etc.) are always present in the faeces of men and other warm-blooded animals. The FC type bacteria are found to survive for a shorter period than FS type (Feter *et at.* 1975 and Davenport, 1976). A case study in Dhaka showed that FC and FS per 100 ml in pond water and Buringanga (river) water samples ranged from $3.5x10^3$ to $3.7x10^5$ and $8.5x10^2$ to $6.8x10^4$ respectively (Rahim *et al.* 1985). The ratio of FC/FS (which is a measure of pollution) was always about 4 and was polluted with the human faeces.

The availability of free dissolved oxygen in the water is very important for fishes and all aerobic species in water. Without it, microbial population can not grow and the self-purification capacity of the water system decreases. If the toxic chemicals enter the water in such a rate that the dissolved oxygen is used up faster than it can be replaced, the water becomes permanently polluted. In case of the complete removal of the pollutant no microbial population increases; some of the microbes will die and disrupt and their components will be utilized by the remaining organisms and the overall population will return to its original level.

1.5 Beel (Swamp) of Bangladesh

Beels are the deepest places of depression within the floodplains, which retain water round the year, or greater part of the year. The saucer shaped basins of floodplains in northern-east region is termed as haor. The number of beels in the northeast region has been reported to be 3,440 (covering 58,500 ha with a mean size of 7 ha) and 6,149 (covering 63,500 ha with a mean size of 10 ha) (Bernacsek *et al.* 1992). About 58% of the beels in the northeast region are permanent and the remainder is seasonal.

In other region of the country, beels are seen almost all over the regions. All low-lying areas inundated and submerged for a number of months, usually from June to September and becoming dry up in the dry season are also termed as beels in other regions of the country.

In the north-west region, Dinajpur district has no big beels. In Rajshahi, Chapai Nawabgonj, Naogaon and Natore districts of the region, beels at one time were plentiful. The most reputed of the beels in this region is the Chalan beel spreading over the districts of Naogaon,Natore, Pabna, Sirajgonj and Bogra. The Chalan beel once consisted of a chain of beels that used to become one continuous sheet of water in the rainy season.

In the central region of the country, a few well-known beel such as Arial beel in Munshigonj district and beel Belai in the Dhaka district once existed. Because of gradual development of human settlements and other human interventions these beels have lost their importance from the point of natural fish habitat and fish production.

1.5.1 Contribution of Beel in fisheries sector in Bangladesh

The open water resources till date supplies a greater proportion of fish needs for the people. The beel fisheries alone contributes 5.85% of the total annual catch (Dash, 2004). The total production of fish from this beel area was 74527 mt (BBS, 2001).

1.6 Loss of Fish Production in Bangladesh

Environment and development are not separate challenges. They are inexorably linked (WCED, 1992). According to a study in Bangladesh made by MPO (1987), about 0.80 m ha of flood plains were removed from fisheries production up to 1985 and 2 m ha are likely to be lost by the year 2005.A.D . The same study revealed that, the share of open water fish production was 62.7% in 1983-84 which was reduced to 51.3% in 1987-88, a decline of 11.4% in five year period. Major factors that cause the declines in capture fisheries are overfishing, indiscriminate fishing, siltation, and drainage.

1.7 Loss of Beel Water Fishery

The major causes of loss of beel water fishery are water pollution due to modern agri-practices, construction of dyke/embankment/sluice gate, catch of brood fish during breeding season, over catching/extraction of fish in dry period and loss of fish habitat due to reduction of wetlands.

Agro-chemical use in HYV Boro fields and in other crops are mainly responsible for water pollution of most of the beels and open water bodies in Bangladesh. Some beel waters nearby the urban area have also been getting polluted with domestic and industrial waste disposal.

Agricultural pollutants include the pesticides, fertilizers, plants and animal debris, and sediment that are carried into the low-lying beel area during rainfall as surface run-off from agricultural fields. Since, most of these pollutants are organic, they increase the BOD level of the beel water.

Inorganic chemical fertilizers such as urea, TSP, MP, gypsum, zinc, etc. are the plant nutrients used in agri-fields. The unused fertilizers can easily enter into the beel environment with surface run-off in monsoon. The addition of excess plant nutrients can lead to a disturbance of phosphorus/nitrogen balance in the aquatic ecosystem as well as excessive growth of plants. When the plants die, they may settle to the bottom of beel. This process will reduce the oxygen level in water and increase the BOD and ultimately create an anaerobic condition, which can kill all the fish and aquatic animals.

On the other hand, the pesticides that are applied in the agri-lands, which can kill the fish within a minute. Among the pesticides, organo-chlorides are more toxic to fish than organo-phosphorus and carbamate pesticides. Among the organochlorides, dieldrin is about 40-50 times as toxic as DDT, aldrin is still more toxic, endrin is the most toxic of all, being about 5 times as poisonous as dieldrin.

The destructive power of endrin is well known, a few drops of which can kill all fishes in a large pond.

Pesticides particularly insecticides not only affected the target species but also a large number of them attack non-target species, killing pests' predators, parasites, bees etc. which are beneficial to human beings. Many of the insecticides are persistent board-spectrum types. Widespread use of pesticide pollutes the total environment as the toxic chemicals are washed away by rain to water bodies. Fishery resources are much affected. Residual toxicity of pesticides in animals and plants finally ends up in the adipose tissue of human beings causing health hazards. The long-term effect of pesticides on environment can not be fully predicted.

The main categories of pesticides are as following

i. Insecticides
ii. Herbicides
iii. Fungicides
iv. Growth regulators
v. Fertilizer etc.

The persistence of some important pesticides in soils (CFTRI, Mysore, India, 1981) is shown in table-1.3

Table 1.3
Persistence of Some Important Pesticides in Soils

Pesticides	Time period in year (75-100%)	Pesticides	Time period in month (75-100%)
Aldrin	3	Diazinon	3
Chlorodrine	5	Malathion	0.25
DDT	45	Parthion	0.25
Heptachlor	2	Propazine	18
Lindane	3	Pictoram	18
Dieldrin		Simazine	12
Telodrin	4	2,4,5-T atrozine	10

In Bangladesh pesticides have been in use since 1950s in agriculture and public health (e.g. malaria eradication program). Bangladesh is an agriculture country with a humid climate conducive to pest attack to crops. They cause about 20 percent damage in the field and 16 percent in the storage amounting a loss of about Tk.1000 crores annually (US dollar 400 million). Pesticides save greatly this huge amount of loss every year. Annually 4-5 thousand tons of solid and liquid pesticides are imported from abroad for this purpose. This cost around Tk. 10 crores (US dollar 4 million) every year.

The residue of aldrin, diedrin, endrin, lindrin, heptachlor, diazinon, parathion, dichlorphos and phosdrin were found in cultivated soils of Bangladesh. Sattar (1985) detected 23-43% organo-chlorine and 3-15% organo-phosphorus pesticides after 336 and 80 days respectively. The degradation was rapid in the beginning of incubation and decreased linearly with time.

1.8 Importance of Study

The importance of assessment of limnological factors can not be over emphasized. The study helps to formulate the guideline for management of fish culture practices. The limnological factors or hydrology deals with many interrelated phenomena such as hydrophytes,phytoplankton, zooplankton, benthic fauna, fish diversity, physical and chemical productivity of waterbody (Lellak, 1965; Banerjee, 1967).

The fishes are aquatic animals. To employ scientific management for fish culture, a through investigation and understanding of water quality becomes the foremost task. The kinds and amount of organisms i.e. the plankton, benthos and their seasonal abundance are greatly related with water qualities. Fishes are more dependent on water temperature, pH, DO, free CO_2, alkalinity, hardness and some salts for growth and development (Nikolsky, 1963). Any change of these parameters may affect the growth, development and maturity of fish (Nikolsky, 1963; Jhingran, 1975). In short, water quality is directly related to productivity of fish and determines the quality of their lives. The surface fauna can be expected to be important or even central issue in ecology of water body. So it is natural to focus attention on the fauna occupying the surface (both phytoplankton and zooplankton) which limit the population increase of fish.

An important factor in limnological condition is the existing food chain in the beel, which directly affects the growth of fish. Plankton is identified as the major nutritional source available to the fish from nature (Williams, 1963). Occurrence of plankton in water has been accepted as a measure of the degree of organic enrichment of water. This underscores the need for investigation of the occurrence of plankton as well as their seasonal trends in a beel to bring it under scientific fish culture.

1.9 Research Scope and Objectives

It is recognized that scientific fish culture can be launched in a water body only when its limnological conditions are properly assessed. Various kinds of limnological data indicate the suitability of water body to be taken as to conducive culture of fish. Hence limnological study is a prerequisite to fish culture. The scope of fish culture in Bangladesh is very bright considering its vast water resources. But for the lack of sufficient limnological data of water bodies, especially beels of this country, the modern technique for fish farming can not be applied.

Though beels are very important among open water bodies in the country but very little works have been done to generate data on the water quality, zooplankton and benthic of habitat. Some related works were done by Zaman (1991), Ehshan (1997), Kabir *et al.* (1997), Hossain (1998), and Saha and Hossain (2002).

The present study has been conducted to assess water pollution status and its impact on fisheries resources of Posna beel. Considering the adverse effects of agro-chemicals on water quality and fish biodiversity in Posna beel from nearby HYV Boro fields, the study has been planned to achieve the following objectives:

i. To assess the Physico-chemical conditions of water of the Posna beel.

ii. To assess the degree of water pollution.

iii. To study the causes of water pollution of Posna beel.

iv. To determine the pesticide residual in water and soil.

v. To study phyto and zooplankton and their abundance in the Posna beel.

vi. To study diversity of fisheries resources through catch assessment.

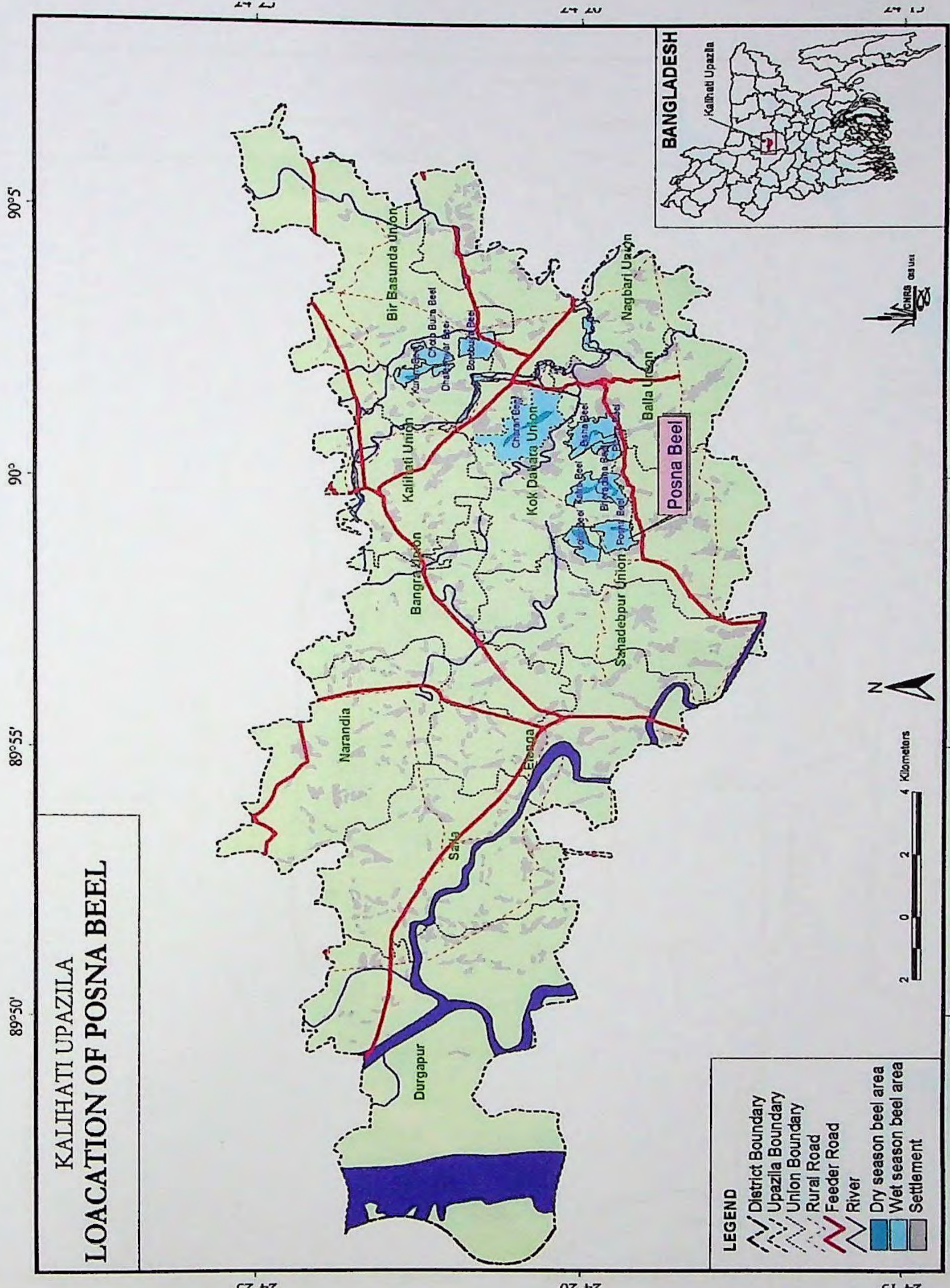
vii. Finally, to study the relationship between fish diversity and water quality.

Chapter 2
Materials and Methods

2.1 Study Area

Posna beel is located $24^0 19' 10''$N to $24^0 19' 55''$N latitude and $89^0 56' 45''$E to $89^0 59' 22''$E longitudes in the north-central region of Bangladesh, about 120 km from capital. It is an important perennial water body in Kalihati Cluster of Tangail District (Map 2.1) under the Community Based Fisheries Resources Management (CBFM) Project, Phase-2 funded by the UK-DFID and implemented by World Fish center. Four villages surround the beel are Posna in east, Kaluha in south, Sheroil in west and Monotia in north (Figure 2.1). This beel is the main source of fish to the villagers and also to nearby Pouzan, Balla, Elenga and Rampur bazars. The average depth of water in the beel during the rainy season is 3 meters while in the summer it stands at 1 meter. The water is clean with high penetration of light reaching the bottom. The entire beel has rich aquatic vegetation all the year round.

HYV Boro cultivation is common in surrounding area of the beel. For extensive agriculture, the beel environment is under stress day by day due to indiscriminate use of fertilizers and pesticides. The residual fertilizers and pesticides are drained into washed away to the beel with surface run-off. Farmers mainly use Urea, TSP, Potash and Zinc fertilizers in rice field, which cause skin irritation during taking bath, locally called "Pani Kamor".



Map 2.1
Map of Kalihati Upazila Indicating Study Area

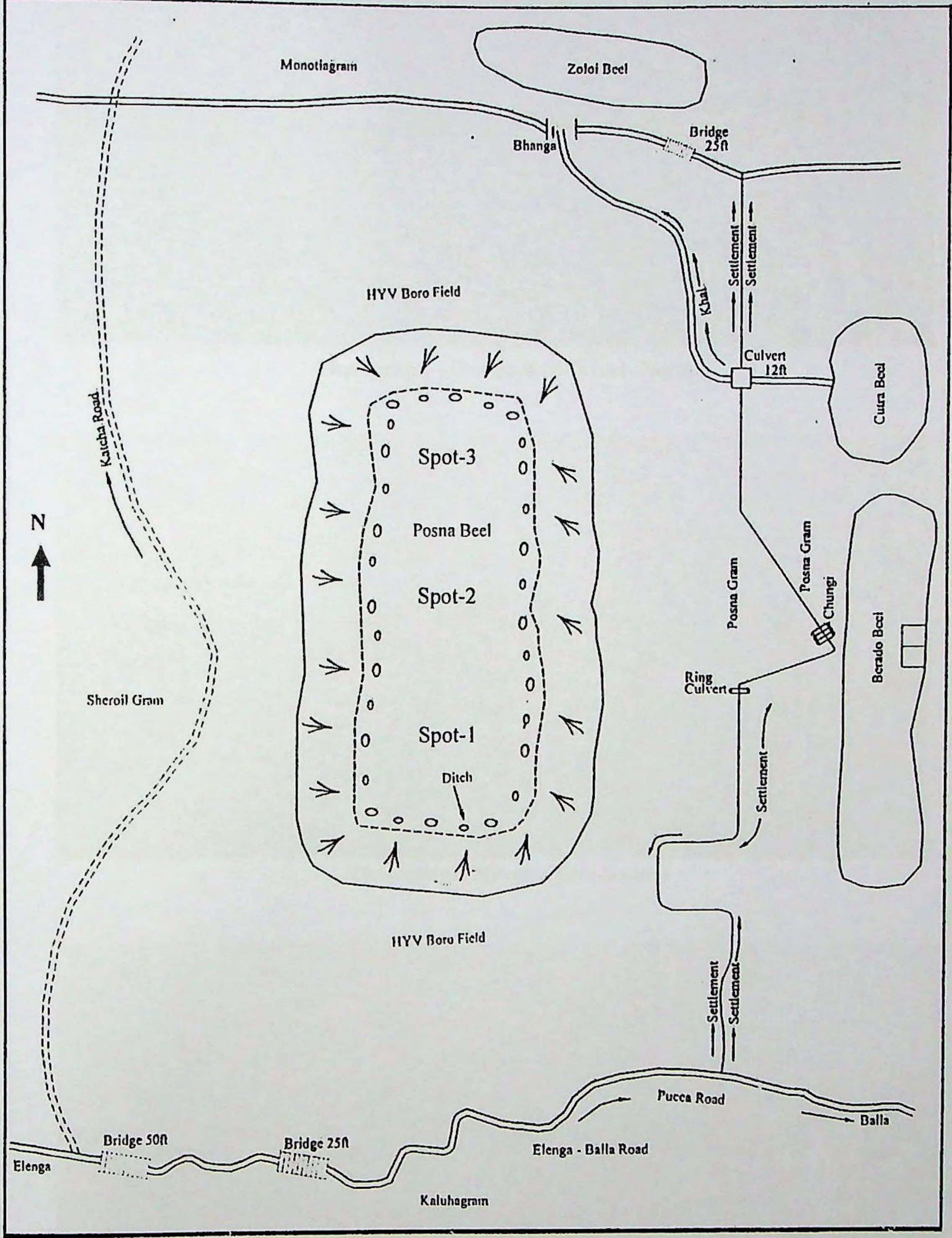


Figure 2.1
Posna Beel and Its Surrounding Environmental Set-up

Photograph-1(Posna Beel-(West -North)

Photograph-2(Posna Beel-South)

Photograph-3(Posna Beel-Middle)

2.2 Field Survey

2.2.1 Field Reconnaissance Survey

A Field Reconnaissance Survey was carried out in Posna, Kaluha and Sheroil villages just after the initiation of lab based work. During this survey, socio-economic, sanitation and environmental conditions of these villages were observed closely through physical observation. Necessary information had also been collected through contact with different categories and mass section of people of the study area.

2.2.2 Agro-chemicals Use Survey

Survey on the agro-chemicals use pattern was carried out on 190 farmers of three villages surrounding the Posna beel as per structured questionnaire (Appendix-XI). It may be noted that though there is a small village (Monotia) on the north (Figure I) side of the beel but the inhabitants possesses negligible agriculture land within the catchment area of the beel. Data analysis of all these questionnaires had been done using Microsoft Excels Program.

2.3 Analysis of Water Quality

2.3.1 Collection of Water Sample

Three water-sampling sites were selected at equal distance along the Posna beel in south-north direction, which could represent the water quality of the total beel area. Water sample was collected on August 15, 2003 and 2004 for monsoon season (rainy); October 22, 2003 and 2004 for post-monsoon; December 31, 2003 and 2004 for winter season, and April 17, 2004 and 2005 for summer season and period between 11.30 AM- 12.30 PM. 1 liter air tied plastic bottle was used to collect the water samples from 20-30 cm below the surface level of beel water. For DO and BOD_5 measurement, 250ml special type white and black glass stoppered bottles were used for sample collection respectively. A small country boat was used to collect the undisturbed water sample.

2.4 Methods

2.4.1 Physical Conditions of Water

Water Temperature

A centigrade thermometer with the range of 0 to 120^{0}C was used to note water temperature .The temperature of water was recorded by dipping the thermometer at the depth of 10 cm meter below from the surface of water.

Transparency of Water

Measurement of limit of visibility i.e. penetration of light in water was done by Secchi disk. The Secchi disk was slowly lowered into the water on a graduated line and the depth at which it disappeared was noted. Then lifted the disk and noted the depth at which it reappeared was noted following Welch (1948). The average of these two readings was considered to be limit of visibility. The sinking of the disk was always viewed under a sunshade for considerable accuracy in results. The data thus obtained were expressed as Secchi disk depth in cm.

Total Solids

250 ml of water from each of five samples was taken in previously weighed five different properly labeled 250 ml beaker. The water samples were evaporated to dryness at 120^{0}C in an oven and weighed again. The differences in weight are simply the total suspended solids in water (Kudesia, 1983).

2.4.2 Chemical Conditions of Water

The essential elements in the form of cations, anions or simple molecules in water were analyzed by instrumental methods. In some cases titrimetric methods as described by Boltz (1958), Chopra and Kanwar (1976), Winkler (1981), Kudeshia (1983), Welch (1948), APHA (1989), and Gautam (1990) were followed.

Hydrogen Ion Concentration (P^H)

The value of hydrogen ion concentration (P^H) of water was determined by using a digital pH meter (Model-HANNA Instrument).

Free Carbondioxide (CO_2)

Carbondioxide was determined by titration of water samples with N/44 sodium hydroxide solution (NaOH) using phenolphthalein as an indicator following Welch (1948). The result was expressed in mg of CO_2 per litre (mg/l) of water.

Alkalinity

Bicarbonate alkalinity or methyl orange alkalinity was determined by titration of 100 ml of water with N/50 sulphuric acid using methyl orange as an indicator following Welch (1948). The results were expressed in mg/l of $CaCO_3$ as bicarbonate alkalinity.

Dissolved Oxygen (DO)

Winkler's modified method was followed for estimation of dissolved oxygen in water. The water samples collected for dissolved oxygen estimation were treated with manganous sulphate solution, alkaline iodide solution and concentrated sulpuric acid on the field. The treated sample was transferred to the laboratory and titrated with sodium thiosulphate. The volume of sodium thio-sulphate used in titration up to end point gave the DO value of water expressed in milligram of oxygen per litre of water (mg/l).

Saturation of Oxygen (% of sat. O_2)

Percentage of saturation of oxygen in the studied water body was determined by dividing the titration value of DO by the solubility value of oxygen and multiplied by 100 according to Hutchinson (1957) and Mukherjee (1996).

Biochemical Oxygen Demand (BOD_5)

Two bottles A and B of 250ml capacity were taken and then the bottles were filled with sample water. The dissolved oxygen in bottle A was determined immediately by adding 1 ml of 48% $MnSO_4$, 1 ml alkaline KI and 2 ml of conc. H_2SO_4 followed by titration with 0.0125 N standard sodium thiosulphate. Then the bottle B was incubated at 20^0C (room temperature) for 5 days. After 5 days, finally the dissolved oxygen was determined by the same method as described above. The value of BOD_5 was obtained by subtracting final dissolved oxygen (DO_f) from initial dissolved oxygen (DO_i) (Kudesia, 1983).

Chemical Oxygen Demand (COD)

50 ml of water was taken in a conical flask (A) and then 100 ml of distilled water, 25 ml of standard N/4 potassium dichromate solutions were added to it followed by the addition of 75 ml of conc. H_2SO_4 acid and 1 gm of silver sulphate. The mixture was refluxed for 2 hours. The condensate was cooled and washed down with distilled water. The content was transferred to 500 ml flask. The mixture was diluted with standard to about 300 ml with distilled water. The excess dichromate was titrated with standard N/10 ferrous ammonia sulphate using ferrion indicator.

The blank (B) experiment was performed by taking 100 ml distilled water, 75 ml conc.H_2SO_4 acid and 1 gm of silver sulphate and 25 ml of N/4 potassium dichromate solution. It was refluxed for 2 hours and the excess dichromate was titrated with N/10 ferrous ammonia sulphate. The calculation of COD was done as follows (Kudesia, 1983) :

$$COD = \frac{(A - B)C \times 8 \times 1000 mg/l}{ml. of\ sample\ taken}$$

When,

A = Volume in ml of N/10 ferrous ammonia sulphate used with sample

B = Volume in ml of ferrous ammonium sulphate used with distilled water

C = Normality of ferrous ammonium sulphate

Oxidation Reduction Potential (Eh)

The oxidation-reduction potential of water was calculated from the pH, partial pressure of oxygen (pO_2) dissolve in water and normal oxidation potential (E_o) through Voznaya (1981); Walters (1981), Gautam (1990) and Mukherjee (1996) by the following equation:

$$Eh = E_o - 0.058ph + 0.0145 \log pO_2$$

The resultant data is expressed in millivolt (mv.).

Oxidation Reduction Index (rH_2)

For the characterization of oxidation-reduction conditions of the beel water, oxidation-reduction index was calculated the following method of Gautam (1990) and Mukherjee (1996):

$$rH_2 = \frac{Eh}{0.029} + 2pH$$

Total Hardness

50 ml of sample water pre-treated with ammonia buffer solution was titrated against EDTA solution using erichrome black-T as an indicator. The resultant data was expressed in mg/l (Mishra *et al.* 1992).

Chloride (Cl^-)

Chloride was determined by using the 'Argentometric method'. Chloride ions of sample water react with $AgNO_3$ producing white precipitates of silver chloride (AgCl) and at the end point the free silver ions reacts with conc. $K_2Cr_2O_7$ ions to give reddish-brown colour of silver chromate. To 50 ml of sample water, 2 ml of $K_2Cr_2O_7$ solution was added and titrated with 0.02N $AgNO_3$ solution. The end point of titration is red-tinge colour (persistent) (APHA, 1989).

Ammonia

40 ml of water was taken into a 50 ml volumetric flask and then 1.0 ml of Nessler's reagent was added to it and made up to the mark with distilled water. The solution was stirred and allowed to stand for 10 minutes when the solution

turned yellow in colour. The ammonia was estimated by measuring its absorbance at 400 nm in the spectrophotometer using a reagent blank and referred it to the calibration curve (Chopra and Kanwar, 1976).

The calibration curve was made in the usual manner by using four standard ammonium chloride solutions containing 0.5, 1.0, and 1.5, 2.0 ppm of ammonia nitrogen.

Nitrate Nitrogen (NO_3. N)

5 ml of water was taken into a 25 ml volumetric flask, 0.1 ml of brucine reagent and 5.0 ml of concentrated sulphuric acid were added in cooling water bath and the hot solution was mixed carefully to avoid spattering. The flask was then allowed to stand for about 10 minutes until the color of the brucine reagent changed from reddish purple to yellow. The volumetric flask was then made up to the mark with distilled water and mixed cautiously. The flask was then cooled at room temperature under a cooling water tap and its volume was adjusted again after cooling. Then the absorbance of the sample solution was measured at 410 nm using a reagent blank and referred it to the calibration curve (Chopra and Kanwar, 1976).

The calibration curve was previously constructed by using 0.4, 0.8, 1.2 ppm of nitrate ions in solutions. Potassium nitrate solution was taken as standard data.

Phosphate Phosphorus (PO_4. P)

25 ml of water was taken into a 50 ml volumetric flask followed by the addition of 5 ml of 2.5 N nitric acid and 5 ml of molybdate reagent, and then made up to the mark with distilled water and mixed thoroughly whereby a yellow bluish color was obtained. The absorbance of the solution was then measure at 380 nm using a reagent blank and referred it to the calibration curve (Boltz, 1958).

The calibration curve was previously constructed by using three standard potassium dihydrogen phosphate solutions containing 2, 4, 8 ppm of phosphorus ions in solutions.

2.5 Biological Conditions

2.5.1 Collection of Plankton Sample

The planktonic sample was collected at 3-month intervals namely four seasons i.e., Monsoon (Rainy) (15^{th} June – 14^{th} September), Post-monsoon (15^{th} September- 14^{th} December), Winter (15^{th} December – 14^{th} March) and Summer (15^{th} March- 14^{th} June). Plankton (both zoo and phytoplankton) was collected at noon and dusk by plankton net. 2-No.(mesh size-0.076 mm) of silk cloth. Through the plankton net 100 liters of surface water, collected with the help of a plastic pan (4 liters capacity) from horizontally selected three (3) sampling spots was passed to collect the plankton (both phyto and zooplankton). After passing down the net, the plankton was collected into a glass test tube (77 ml) fixed firmly at the lower end of the plankton net following Welch (1948). After sieving, the planktonic materials was transferred into a vial and preserved permanently in transeau's solution on the spot. For sedimentation of plankton materials the vial's materials were transferred in a measuring test tube and were kept undisturbed in dark for 48 hours at room temperature. Then the overlying water from the test tube was decanted and the final volume was adjusted in 30 ml. and transferred to glass bottle.

The composition of the preservative is as follows:

Distilled Water	60 ml or 6 parts
Absolute Alcohol	30 ml or 3 parts
Formaldehyde	10 ml or 1 parts

To each 100 ml of solution 5 ml glycerine was added to prevent the materials from becoming brittle (Transeau, 1951).

2.5.2 Mounting Fluid

Ten percent glycerine solution in distilled water was used as mounting fluid for the preparation of temporary slides. Sometime twenty percent glycerin solution in distilled water was used as mounting fluid for the preparation of permanent slides.

2.5.3 Quantitative Study

The quantitative enumeration of the phytoplankton and zooplankton were carried out with the help of Sedgwick Rafter counting cell and ocular whiple micrometer according to Welch (1948). The counting cell was filled with water to test for any leakage and it was emptied and dried properly. The vials containing the original concentrate were shaken properly and 1 ml of concentrate was taken into the Sedgwick Rafter counting cell. Numerical counts of all members of phyto and zooplankton were made using the whiple micrometer. To achieve a random sampling, each time 3 sampling spots were examined for each sample and an average of the counts had been recorded. The organisms thus counted were expressed units per litre (units/litre) of the sample, irrespective of whether they were solitary cells, colonies or filaments part thereof. The abundance of plankton groups were calculated according to the following formula (Welch, 1948) :

$$N = \frac{(a \times 1000)C}{L}$$

Where,

N = Number of planktons per liter of original water.

a = average no. of plankton in all counts in the counting unit.

C = Volume of original concentrate in ml.

L = Volume of water passed through the net.

The phytoplankton was identified following Smith (1950); Deshikachary (1959) and Fritch (1965) etc, whereas the Zooplankton prevailing at the sampling area was identified following Ward and Whipple (1959), Mellanby (1963), Venkataraman *et al.* (1974), Tonapi (1980), Battish (1992), and Bhouyain and Asmat (1992).

2.6 Pesticide Residue Determination

The residues of Organochlorine (Ocs) compounds in experimental samples were determined by Gas Chromantography (GC) using Electron Capture Detector (ECD), and the residues of Organophosphorus (Ops) and Carbamate compounds were determined by High Pressure Liquid Chromatography (HPLC).

2.6.1 Pesticide Residue Collection and Analysis

For Pesticides residue analysis, water and sediment samples collection was carried out on August 31, 2003 and April 14, 2004. On the next day of collection, the samples were sent to the Atomic Energy Commission, Savar, Dhaka and samples were analyzed following the methods established by Agrochemical and Environmental Research Laboratory, Institute of Food and Radiation Biology, Atomic Energy Research Establishment, Savar, Dhaka. According to D. F. G. manual of pesticide residue analysis volume-1.

Brief Method for Extraction of Ocs, Ops and Carbamate Residues from water Samples

Water 250 ml + Hexane 100 ml (double distilled)
gently shaken in a separatory funnel
⇩
After 10-20 minutes, the upper thick solvent
Layer (of hexane with Ocs residues) was collected
⇩
Re-extraction of the aqueous layer with hexane
for 2-3 times with another 50 ml hexane (double distilled)
⇩
Combined extract was treated with Na_2SO_4
(Anhydrous) for removing water (if any)
⇩
Evaporation with the extract by Rotary
⇩
Vacuum Evaporator at 40^0C-50^0C /by N_2 gas flow
⇩
Transfer of the extract in volumetric flask
⇩
Making of final volume, prior to injection into
GC-ECD mode (for OCs)/ HPLC(for Ops and Carbamate)

Brief Method for Extraction of Ocs, OPs and Carbamate Residues from Soil Samples

Two different procedures were applied to extract Ocs residues from soil samples

Method-I: In shaker, using only Hexane

Method-II: In shaker, using Hexane 95% + Diethyl ether 5%

For this purpose the first method was followed and which is as follows:

20 gm dried and powdered soil from each sample
was mixed with 25 ml of DD Hexane

⇩

Contents were taken in 250 ml conical flask, flask
Opening were blocked with aluminum foil

⇩

Re-extraction of the aqueous layer with hexane
for 2-3 times with another 50 ml hexane (double distilled)

⇩

Flasks with soil and hexane mixture were set accurately in a
Rotator and it was continuously rotated (@ 225) RPM for 12 hours

⇩

After 12 hrs, solvents were let to settle down and
Na_2SO_4 (Anhydrous) was added for removing water (if any)

⇩

The clean upper layer was separated to volumetric flask carefully

⇩

Extratcs were concentrated by Rotary Vacumm Evaporator
At (40°C-45°C) under pressure/ in N_2 gas flow

⇩

Cleaning up the extract though glass column florisil
(Magnesium Silicate) if colour appeared

⇩

Final volume was made to 5 ml prior to injection into
the GC-ECD mode (for OCs)/ HPLC(for Ops and Carbamate).

Detail Analytical Scheme of Pesticide Residues for Water and Soil Samples

The Following steps were performed for the analysis of pesticide residues from collected samples-

Extraction Procedure

Extraction of Water

Following the liquid- liquid separatory funnel method all the glass wires are washed carefully with the relative extraction solvent(s) for this purpose to maintain the procedure accurately. Short description of the method :

1. 250 ml water + 100 ml Hexane (Double distilled) was taken in a separatory funnel and was vigorously shaken for 5 minutes. The separatory funnel was kept in suitable stand for certain time for water-Hexane separation, lower portion was removed in a bottom flask.

2. the remaining aqueous layer was extracted with hexane for 2-3 times with another 50 ml Hexane(Double distilled).

3. The combined extract was treated with anhydrous sodium sulphate (Na_2SO_4) to remove any little amount of water, otherwise this matter can make critical problem during injection to GC or HPLC. Extracts were evaporated by Rotary Vacuum Evaporator at 40°C-45°C under mild pressure or by N_2 gas flow dryer.

4. Extraction was transferred to the 5-ml volumetric flask by repeated washing the Rotary Vacuum Evaporator with hexane, as some little amount of pesticide residues could be attached to the glass wall.

5. Clean up would be required if it appeared.

6. Final volume was made with hexane as required prior to injection into Gas-Chromatoraphy (GC) with Electron Captured Detector (ECD) or to HPLC.

Extraction of soil

1. 20 g air dried soil samples (finally dried in oven) were extracted with hexane using Electron Rotator @225 RPM for continuous 12 hrs.

2. Samples were allowed to settle down

3. The extracts were concentrated by Rotary Vacuum Evaporator at 40^0C-45^0C under mild pressure. Extracts were transferred to 5 ml volumetric flask.

4. Then extracts were cleaned up through glass column florisil (Magnesium Silicate) if any of the sample showed colour.

5. Acetone (2%) in hexane was use for elution. The elute was evaporated to dryness and dissolved in double distilled hexane and made the required (5 ml) before injection to GC-ECD or to HPLC.

Clean-up Procedure

The combined extracts were filtered to avoid undissolved materials. The collected extract was then evaporated to 5 ml with a steam of nitrogen. To avoid the co-extractives from the extract, the Florisil Column Chromatography was applied where necessary. The Elecron Capture Detector of gas Chromatography is very sensitive to co-extractives and would otherwise, contaminate the detector. Following procedures were taken for florsil column chromatography.

Florisil Preparation

Florisil, 60-100 mesh (magnesium silicate) was heated overnight at 550^0C, then cooled and stored in a tightly stoppered desiccator. Prior to use (if used after a long time of preparation) the florisil was activated by heating in an oven at 130°C, for 6 hr and cooled in desiccator. The freshly activated florisil was then partly deactivated with drop-wise addition of distilled water (3% v/w, water/florisil) at 40°C, with constant stirring for 1 hr. Florisil was partly de-activated to increase the polarity of the absorbent, which is very essential for perfect cleanup.

Column Preparation

A fresh chromatograph glass column (accurately washed and rinsed) was set with a stand, the column was rinsed with double distilled hexane, about two-third of the column was filled with double distilled hexane and then 10g of deactivated florisil was slowly applied into the column by gently tapping the tube with a non-contaminated glass rod to avoid the formation of any bubble in the column packing. The absorbent was allowed to settle down. Then the stopcock of the column was opened to drain out the hexane up to a level of 1 cm above the florisil layer. The florisil of the column was covered with an approximate 23 cm layer of anhydrous sodium sulfate to remove the water (if any) from the extracts.

Elution Procedure

All the 5 ml extracts derived from the above mentioned extraction procedure were pipetted on to the chromatographic column and allowed the solution to percolate to a level of aroud 1-2 mm above the top of the florisil of the column. Then the flask was rinsed with a small portion of eluting mixture and the rinsed content was again applied to the column and was allowed to percolate. The column was eluted with 100 ml dichloromethane in hexane at a flow rate of 1-2 drops per second (5 ml/min). The eluted extract was collected in a stoppered flask. The elute was made to volume with or without evaporation depending on the initial injection at the appropriate mode of the gas chromatography.

Gas -Chromatography (GC) Determination

From the final solution derived after cleanup, aliuot (usually 0.5 ul) was injected by micro-liter syringe into the Gas Chromatography (GC) fitted with the column-Electron Capture Detector.

Operating Conditions of GC (For ECD Mode)

Apparatus (type)	:	HP 5890, Series II
Detector (type)	:	Electron Capture Detector
Injection technique	:	Manual by Microsyringe
Injection Volume	:	0.5 ul or 1ul
Carrier gas	:	N_2, Purity 99.997%
Carrier gas flow	:	8 cm^3. min-1
Column (type)	:	Capillary Column
Temperature program	:	
Column initial temp.	:	175^0C
Initial time	:	4 min
Final temperature	:	255^0C
Final time	:	10 min
Dectector temperature	:	275^0C
Detector make up gas	:	N_2
Make up gas		75 cm^3. min-1
Recorder/Integrator (type)	:	HP 3396 Series III

Chromatographic Process

Column is the most important of any Gas Chromatograph. The samples are normally injected into the carrier gas stream using a micro -liter syringe via a rubber septum in an injection port at the front end of the column. The injector, column and detector are in close proximity to each other and are all electrically heated to a suitable temperature. When the components elute, they pass into a detector where, assuming they are above a threshold level, and their presence is detected and the electrical signal produced is amplified to a suitable level/ range. The response of the detector is displayed on recorder or printer as a chromatogram.

Principle of Detector Function

It has been established that the purpose of a detector is to produce a response that is proportional to the concentration (or amount) of compound passing through it, in the form of signal which can be measured through the output device, the printer.

Electron Capture Detector (E.C. D)

The electron capture detector is probably the most sensitive detector available for gas chromatography in routine use. The detector is essentially an ionization chamber and operates on the principle that, '*the conductivity of gases in such a chamber can be markedly altered by the presence of a contaminating gas.*'

The process occurring within the detector may be represented as series of reactions, connecting with the ionization of the gas by radioactivity β-emitting source:

$$N_2 + \beta = N_2 + e^-$$

Carrier gas + high energy = Carrier gas + low energy

Hence free electrons are produced by the collision of the *Beta* particles with the carrier gas molecules. By employing a potential between the source and anode situated in the chamber, is possible essentially to collect the electrons thereby establishing a current, which may be amplified and accurately displayed on a recorder (Printer). This current is known as the 'standing current'. When an electrophilic compound (usually one containing fluorine, chlorine, bromine or iodine) is eluted into the chamber, a reaction occurs between the compound and free electrons according to either or both of the following schemes-

$$e^- + AB = AB^- \text{ non-dissociative reaction}$$

$$e^- + AB = A + B^- \text{ dissociative reaction}$$

The outcome to this reaction is a replacement of fast- moving electrons with slow moving negative ions. These ions take longer to transform to positive ions before reaching the anode than electrons. As a result, the standing current of the detector is decreased during the elution of the electrophilic sample, and it is the change, which is displayed in the form of a peak on the recorder. For convenience the signal to the recorder is usually reversed inside the electronics to produce the more familiar positive peaks.

Identification and Quantification Procedures

Tentative identification of the suspected insecticide was carried out in relation to the Retention Times (RT) of the pure analytical standard of that insecticide.

Quantification of the identified pesticide was performed by the calibration technique. For this purpose, calibration curve for each pesticide was prepared by injecting equal volumes of differently concentrated standard solutions into GC. The calibration curve was drawn by plotting the obtained peak area was read from the calibration curve.

High performance liquid Chromatographic Process

Pump	:	water 510 HPLC isocratic pump
Injector	:	waters model U6K universal liquid chromatography indicator
Detector	:	Waters TM486 Turnable absorbence detector
Integrator	:	PU 4815 computing Integrator
Column	:	3.9 X 150 mm (in diameters) NOVA- Pak C_{18} column, containing dimelthyloctadylsicyl bonded amorphous silica.

Calculation of Residues

The residues R, expressed in ng/ml for water, ng/gm for soil samples and fishes were calculated from the following equations (DFG Manual, 1987) :

$$R = \frac{H_n - V_{end} - W_{st} \cdot}{H_{st} - V_i - G}$$

Where,

G	=	sample weight (g)
V_{end}	=	terminal volume of the sample solution (in ml)
V_i	=	portion of volume Vend injected into GC (in ml)
W_{st}	=	amount of standard pesticides injected with standard solution (ng)
H_a	=	peak area obtained from Vi (in mm^2)
H_{st}	=	peak area obtained from Wst (in mm^2)

2.7 Beel Sediment Conditions

2.7.1 Sediment Collection

The beel sediment was collected during Monsoon (August 2003 and 2004), Winter (December 2004) and Summer (April 2004 and 2005) periods. The samples were collected from different places and different depths (0-20 cm depth of the bottom soil). After collection, the sediment samples were kept in institute laboratory for one month for air-drying. After completion of drying, the samples were grinded to make powder. Later, the samples were sieved and about 500 gm of powder sample had been sent to the SRDI (Soil Resource Development Institute) Lab, Rajshahi for nutrient analysis.

2.7.2 Sediment Analysis

The following convenient analytical technique were used for soil analysis-

pH

The pH of the soil was measured electro chemically using a glass electrode pH meter (Model-Hi 9210 NATC) (HANNA instrument). The ratio of soil and water as well as soil and 0.01M $CaCl_2$ solution was 1: 2.5, as suggested by Jackson (1962).

Organic Matter (OM)

The organic matter of the soil samples was determined by multiplying the percentage of organic carbon with conventional Van- Bemmelen's factor of 1.724 (Piper, 1950).

Total Nitrogen (TN)

The total nitrogen of the soil samples was determined by Micro-Kjeldhal method following sulphuric acid (H_2SO_4) digestion (Jackson, 1962) and tritated with 0.05 NaOH.

Phosphorus (Available)

Available phophorus of the soil samples was extracted by ammonium floride (NH_4F) extraction method. The sample was prepared by using 1.25 M HCl Solution, ammonium floride (NH_4F) solution, ammonium molybdate solution, ammonium molybdate-ascorbic acid solution and determined by Spectrophotometer Lumbda-II, UV/vis (Perkin Elmer) at 890 nm wavelength (Bray and Kurtz, 1945).

Sulpher (Available)

The available sulpher of soil samples was extracted by using calcium dihydrogen phosphate solution and determined by turbidiometric method using Lumbda-II Absorbance Spectrophotometer at 535 nm wavelength (Piper, 1950).

Boron (Available)

Boron of the sample soil was extracted by 0.01M $CaCl_2$ and determined by acetate buffer solution and Azomethine-H reagent method using Lumbda-II, UV/vis Spectrophotometer (Perkin Elmer) at 420 nm wavelength (Bringham, 1982).

Potassium and Sodium (Available)

Exchangeable K and Na of soil were extracted with neutral normal ammonium acetate (NH_4OAC) solution, as described by Piper (1950) and Jackson (1972). Then the extracted soils were analyzed for K and Na by using a flame Photometer.

Calcium and Magnesium

Exchangeable Ca and Mg of soil were extracted with neutral normal ammonium acetate (NH_4OAC) solution, as described by Piper (1950) and Jacson (1972). Then the extracted/extracts soil were analyzed for Ca and Mg by adding $LaCl_3$ using Atomic Absorption Spectrophotometer (AAS) Model-3310 (Perkin Elmer) at 422.7 and 279.5 nm wavelength respectively.

Zinc, Copper, Iron and Manganese (Available)

For available Zn, Cu, Fe and Mn, the soil samples were extracted with DTPA extraction method and then diluted Fe, Zn and undiluted Cu and Zn soils extracts were analyzed by Atomic Absorption Spectrophotometer (AAS) Model-3310 (Perkin Elmer) at 213.9, 324.8, 248.3 and 279.5 nm wavelength respectively (Lindsay and Norvell, 1978).

2.8 Fish Diversity Monitoring

Fish diversity was monitored monthly in Posna beel. For fish diversity monitoring, an investigator of CNRS (Center for Natural Resource Studies) was assigned for this beel, to analyze the daily fish catch of fishermen twice in a month.

2.8.1 Sampling

The fish catch assessment was followed the same methods as used by WorldFish (formerly ICLARM) for their sampling of river Titas. Sampling was done twice in a month. Sampling covered gear census and catch monitoring study. Gear census performed number and types of gear operated in the beel. Catch monitoring study was designed to cover all types of gear in the studied section of the beel and selected randomly. A catch assessment monitoring questionnaire developed for CBFM (ICLARM, 2001) was used in the present study. Calculation of annual yield in each gear type and total yield from all gears was made using equation below:

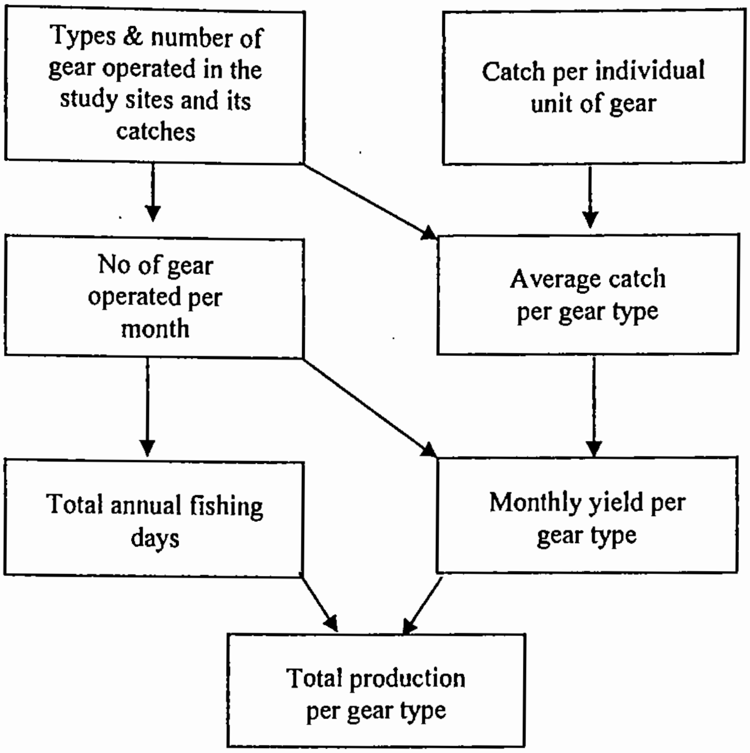
$$\text{Annual yield in each gear type} = \sum_{i}^{n} Average\ i$$

where i = 1, 2, 3, 4 ...., n

$$\text{Total Yield} = \sum_{j=1}^{k} \text{Annual yield in each gear type i}$$

where j = 1, 2, 3, 4 ...., k

Diagram of Annual catch estimation in the Posna Beel



An access based software was used to store and analyzed catch monitoring, gear and other data. Monthly catch monitoring data further pooled to analyzed yearly percentage distribution over species. Average number of gear per day was used to estimate total number of gear wise fishing effort for that month as well as for the whole year. Simultaneously gear wise catch rate (average) was used to estimate the total catch for that month as well as for the whole year.

Year wise as well as overall species distributions were calculated using catch statistics data. Overall production was estimated by summing all estimated production of different gear types in each year.

Monthly catch statistics data from different gear were used to estimate annual catch and species composition (percent composition). Based on annual contributions in percentage of different species and number of contributed species, grouping of species was performed. Species number and their presence in the range of percentage frequency were studied annually to determine the number of species and their impact over the time series. Pooling all annual catch statistics data overall percent composition of all species also studied to observe total situation of the fishery in the Beel. Species grouping was made based on their contributions in the wetland fishery.

All types of fisheries species were identified with the help of relevant literatures, e.g. Berg (1940), Munro (1955), Bhuiyain (1964), Srivastava (1968), Doha (1973), Rahman (1989), Jhingran (1975), Shafi and Qaddus (1982), Rao (1989), Day (1889) and Jahan (1993).

Chapter 3
Observations and Results

3.1 Field Survey

3.1.1 Agro-Chemical Use Scenario of Posna Beel

According to farmers' opinion, use of agro-chemicals in HYV Boro field was the main cause of water pollution of Posna beel. An average, 62.40% farmers of three villages of Posna, Sheroil and Kaluha have expressed the above opinion. They have identified the fertilizer, the decomposition of aquatic weeds and organic matters are first, second and third major causes of water pollution respectively (Table 3.1).

Table 3.1
Major Environmental Factors Causing Water Pollution of Posna Beel as per Farmer's Opinion

Village	Number of Respondents	Percent Respondents Regarding Environmental Factors				
		Fertilizer	Pesticide	Household Waste	Decomposition of Organic Matters	Decomposition of Aquatic Weeds
Posna	108	62.96	0	4.63	17.59	14.81
Sheroil	48	62.5	6.25	2.08	20.83	8.33
Kaluha	34	61.76	11.76	2.94	2.94	20.58
Total & Average	190	62.40 (Avg.)	6.00 (Avg.)	3.21 (Avg.)	13.78 (Avg.)	14.57 (Avg.)

Farmers in the project area use more nitrogenous chemical fertilizer (Urea and NH_4Cl) above the government recommendation level. The farmers in the beel area have been using 113.14 Kg Urea per acre against the government recommendation level of 87.0 Kg per acre (Table 3.2). In addition to Urea, they were also applying another nitrogenous fertilizer NH_4Cl. These two chemical fertilizers were the major causes of skin irritation (locally called "Pani Kamor") and other water pollution problems of Posna beel. However, the application of TSP (42.52 Kg/acre), MP (13.29 Kg/acre) and Gypsum (0.84 Kg/acre) were below the government recommendation level (Table 3.2)

Table 3.2
Fertilizer Use Pattern in three Villages around the Posna Beel on the basis of the Farmers Response to Questionnaire

Villages	Fertilizer Applied							
	HYV Boro Area (Acre)	Urea (Kg)	MP (Kg)	TSP (Kg)	NH_4Cl (Kg)	Gypsum (Kg)	Cowdung (Kg)	Ash (Kg)
Posna	87.95	10,133.5	1202.5	3740.0	1356.5	59	180	0
Sheroil	42.11	4276.5	457.5	1703.5	1003.5	32	320	1000
Kaluha	14.71	1962	263	709	193.75	30.5	0	700
Total	144.71	16,372	1,923	6,152.5	2,553.75	121.5	500	1,700
Average Use/Acre		113.14	13.29	42.52	17.65	0.84	3.45	11.75
Bangladesh Standard (AEZ-9)		87.0	32.39	50.20	-	1.12	-	-

AEZ-9: Brahmaputra Alluvial Soil (BARC, 1997)

Basudin and Furadan were mainly used in the HYV Field around the Posna beel (Table 3.3). Chemically, both of these pesticides were organophosphate types, which contain diazinon. However, a little amount of liquid malathion was also used in the project area, which was under carbamate group pesticides, containing carbofuran.

Table 3.3
Pesticide Use Pattern in three villages around the Posna Beel

Villages	HYV Boro Land (Acre)	Pesticide Applied						
		Dimecron (Kg)	Diazinon (Kg)	Basudin (Kg)	Furadan (Kg)	Carbaryl (Kg)	Malathion (ml)	Linuron (ml)
Posna	27.92	0	0	45.65	0	0	500	250
Sheroil	9.64	0	0	13.25	6.5	0	0	0
Kaluha	0.75	0	0	0	1	0	250	0
Total	38.31	0	0	58.9	7.5	0	750	250
Average Use/Acre		0	0	1.54	0.20	0	19.58	6.53

Among the three villages, the farmers of Posna Village used more pesticides in the HYV Boro fields. They have applied 45.65 Kg Basudin in 27.92 acre land with an average 1.64 Kg per acre. However, the farmers of Kaluha village have used pesticide only in 0.75 acre of 14.71 acre HYV Boro land (Table 3.3). Most of the farmers have purchased their pesticides from nearby Pouzan Bazar (public market place).

Among the 190 respondent farmers, 184 persons did not know the proper dosing of agro-chemicals in HYV Boro fields (Table 3.4). They were interested to learn the proper dosing of fertilizer and pesticides by participating the Farmers' Training Program.

Table 3.4
Agro-chemicals' Dosing and IPM Training Knowledge of Farmers in three villages around the Posna Beel

Villages	Respondents	Having Knowledge about Proper Dosing of Agro-chemicals		Having Knowledge about IPM		Interested to Learn Proper Agro-chemical Dosing	
		Yes	No	Yes	No	Yes	No
Posna	108	0	108	0	108	108	0
Sheroil	48	6	42	2	46	42	6
Kaluha	34	0	34	1	33	34	0
Total	190	6	184	3	187	184	6

3.2 Physical Conditions of Water

Water Temperature

During the study period, the surface water temperature was found to vary from 16.5 to 33.33°C with a mean of 28.01±5.46°C (Appendix table-I). The highest (34.0°C) temperature was recorded in summer'05 and lowest (16.5°C) in winter. The seasonal fluctuation of surface water temperature is shown by figure 3.1.

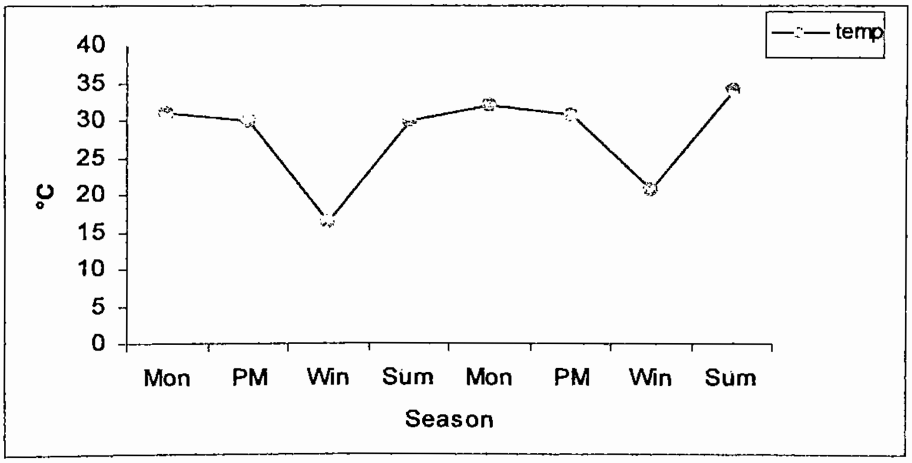


Figure 3.1
Seasonal Fluctuation of Water temperature during the Study Period

Transparency (Secchi disk depth)

Transparency varied from 25.62 to 189.50 cm throughout the study period. The highest value was recorded in winter'03 and lowest value was recorded in summer'04. The mean value was 89.23±58.87 cm (Appendix table I). The fluctuation of transparency is depicted by the figure 3.2.

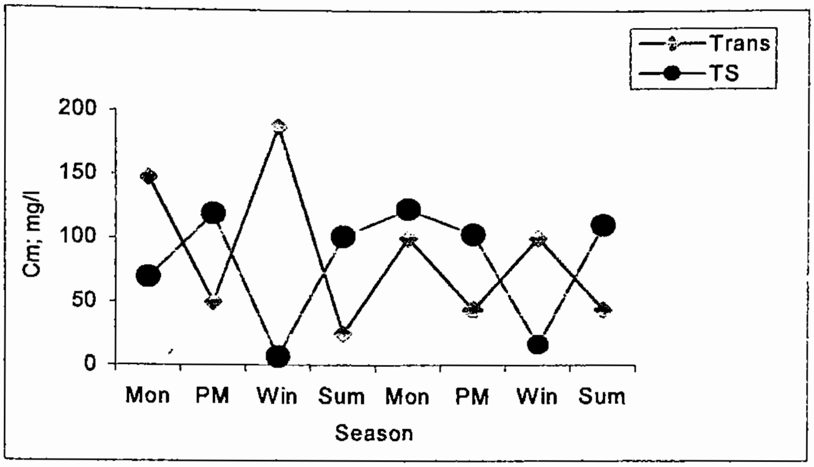


Figure 3.2
Seasonal Fluctuation of Transparency and Total Solids

Total Solids

During the study period, the total solid of water was ranged from 7 mg/l to 123 mg/l. The highest value (123.33 mg/l) was recorded in monsoon'04 while lowest (7 mg/l) was recorded in winter'03. The mean value was 81.53±46.14 mg/l (Appendix table I). The pattern of rise and fall of TS and transparency almost same (Figure 3.2).

3.3 Chemical Conditions of Water

Hydrogen ion Concentration (pH)

The pH value of beel water varied from 6.83 to 8.0. The maximum (8.0) pH was found in monsoon (2004) and minimum was (6.83) found in summer (2005). The mean of pH throughout the study period was 7.39±0.49. During the period of study all the pH values were very near to the mean value (Appendix table I).

Free Carbon dioxide (f CO_2)

The free carbon dioxide of water of the study beel was determined. The highest and lowest carbon dioxide of water in the study period were 13.33 mg/l (summer'05) and 5.0 mg/l (winter'03 and monsoon'04) respectively .The mean value of free carbon dioxide was 9.58±3.05 mg/l (Appendix table I). The variations of free carbon dioxide values are shown by figure 3.3

Alkalinity

The alkalinity of water of the Posna beel throughout the study period was determined. The maximum (51.3 mg/l) alkalinity was found in winter season and minimum (28.50 mg/l) was found in post- monsoon. The mean value of alkalinity of water of Posna beel was 37.76±8.58 mg/l (Appendix table I).

Dissolved Oxygen

Dissolved Oxygen content of water was found to vary from 6.66 to 9.66 mg/l. The maximum (9.66 mg/l) DO was recorded in winter'03 and minimum (6.66 mg/l) was recorded in monsoon'03 .The mean value of dissolved oxygen was recorded as 8.08±0.90 mg/l (Appendix table I).

The seasonal variation of DO value during the study period is presented by figure 3.3.

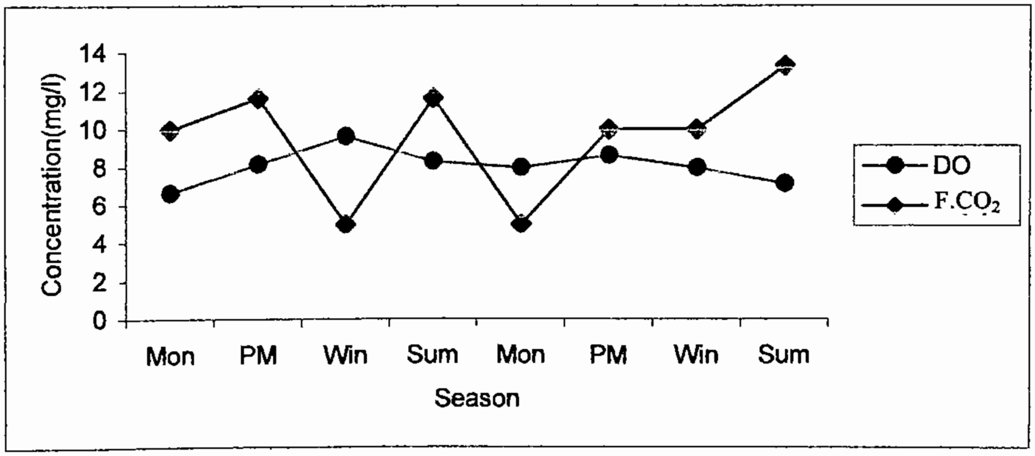


Figure 3.3
Seasonal Variations of Dissolved Oxygen and Free Carbon Dioxide

Percentage Saturation of Oxygen (% Sat. O_2)

The % Sat. O_2 values in the water of the beel are depicted in the appendix table- I. The values indicate that the water remained supersaturated in the post-monsoon and summer seasons varying from 102% to115.7%, in the winter these values came down slightly (88% to 98%). While it showed an under saturation of 88.8% at one time and a supersaturating of 109.5% at other time, However, the % sat. O_2 values were found to vary from 88% to 115.7 % during the study years (Figure 3.4).

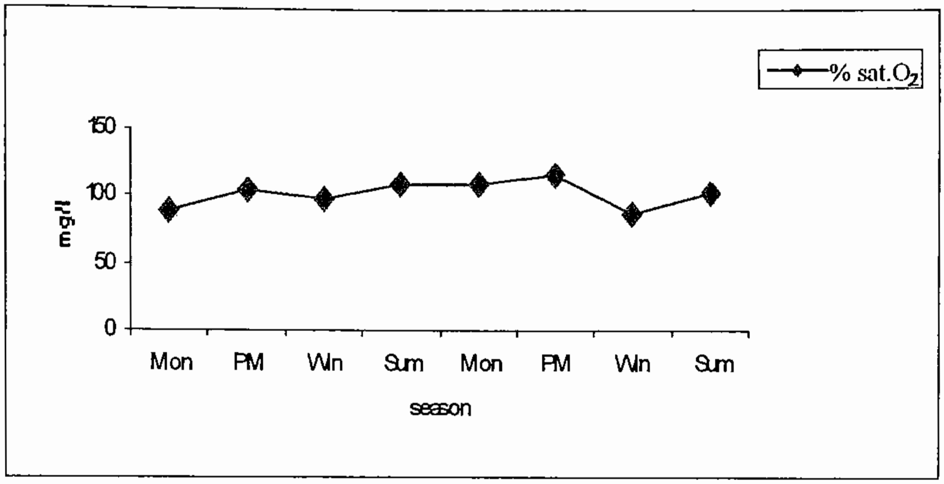


Figure 3.4
Seasonal Variation of Saturation of Oxygen of Posna Beel

Biochemical Oxygen Demand (BOD_5)

The biochemical oxygen demand of the beel water was found to vary from 2.7 to 5.43 mg/l during the entire period of study. The mean value was recorded as 4.15±0.80 mg/l. The highest BOD_5 value was recorded in post-monsoon'03 while lowest was recorded in winter'03. The fluctuation of BOD_5 is presented by figure 3.5.

Chemical Oxygen Demand (COD)

The chemical oxygen demand varied from 5.2 to 8.15 mg/l during the entire period of study. The maximum COD value was recorded in summer'03 while minimum was recorded in winter'03 .The mean value of COD throughout the study period was 6.87±0.99 mg/l. The COD curve ran hand in hand with the BOD_5 curve during the period of study. The seasonal fluctuation of COD is shown by the figure 3.5.

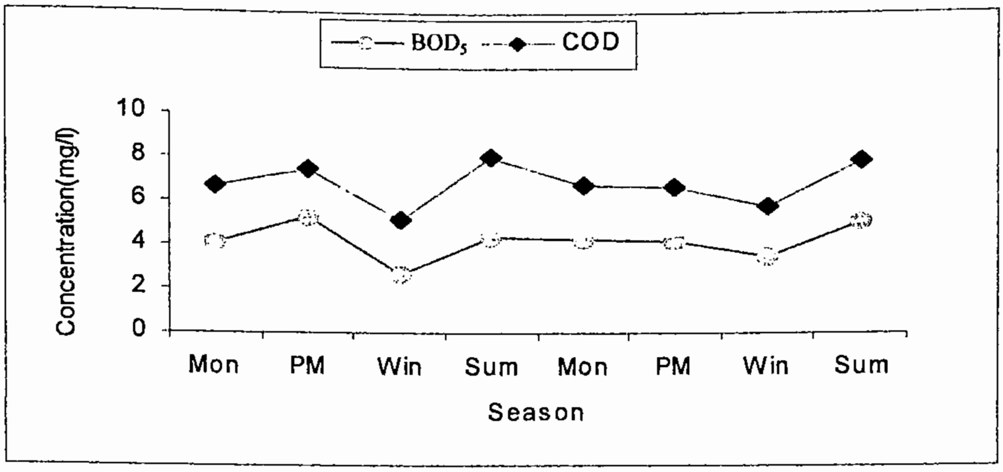


Figure 3.5
Seasonal Fluctuation of BOD_5 and COD in the Study Area

'P' COD-BOD_5

The COD values were always higher than that of the BOD_5 value. The 'P' COD-BOD_5 values are presented in appendix table-I.

Oxidation-reduction Potential (Eh)

The oxidation-reduction potential of water body ranged from 0.25 mv. to 0.59 mv. The highest was recorded in summer'04 and lowest in summer'05. The mean value recorded as 0.047±0.098 mv. The Eh curve throughout the study seasons shows almost a less undulated line indicating a uniform value except a sudden fall in the summer season of 2005. The seasonal fluctuation is shown by figure 3.6.

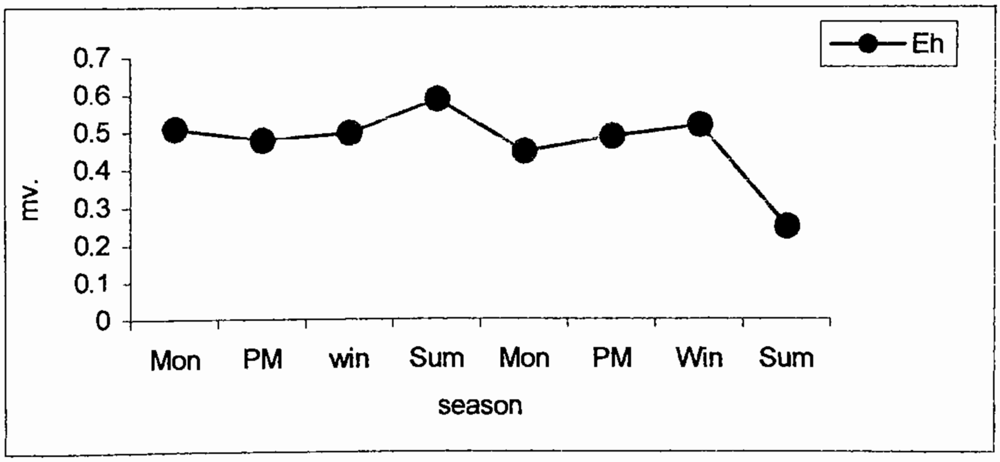


Figure 3.6
Seasonal Fluctuation of Oxidation-Reduction Potential

Oxidation -reduction Index (rH_2)

During the study period, the oxidation -reduction index values of water varied from 29.31 to 32.80. The mean value was 31.90±1.20. The highest value was noted in winter'05 and lowest was in monsoon'05. The values were recorded with regular downhill and uphill fluctuation during the entire study period. Seasonal fluctuation of curve of rH_2 is shown by figure 3.7.

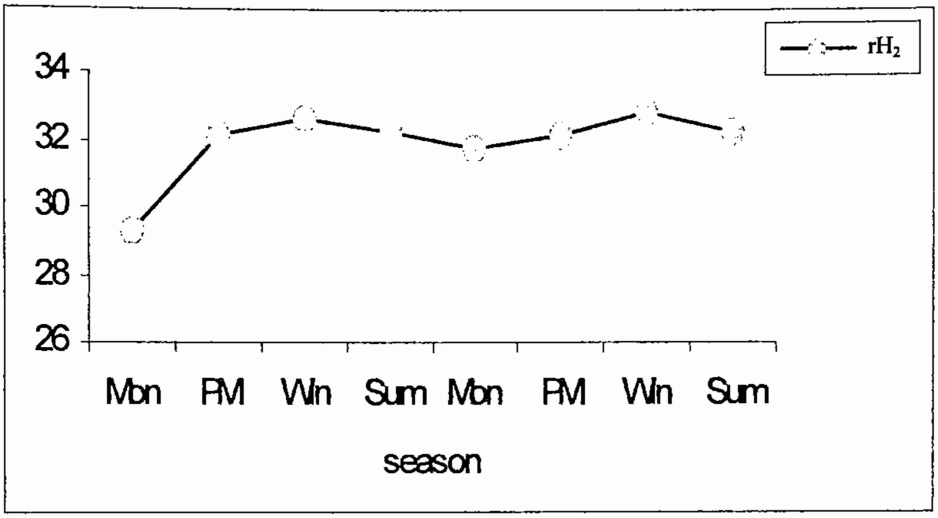


Figure 3.7
Seasonal Fluctuation of Oxidation-Reduction Index

Total Hardness

Total hardness varied from 51.30 to 74.10 mg/l with mean value of 61.40±7.45 mg/l (Appendix table I). The highest and lowest hardness were observed as 74.10 mg/l (summer'05) and 51.30 mg/l (monsoon'03) respectively.

Chloride (Cl^-)

Throughout the period of study the highest amount (31.25 mg/l) of chloride was recorded in post-monsoon in 2003 and 2004 as well as the lowest amount (25.58 mg/l) was recorded in monsoon'04. The mean value of chloride of water of the posna beel during the study periods was 29.15±2.05 mg/l (Appendix table I). The seasonal variation of chloride is presented by figure 3.8.

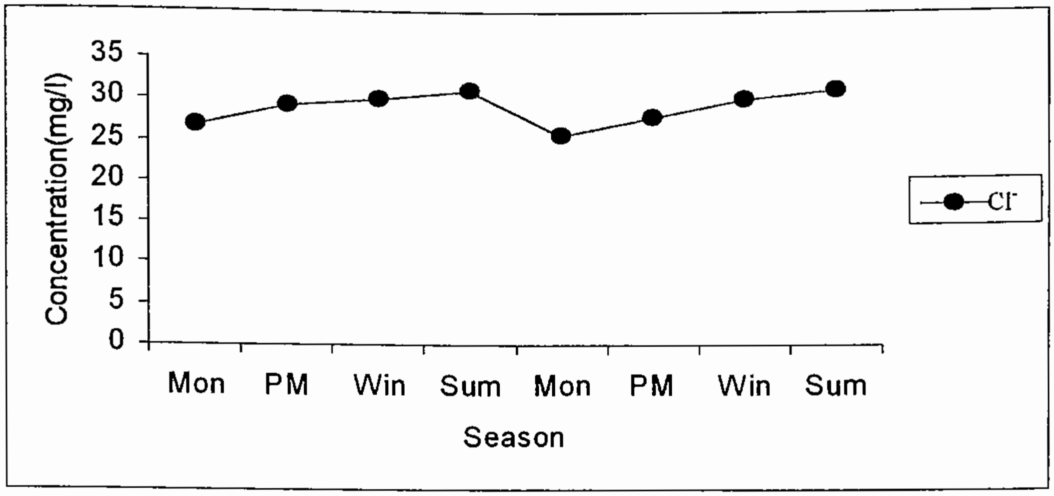


Figure 3.8
Seasonal Variation of Chloride during the Study Period

Ammonia

The ammonia contents of surface water of Posna beel throughout the study period was estimated, the maximum value (0.073 mg/l) was found in monsoon in 2004 and minimum (0.012 mg/l) was in the summer'03. The mean value of ammonia was 0.04± 0.02 mg/l (Appendix table I). The seasonal variations of ammonia content in water are shown by figure 3.9.

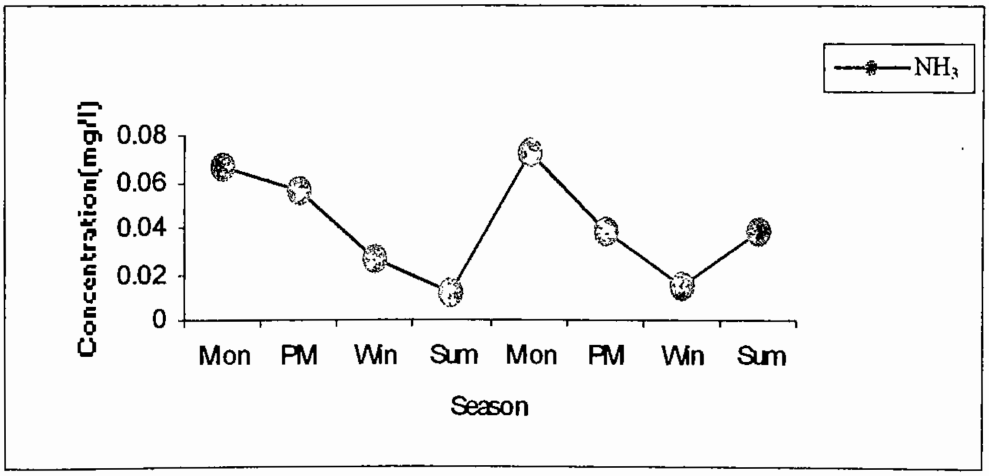


Figure 3.9
Seasonal Variation of Ammonia during the Study Period

Nitrate

In case of nitrate contents the maximum value (0.48 mg/l) and minimum (0.15 mg/l) were obtained in monsoon'03 and winter'04 respectively with the mean value of water as 0.26 ± 0.12mg/l (Appendix table I). The seasonal variation of nitrate is shown by figure 3.10.

Phosphate

The amounts of phosphate contents were determined .The maximum amount (5.39 mg/l) of phosphate was recorded in summer'04 while minimum (2.68 mg/l) was recorded in winter' 03. The mean value of phosphate concentration in water during the study period was 4.20±0.95 mg/l (Appendix table I). The seasonal variation of phosphate is presented by figure 3.10.

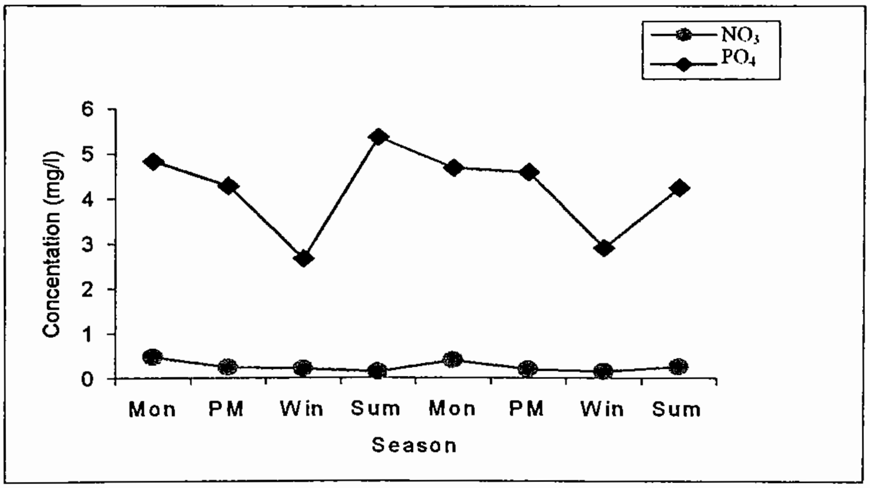


Figure 3.10
Seasonal Variations of Nitrate and Phosphate during the Study Period

3.4 Pesticide Residue in Water and Sediment

Pesticide residue analysis from water and sediment samples has been carried out during monsoon (August, 2003) and summer (April, 2004) seasons. Residue analysis was done at the Atomic Energy Commission Lab, Savar, Dhaka. Three groups of pesticides such as Organochlorine, Carbamate and Organophosphorus have been analyzed with GC-ECD and HPLC.

Trace amounts of DDT, Heptachlor and Dieldrin were detected in both water and sediment samples. Very trace amount of organochlorine pesticide residues as DDE, DDD and DDT were found in sediment samples only in summer season whereas DDT was found in trace amount in the water samples of both the seasons and Heptachlor and Dieldrin were found in water samples of monsoon (Table 3.5). Organophosphorus and carbamate pesticides were totally absent in all samples of water and sediment of Posna beel.

Table 3.5
Average Pesticide Residue in Composite Samples of Water and Sediment of Posna Beel in Monsoon and Summer Seasons

Pesticides		Sample Matrix			
		Water		Sediment	
		Monsoon	Summer	Monsoon	Summer
Organochlorine	DDE	ND	ND	ND	Trace
	DDD	ND	ND	ND	Trace
	DDT	Trace	ND	Trace	Trace
	Endo-sulfan	ND	ND	ND	ND
	Heptachlor	Trace	ND	Trace	ND
	Aldrin	ND	ND	ND	ND
	Dieldrin	Trace	ND	Trace	ND
	Lindane	ND	ND	ND	ND
	HBC	ND	ND	ND	ND
Organophosphorus	Malathion	ND	ND	ND	ND
	Diazinon	ND	ND	ND	ND
	DDVP	ND	ND	ND	ND
	Chlorpyriphos	ND	ND	ND	ND
Carbamate	Carbofuran	ND	ND	ND	ND
	Carbaryl	ND	ND	ND	ND
	Cypermethrin	ND	ND	ND	ND

ND – Not Detected
Trace – Very small amount (Not Quantifiable)

3.5 Nutrient in Beel Sediment

The sediment samples of Posna beel was studied for one year namely three seasons (monsoon, winter and summer) to know the nutrient status of the beel. The Physico-chemical properties of beel sediment are given in table 3.6. The range and mean values with SD of different nutrient properties were as follows.

pH (ranged 4.33-5.33) was always found below neutral value. Low (4.33) pH contain in soil was in summer. The mean value and SD of pH were 4.85±0.50, the Organic Matter varied from 3.84 to 6.25 with an average value 4.75±1.30 (%). Total Nitrogen (N) value almost same in three seasons and mean value with SD was 0.25±0.02 (%) (Table 3.6). Phosphorus (P) mean value was 10.47±14.40 µg/g, high level of Phosphorus was recorded in summer season. The peak (2.15 meq/100g) Potassium was found in winter of which mean value of Potassium (K) was 0.87±1.10 meq/100gm. The mean value and SD of Sodium was 0.17±0.16 meq/100g, lowest (0.04 meq/100g) content of sodium in beel sediment was found in summer season; Sulphur (S) content in sediment varied from 34.00 to 68.94 µg/gm and mean value was 51.25±19.21µg/gm. The mean value with SD of Calcium, Magnesium Boron, Copper and Iron were 6.26±1.08meq/100g, 2.13±0.38 meq/100g, 9.95±1.83 µg/g, 9.95±1.83 µg/g and 422±15.27 µg/g respectively. The mean value of Manganese was 46.18±19.34 µg/g. Lower level of Mn was found in winter season. The amount of Zinc (1.36±0.15 µg/g) in beel sediment was almost same in all seasons (Table 3.6).

Table 3.6
Physico –chemical Properties of Sediment of the Posna Beel

Name of Elements	Monsoon	Winter	Summer	Mean ± SD	Comments
pH	5.33	4.33	4.90	4.85±0.50	Medium
Organic Matter (%)	3.84	4.17	6.25	4.75±1.30	High
Total Nitrogen (N), %	0.26	0.24	0.26	0.25±0.02	Medium
Phosphorous (P), µg/g	3.32	1.04	27.05	10.47±14.40	Very Low
Potassium (K), Meq/100g	0.35	2.15	0.13	0.87±1.10	High
Sulphur (S), µg/g	54.00	30.81	68.94	51.25±19.21	Very High
Sodium, meq/100 g	0.12	0.35	0.04	0.17±0.16	-
Calcium, meq/100 g	7.33	5.16	6.30	6.26±1.08	High
Magnesium, meq/100 g	2.56	2.00	1.83	2.13±.38	Very High
Boron, µg/g	0.45	0.44	0.84	0.57±0.22	Optimum
Copper, µg/g	10.24	11.63	8.00	9.95±1.83	Very High
Iron, µg/g	417.96	418.66	440.0	422±15.27	Very High
Manganese, µg/g	55.63	23.93	59.0	46.18±19.34	Very High
Zinc, µg/g	1.23	1.31	1.53	1.36±0.15	Medium

3.6 Biological Conditions

3.6.1 Phytoplankton

Phytoplankton population of the Posna beel was studied at three-month intervals by four seasons throughout the study period. A total of 47 genera were recorded from the study area of which 19 genera (42 species identified) belonged to Chlorophyceae, 13 genera (27 species identified) to Cyanophyceae, 10 genera (24 species identified) to Bacillariophyceae, 3 genera (18 species identified) to Euglenophyceae and 2 genera (4 species identified) to Dinophyceae. Phytoplankton composition was always higher than that of zooplankton and constitutes 85.05% of total plankton. The highest abundance was observed in winter'05 and lowest was in summer'05. The mean value of phytoplankton during the study period was 17642±30818 units/l. Seasonal abundance of different classes of phytoplankton is shown by figure 3.11.

Dinophyceae (57.60%) was found to be more dominant group of phytoplankton population followed by Chlorophyceae (25.26%), Cyanophyceae (9.02%), Bacillariophyceae (4.95%) and Euglenophyceae (2.09%) during the study period in the Posna beel (Figure 3.13).

Chlorophyceae

The green phytoplankton constituted 25.26% of the total phytoplankton throughout the study period. The highest (13900 units/l) abundance of Chlorophyceae population was recorded in winter'04 (Figure 3.11) while the lowest was recorded in winter'03. The mean abundance was found to be 5715±5847 units/l in the entire study period. The green phytoplankton population occupied the second highest position among all the phytoplankton classes in abundance. Among the 19 genera of Chlorophyceae, *Chlorella* was found to be most dominant (20.61%) genus (Appendix table III) during the winter'04 and summer' 05 respectively. Only *Cosmarium* genus found in all seasons except post-monsoon'04 during the entire study period.

Cyanophyceae

The Cyanophyceae constituted 9.20% of the total bulk of phytoplankton and were found to be third dominant group. Higher (3725 unit/l) abundance of Cyanophyceae was noted in post-monsoon'04 and lowest (200 units/l) abundance was in summer'04. Cyanophyceae class was totally absent in winter'04. The mean abundance of Cyanophyceae were 1289±1356 units/l (Appendix table V). This class included 13 genera. Among them *Aphanocapsa* (2.35%) and *Oscillatoria* (3.06%) were more dominant than others genera (Appendix table III). The abundance of the class was dominant in the post-monsoon in both the years. Only 2 genera like *Aphanocapsa* and *Gleocapsa* were found throughout the study period. Any genus of Cyanophyceae was not found in winter season (2005). On the other hand, only two genera were noted in summer season (2005) from the Posna beel (Appendix table III).

Bacillariophyceae

Bacillariophyceae represents the third dominant class among the algal plankton and constituted 4.95% of the total phytoplankton population. The highest abundance was observed in post-monsoon (2003) .The Bacillariophyceae population was totally absent in winter'04 during the study period. (Appendix table V). During the entire study period, *Melosira* was dominant (1.93%) genera followed by *Fragilaria* (0.81%), *Navicula* (0.62%) and *Pinnularia* (0.44%). A total of 10 genera were recorded during the course of study (Appendix table III).

Euglenophyceae

The Euglenophyceae constituted 2.09 % of the total bulk of phytoplankton. The seasonal abundance of euglenoid was found to vary from 67 to798 units/l. The mean abundance of euglonoid was 370±285 units/l. The highest abundance was recorded in post-monsoon'04 and lowest was in winter'04. During the study period, only 3 genera of euglenoids were found from the study area. *Euglena* (1.26%) was dominant genus followed by *Trachelomonus* (0.63%) and *Phacus* (0.52%) of the total phytoplankton. *Euglena* genus was found in all seasons throughout the study period (Appendix table III and V).

Dinophyceae

Dinophyceae was found to be the first dominant class and constituted 55.60% of the total phytoplankton population. The highest abundance of Dinophyceae was noted in winter season in 2004. Only two genera were identified from the Posna beel during the study period. Of the two genera *Ceratium* was the most dominant genus which was unique with 57.66 % of the total phytoplankton (Figure 3.14). Whereas abundance of another genus *Peridinium* was found to be poor which contained 0.04% of the total phytoplankton. A few *Peridinium* populations were found only in winter season in 2003. On the other hand, *Ceratium* was totally absent in monsoon, post-monsoon and winter in 2004 and summer in 2005. Notably in 2004, the tremendous abundance (79066 units/l) of *Ceratium* was observed only in winter season, which contained 99.94 % of the class (Appendix table III).

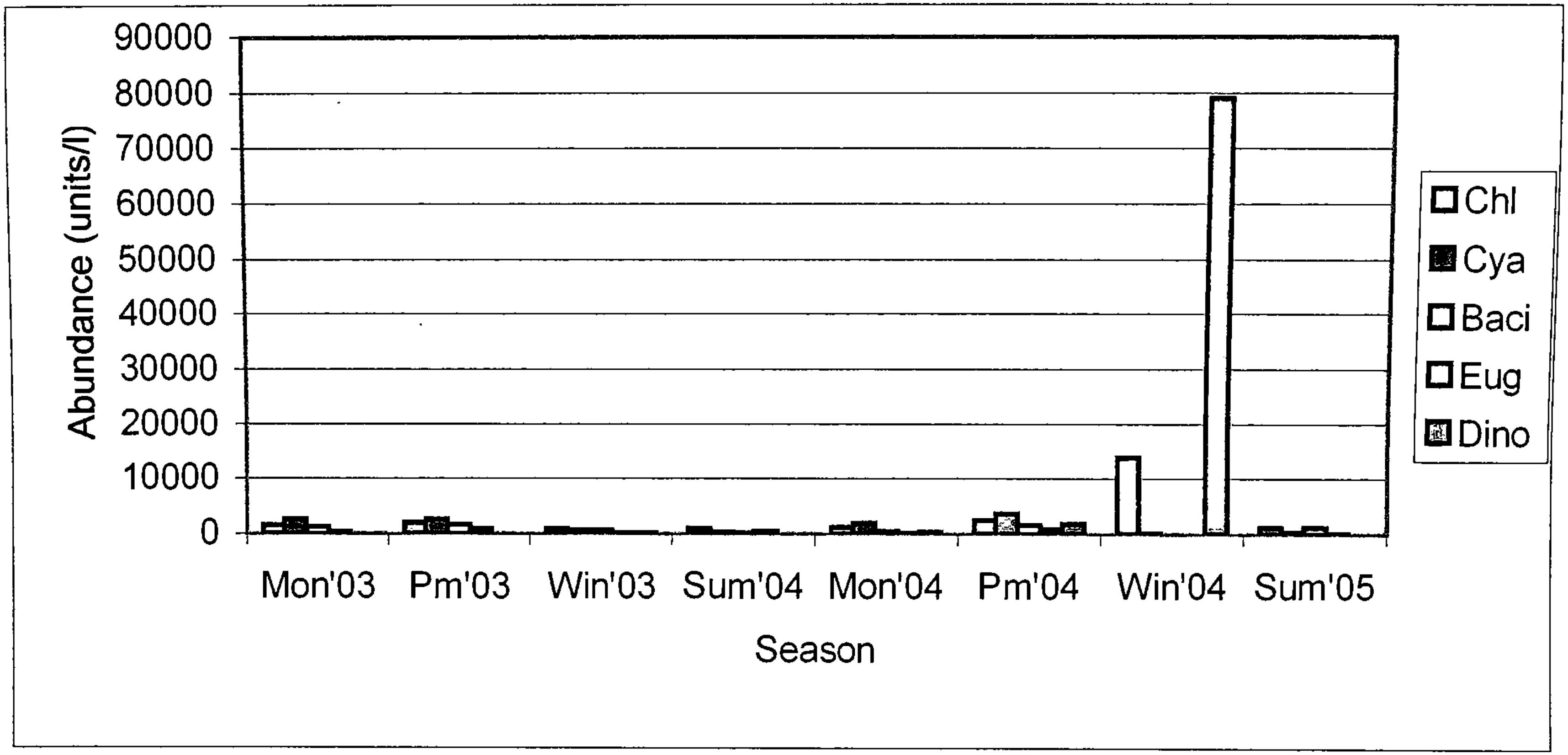


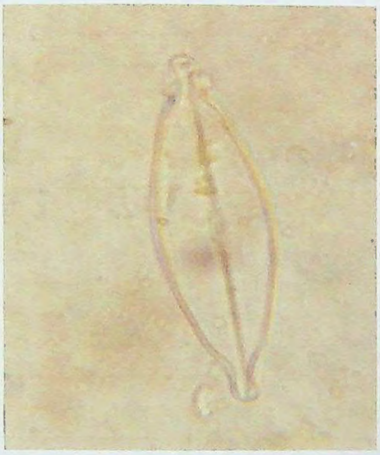
Figure 3.11
Seasonal Abundance of Different Classes of Phytoplankton in Posna beel during the Study Period 2003 to 2005.

Micro-photographs (Phytoplankton)

Pediastrum simplex

Cosmarium sp.

Closterium sp.



Navicula sp.

Phacus pleoronectus

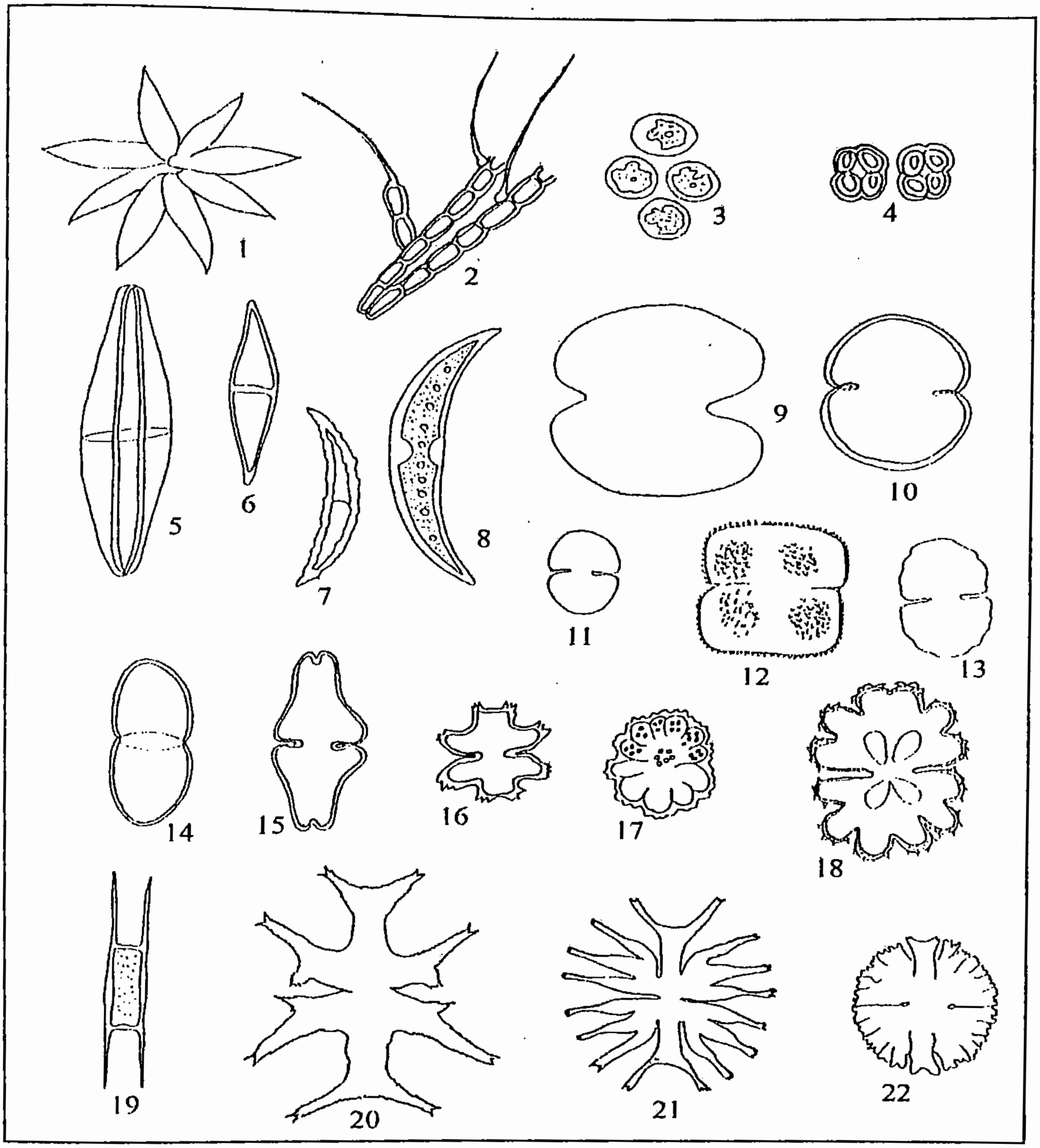
Trachelomonas lacustris

Euglena Cyst

Peridinium sp.

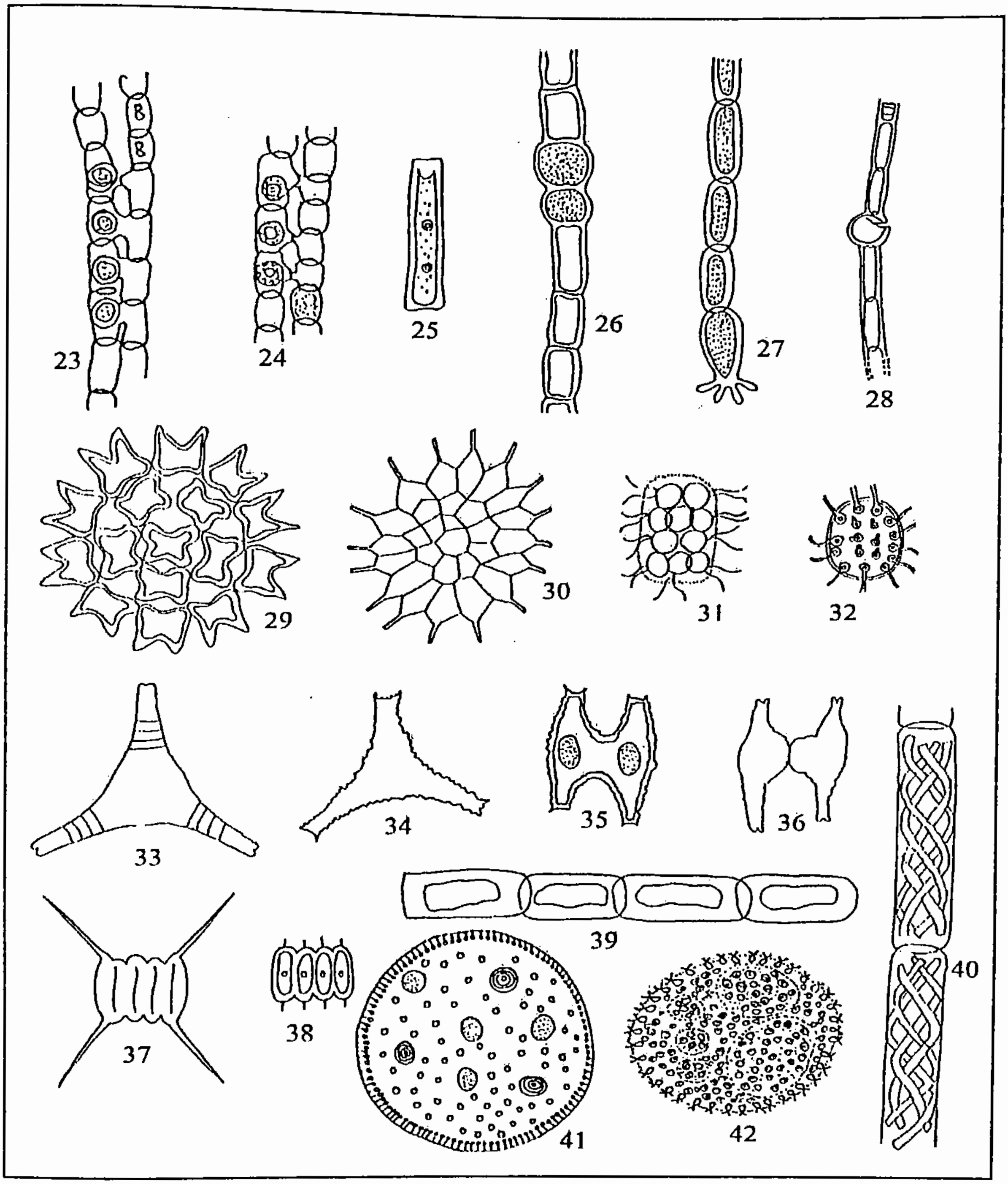
Ceratium sp.

Plate-1: Chlorophyceae



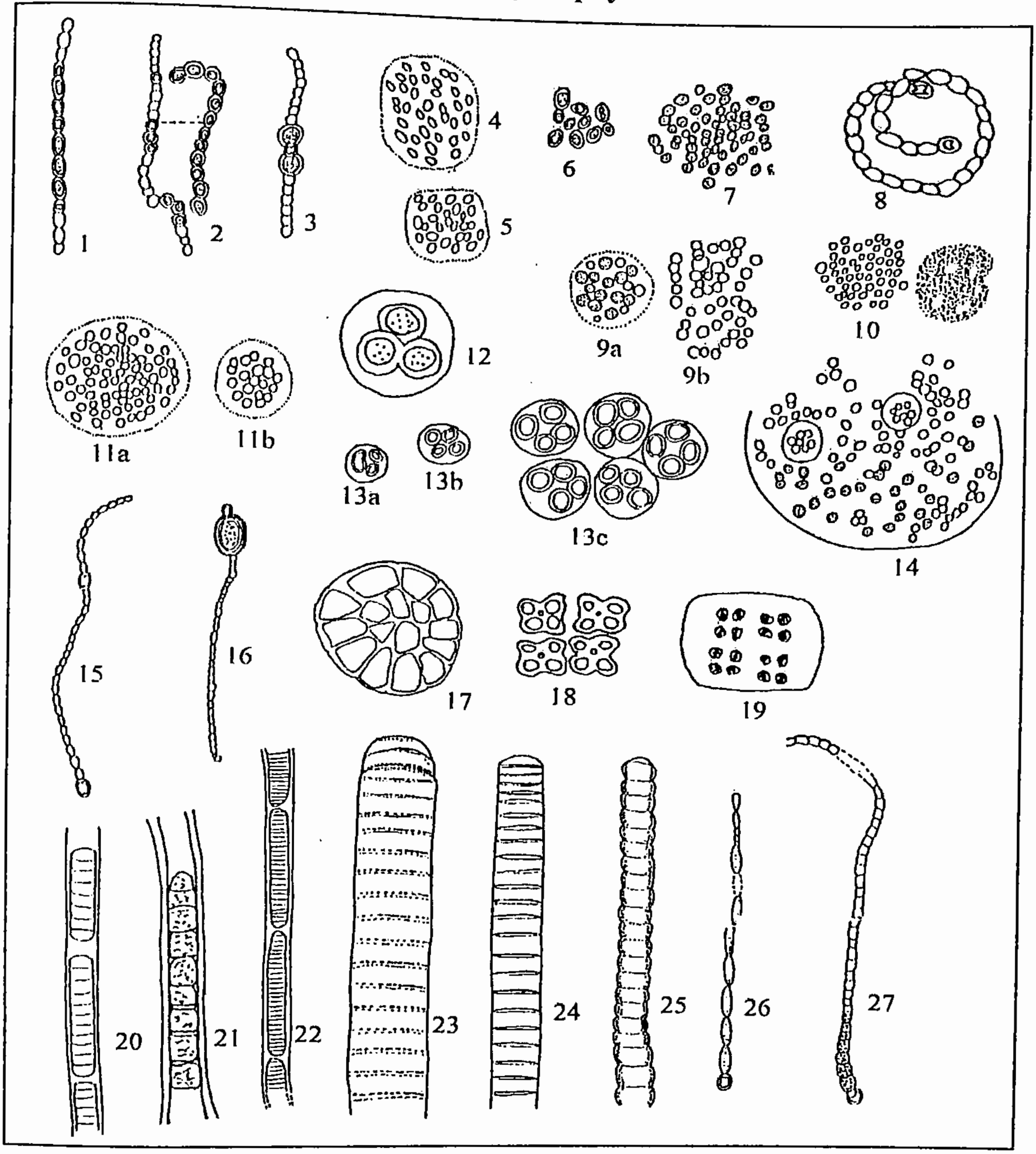
1. *Actinastrum gracillimum* 2. *Bulbochaete annularis* 3. *Chlorella sp.* 4. *Crucigenia fenestrata* 5. *Closterium libellula* 6. *Closterium sp.* 7. *Closterim genneri* 8. *Closterium moniliferum* 9. *Cosmarium connatum* 10. *Cosmarium lundellii* 11. *Cosmarium subtumidum* 12. *Cosmarium quadrum* 13. *Cosmarium subprotumidum* 14. *Cosmarium pseudopyramidatum* 15. *Euastrum membraniporum* 16. *Euastrum platycerum* 17. *Euastrum spinulosum* 18. *Euastrum spinulosum var. inermius* 19. *Microspora sp.* 20. *Micrasterias tropica* 21. *Micrasterias alata* 22. *Micrasterias rotata.*

Plate-2: Chlorophyceae



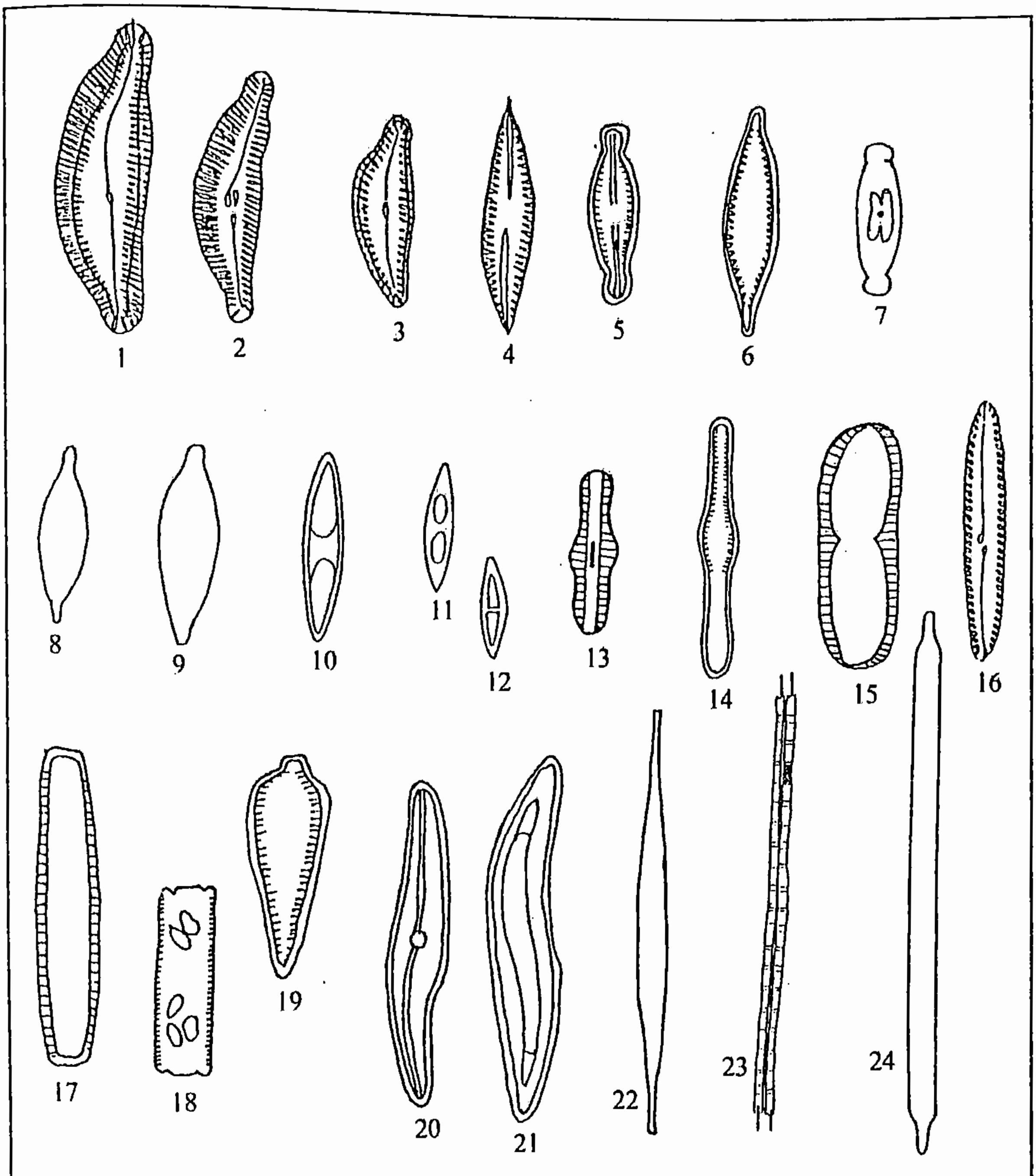
23. *Zygnema spontaneum* 24. *Zygnema cylindrospermum* 25. *Mougeotia viridis* 26. *Oedogonium dacchense* 27. *Oedogonium intermidia* 28. *Oedogonium crispum* 29. *Pediastrum duplex* 30. *Pediastrum simplex* 31. *Pandorina morum* 32. *Pleodorina morum* 33. *Staurastrum manfeldtii* 34. *Staurastrum cyclacanthum* 35. *Staurastrum longibrachiatum* 36. *Staurastrum coroniferum* 37. *Scenedesmus opoliensis* 38. *Scenedesmus longus* 39. *Mougeotia sp.* 40. *Spirogyra sp.* 41 *Volvox carteri* 42. *Volvox mononae*

Plate-3: Cyanophyceae



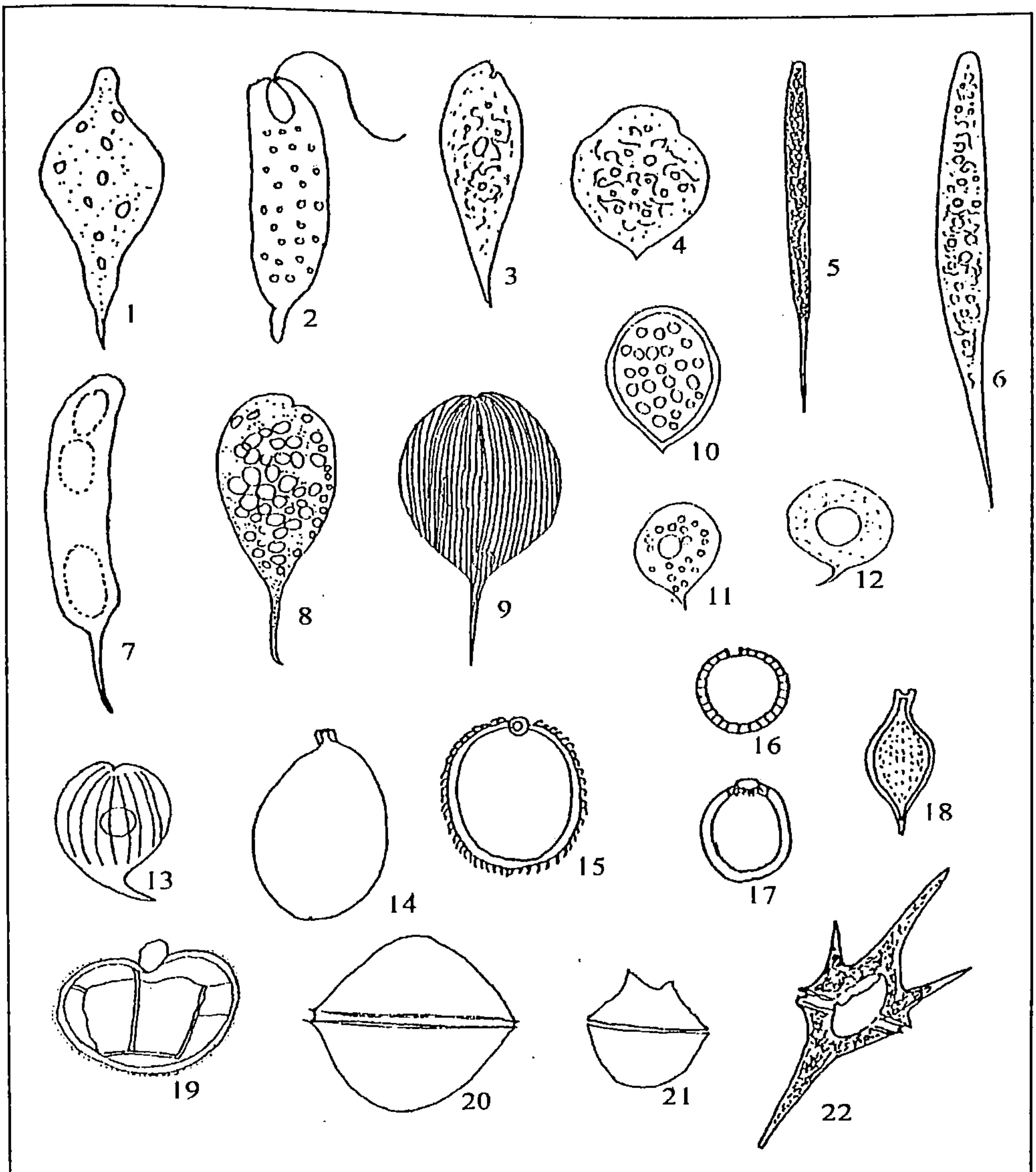
1. Anabaena variabilis 2. Anabaena anomala 3. Anabaena spherica 4. Aphanothece microscopia 5. Aphanothece naegelli 6. Gloeocapsa luteo fusca 7. Aphanocapsa montana 8. Anabaenopsis circularis 9. Microcystis robusta fusca 10. Microcystis flos-aqua 11(a-b). Aphanocapsa biformis 12. Gloeocapsa stegophila 13(a-c). Gloeocapsa sp. 14. Microcystis viridis 15. Nostoc carneum 16. Choleochaete scutata 17. Cylindrospermum indicum. 18. Merismopedia punctata 19. Merismopedia elegans 20. Lyngbya hieronymusii 21. Lyngbya sp. 22. Lyngbya truncicola 23. Oscillatoria princeps 24. Oscillatoria sp. 25. Oscillatoria tenuis 26. Rivularia aquatica 27. Rivularia varia

Plate-4: Bacillariophyceae



1. Cymbella hustedtii 2. Cymbella tumida 3. Cymbella turgida 4. Navicula menisculus 5. Navicula grimmei 6. Navicula exigna 7. Navicula halophila var. robusta 8. Navicula halophila 9. Navicula cuspidata 10. Navicula sp. 11. Navicula sp. 12. Navicula sp. 13. Pinnularia gibba 14. Pinnularia tabellaria 15. Pinnularia gibba 16. Pinnularia saga 17. Pinnularia gibba var parva 18. Fragilaria sp. 19. Gomphonema olivecea 20. Gyrosigma acuminatum var. lacustre 21. Gyrosigma acuminatum 22. Nitzschia acicularis 23. Melosira granulata 24. Synedra alna.

Plate-5: Euglenophyceae & Dinophyceae



1. Euglena rostifera 2. Euglena rubra 3. Euglena flava 4. Euglena sp. 5. Euglena sp. 6. Euglena acus 7. Euglena charkowiensis 8. Phacus elegans 9. Phacus ranula 10. Phacus sp. 11. Phacus sp. 12. Phacus sp. 13. Phacus hamatus 14. Trachelomonas volzii 15. Trachelomonas hispida 16. Trachelomonas Superba 17. Trachelomonas oblonga 18. Trachelomonas allorgei 19. Peridinium sp. 20. Peridinium sp. 21. Peridinium sp. 22. Ceratium.

3.6.2 Zooplankton

Both qualitative and quantitative fluctuation in zooplankton was observed during the two-year study period. Zooplankton of the study period constituted the minor bulk of the total plankton population of Posna beel, which constituted 14.95% of total plankton (Figure 3.15). The highest abundance of zooplankton population was observed in post-monsoon while lowest abundance was observed in winter'03 and summer'05. The mean abundance of zooplankton was 3100±1003 units/l (Appendix table VII). The major groups were Rotifer, Cladocera, Copepoda, Ostracoda and Crustacean Larvae, Copepoda was the dominant group. It constituted 37.87% of total zooplankton population. A total of 40 genera including 63 Species of which 13 to Rotifer, 13 to Cladocera, 8 to Copepoda and 6 to Ostracoda were recorded. The seasonal abundance and percent composition are shown by figure 3.12 and figure 3.14 respectively.

The sequence of dominance of different groups of zooplankton was as follows: Copepoda (37.87%) > Cladocera (27.32%) > Rotifera (20.95%) > Crustacean Larvae (7.625) > Ostracoda (6.215%).

Rotifera

The Rotifera group (5198 units/l) was found to constitute 20.95% of the total zooplankton during the study period. Their abundance varied from 82 to 1346 units/l with a mean abundance 650±413 units/l. The highest (1346 units/l) abundance was found in the season of post-monsoon in 2004 and lowest (275 units/l) was in summer in 2004 (Appendix table V). A total of 13 genera including 26 species were identified. *Keratella* was dominant (7.91%) of the total Rotifera population throughout the study period followed by *Brachionus* (4.39%) and *Notholca* (1.53%). The genera identified were *Brachionus, Ecdyuaridae, Filinia, Keratella, Lecane, Notholca, Monostyla, Platiyas, Pomphodyx Polyarthra, Rotaria, Squantinella* and *Trichocerca* (Appendix table IV)

Cladocera

The Cladocera constituted the second dominant group of zooplankton comprising 27.32 % of the total bulk of zooplankton population. The highest (1533 units/l) abundance was recorded in monsoon in 2004 and lowest (379 units/l) was in summer in 2004. The mean abundance was 847±513 units/l during the entire study period (Appendix table VI).

They showed their peak abundance (1537 units/l) in monsoon'03 and post-monsoon'03 (1440 units/l) as well as the lowest abundance (305 units/l) in winter in 2003 and 2004. A total of 13 genera including 19 species were identified from the Posna beel. *Diaphanosoma* was dominant (9.82%) of the total Rotifera population throughout the study period. *Bosmina, Ceriodaphnia* and *Diaphanosoma* were found in all seasons throughout the study period. *Macrothrix* was found only in post-monsoon season in 2003 (Appendix table IV).

Copepoda

The Copepoda was the first dominant group that constituted 37.87% of the total zooplankton population. The highest density (2500 units/l) of Copepoda was observed in mosoon'03 and the lowest (633 units/l) was in winter'04. The mean abundance of Copepoda was recorded as 1174±6.30 units/l (Appendix table VI). A total of 8 genera including 13 species were recorded in the Posna beel, among them *Cyclops* (22.94%) was dominant genera in total Copepods population followed by *Diaptomus* (19.77%), *Heliodiaptomus* (19.14%), *Mesocyclops* (16.00%) (Appendix table IV).

Ostracoda

The Ostracoda group (1541 units/l) was found to occur in less number than the other groups. In the study period, which was 6.21% of the total zooplankton. The Ostracod population varied from 33 to 414 units/l with a mean abundance 193±81 units/l (Appendix table VI). The highest abundance was recorded in winter season in 2003 and lowest was in monsoon'04. *Euypris sp.* showed dominance (741units/l) in abundance of the total Ostracods which was 2.97% of the total zooplankton while *Cypria* showed the lowest (42 units/l) abundance which was 0.16% of the total plankton (Appendix table IV). *Cypris* was found in all seasons except post-monsoon'04. A total of 6 genus viz. *Cypris, Cypria, Centrocypris, Eucypris, Heterocypris* and *Stenocypris* were identified from the study area (Appendix table IV).

Crustacean Larvae

Crustacean larvae comprise mainly of Nauplia and Metanauplias, and constituted 7.62% of the total zooplankton throughout the study period. Crustacean larvae showed their peak in post-monsoon'03 and lowest number in summer'04. The highest number of Crustacean larvae was noted in post-monsoon. Total abundance and seasonal distributions are shown in Appendix table VI.

3.7 Total Plankton

The population of phytoplankton was higher in winter'04 and summer'05 while zooplankton population was higher in post-monsoon season in 2003 and 2004 respectively (Appendix table VII). Among the plankton population, phytoplankton constitutes 85.05% and zooplankton 14.95% of total plankton population of Posna beel .The percentages of total phytoplankton and zooplankton during study period are shown by figure-15. The total phytoplankton- zooplankton ratio throughout the study period was **5.7 : 1** (Appendix table VII).

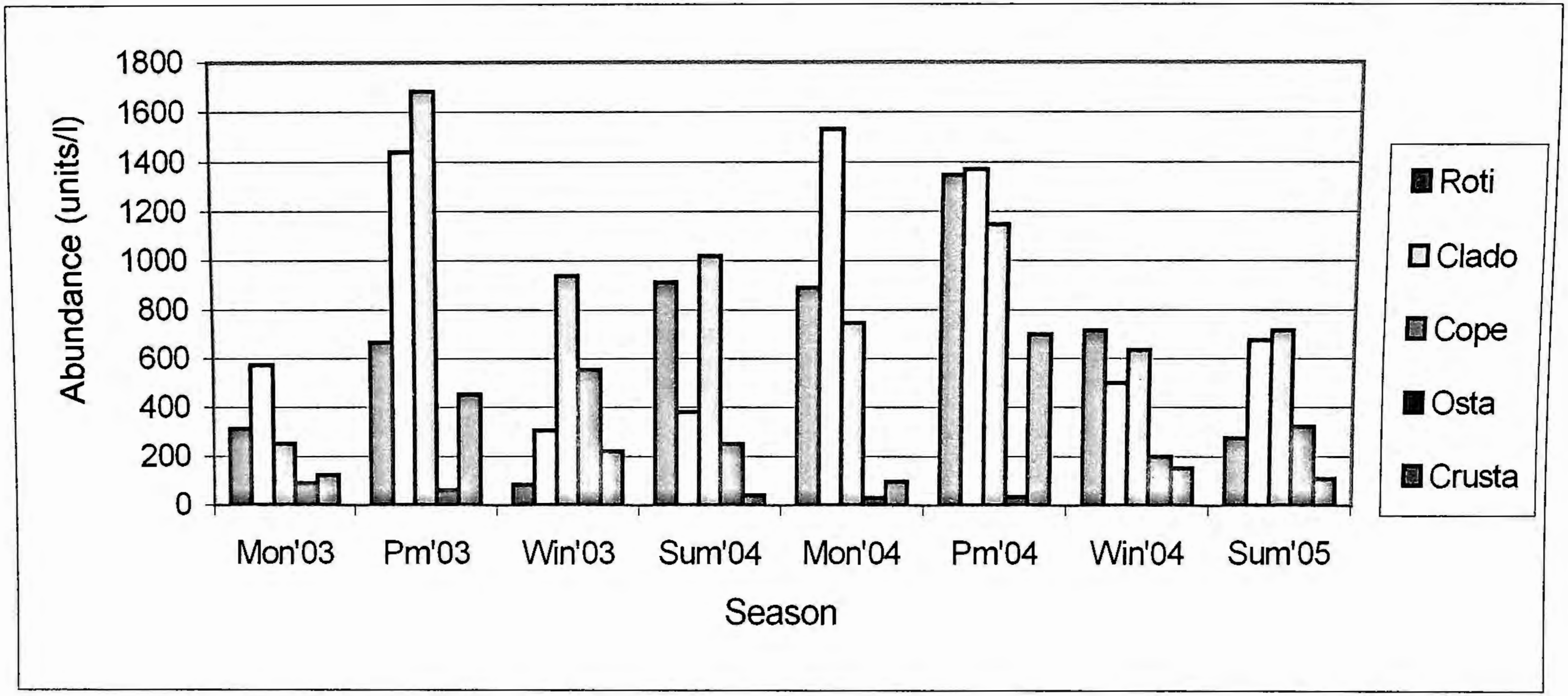


Figure 3.12
Seasonal Abundance of Different Groups of Zooplankton in Posna Beel during the Study Period 2003 to 2005

Micro-photographs (Zooplankton)

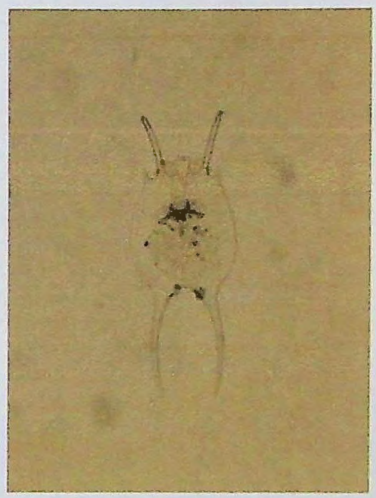
Diaphanosoma sp.

Diaphanosoma sp.

Moina sp.

Diaptomus sp.

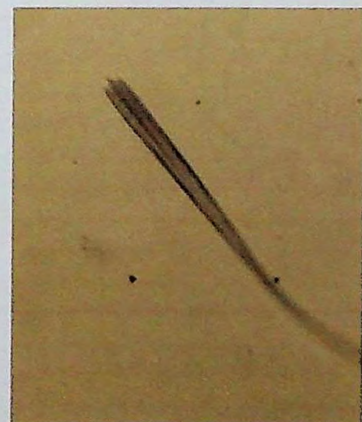
Heliodiaptomus sp.



Brachionus sp.

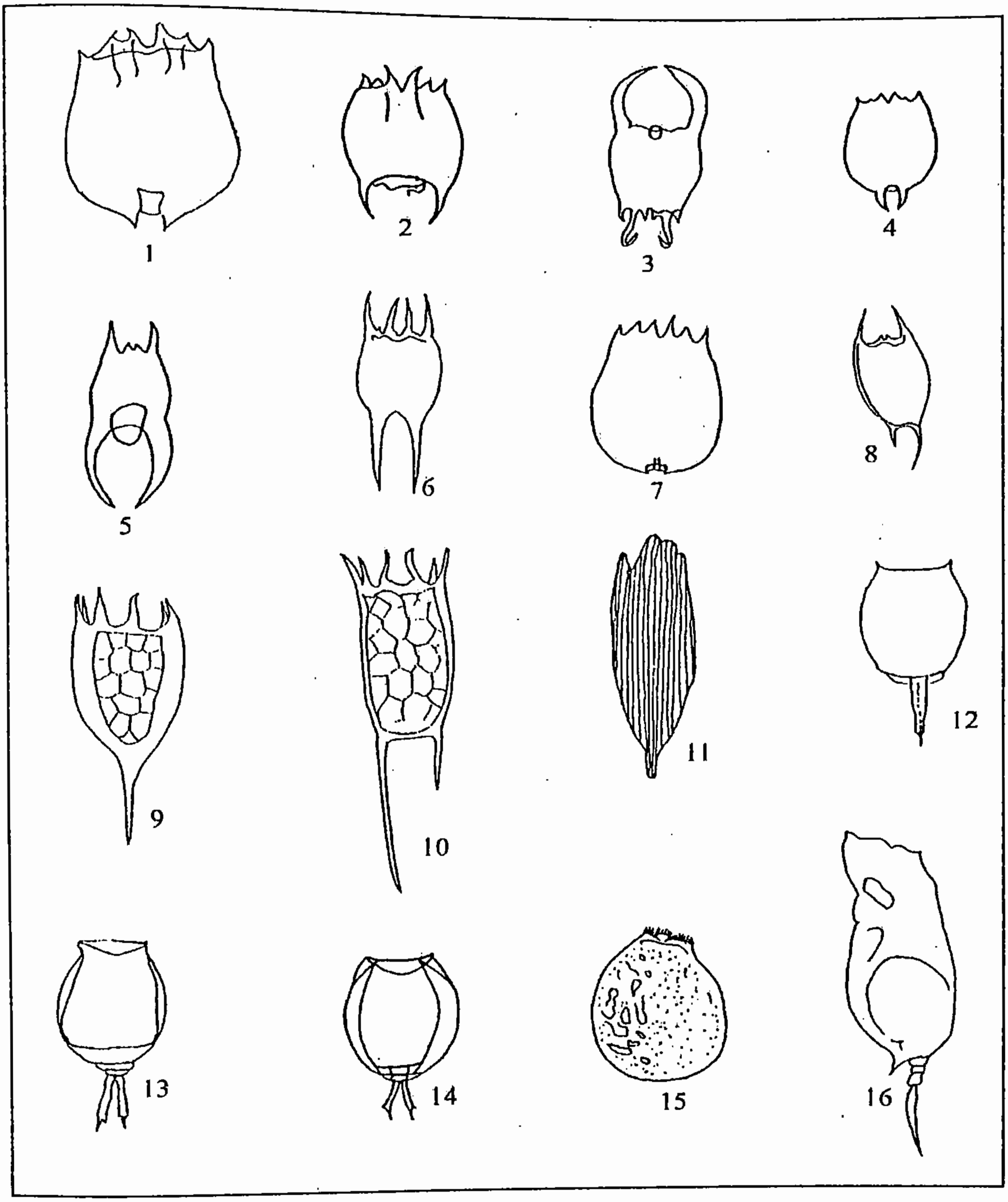
Keratella sp.

Filinia sp. & Bosmina sp.



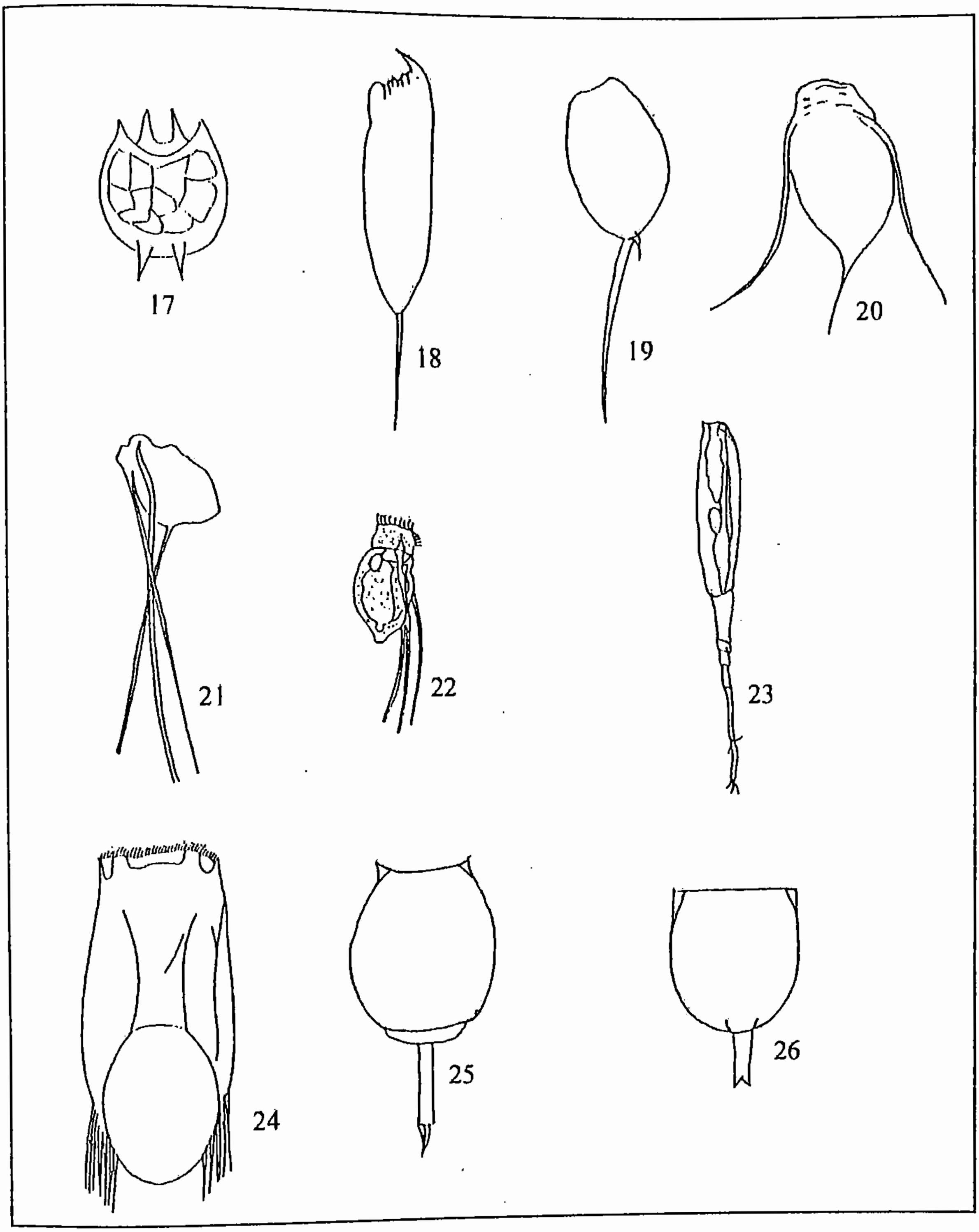
Notholca sp.

Plate-6: Rotifera



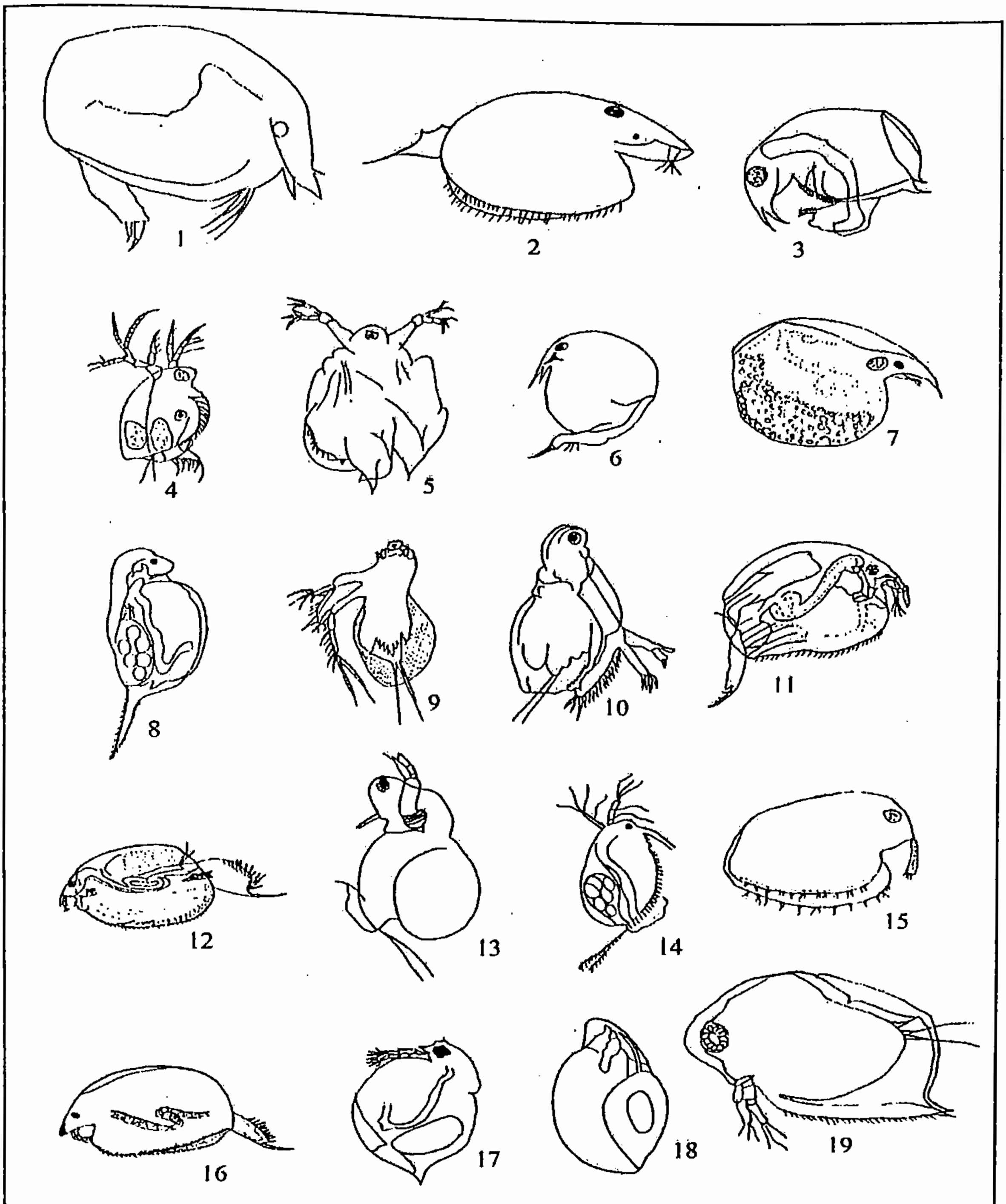
1. Brachionus urceolaris 2. Brachionus quadridentatus 3. Brachionus falcatus 4. Brachionus caudatus 5. Brachionus forficula 6. Brachionus havanensis 7. Brachionus nilsoni 8. Brachionus diversicornis 9. Keratella cochlearis 10. Keratella tropica 11. Notholca sp. 12. Lecane ploensis 13. Lecane curvicornis 14. Lecane luna 15. Pomphodyx sulcata 16. Squantinella sp.

Plate-7: Rotifera



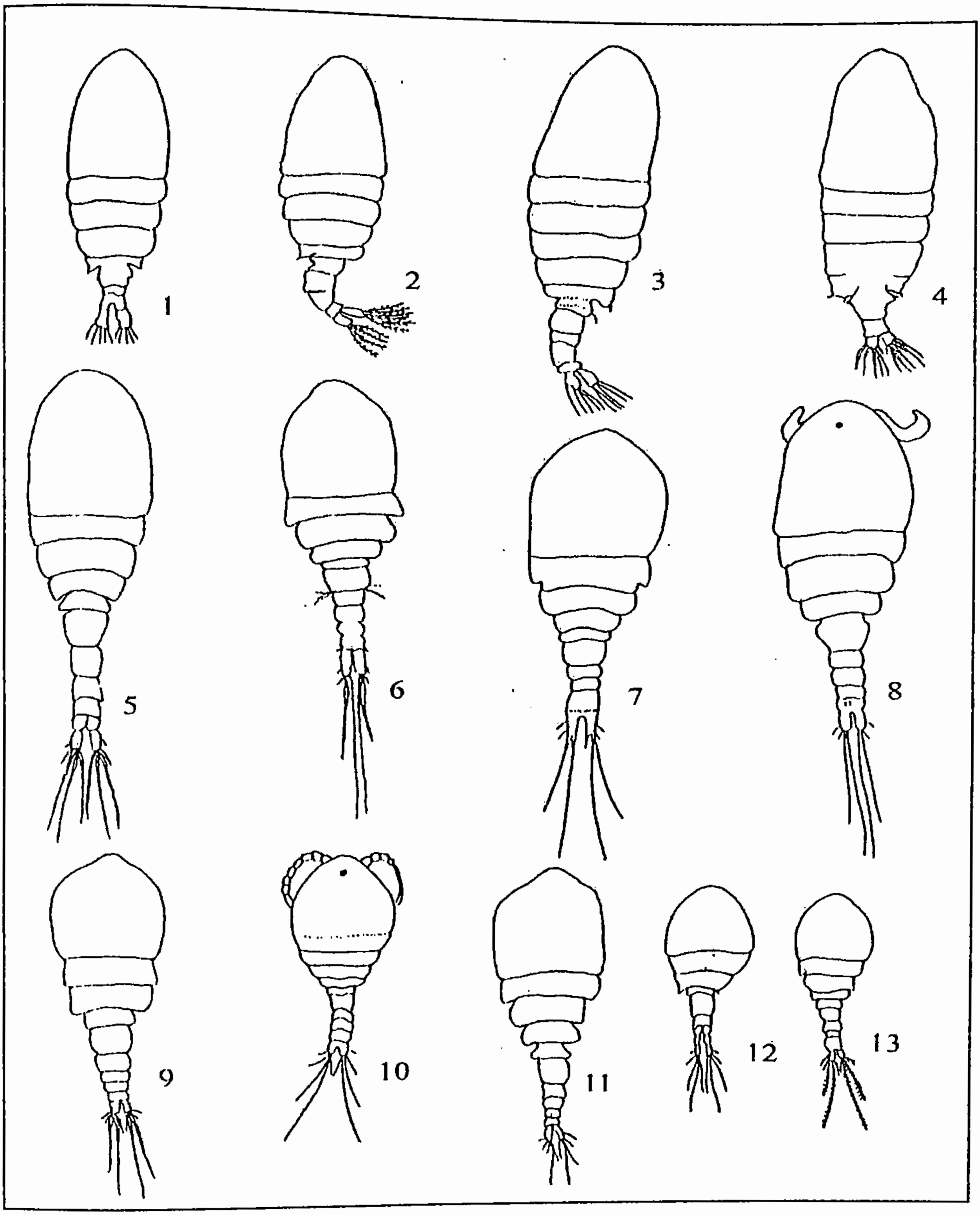
17. Platiyias quadricornis 18. Trichocerca cylindrica 19. Trichocerca braziliensis 20. Filinia terminalis 21. Filinia longiseta 22. Filinia opolinesis 23. Rotaria neptunia 24. Polyarthra sp. 25. Monostyla furcata 26. Monostyla lunaris.

Plate-8: Cladocera



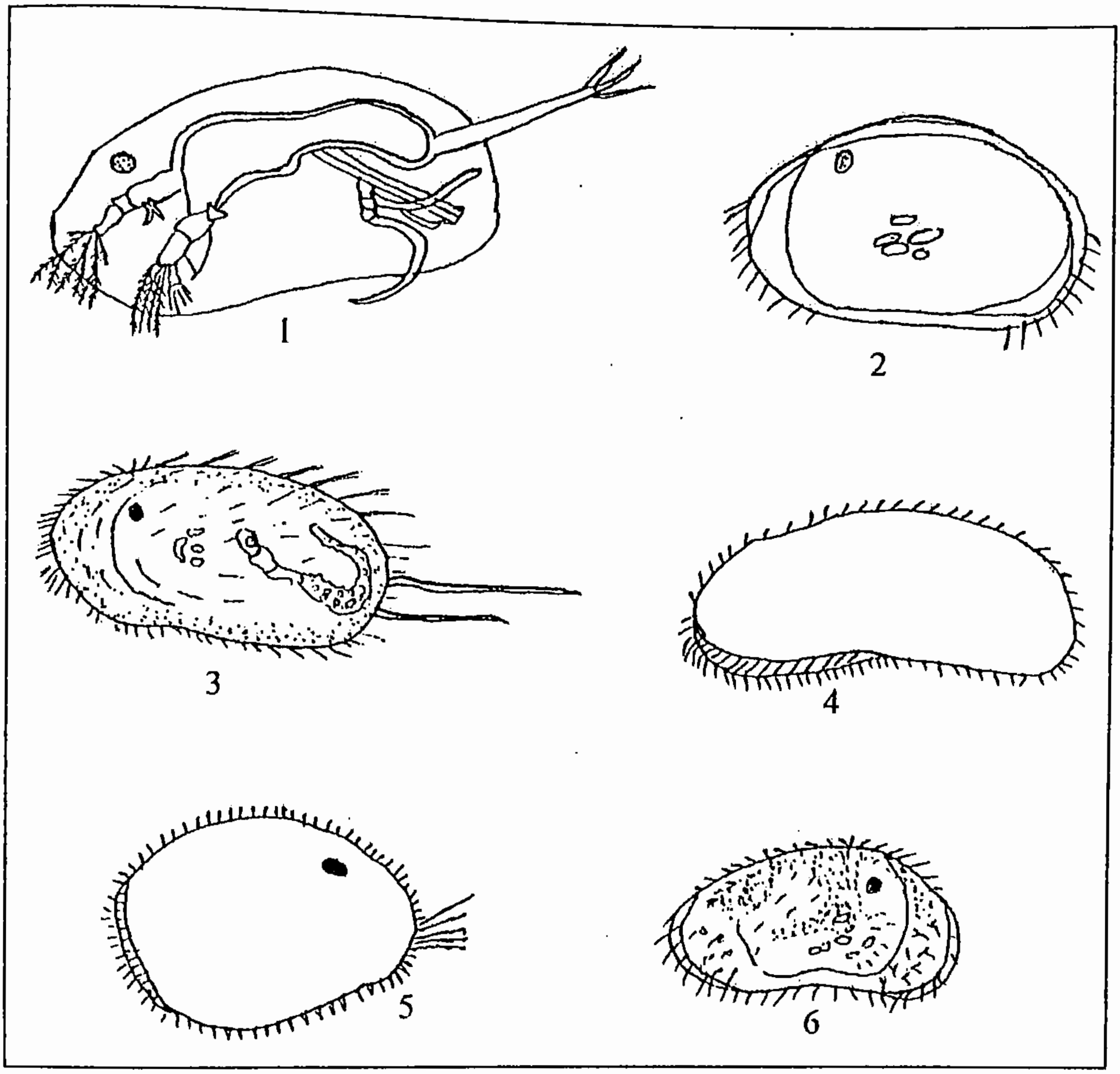
1. Alona costata 2. Alona rectangula 3. Bosmina coregoni 4. Ceriodaphnia pulchella 5. Ceriodaphnia laticaudata 6. Chydorus sphaericus 7. Chydorus globosus 8. Daphnia magna 9. Diaphanosoma brachyurum 10. Diaphanosoma beuchtembergianum 11. Kurzia latissima 12. Leydigia acanthocercoides 13. Moina brachiata 14. Macrothrix rosea 15. Macrothrix laticornis 16. Oxyurella tenuicaudis 17. Simocephalus serrulatus 18. Simocephalus sp 19. Schapholeberis kingi

Plate-9: Copepoda



1. Diaptomus gracilis 2. Heliodiaptomus contortus 3. Heliodiaptomus latifi 4. Neodiaptomus strigilipes 5. Cyclops vernalis 6. Cyclops nanus 7. Mesocyclops dybowskii 8. Cyclops varicans 9. Mesocyclops inversus 10. Mesocyclops leuckarti 11. Mesocyclops hyalinus 12. Macrocyclops destictus 13. Microcyclops sp.

Plate-10: Ostracoda



1. Cypris sp. 2. Cyclocypris sp. 3. Stenocypris sp. 4. Heterocypris 5. Centrocypris sp. 6. Eucypris sp.

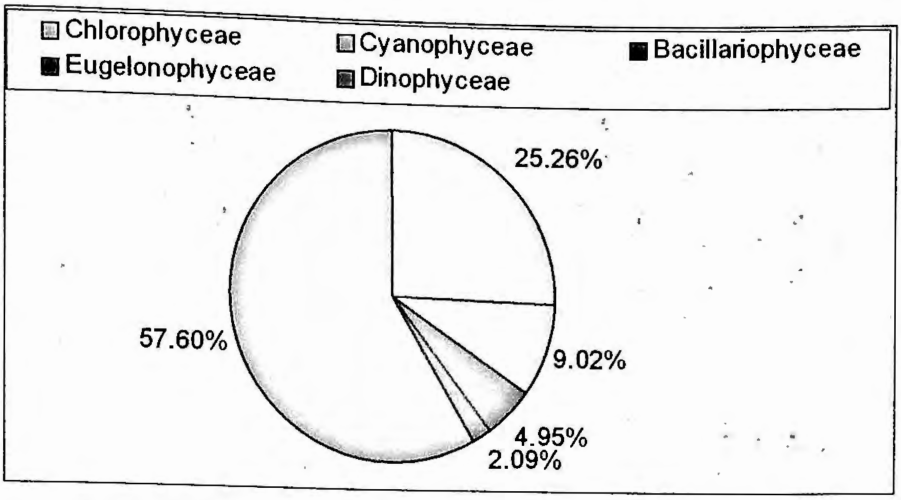


Figure 3.13
Percent composition of different classes of Phytoplankton during the study period

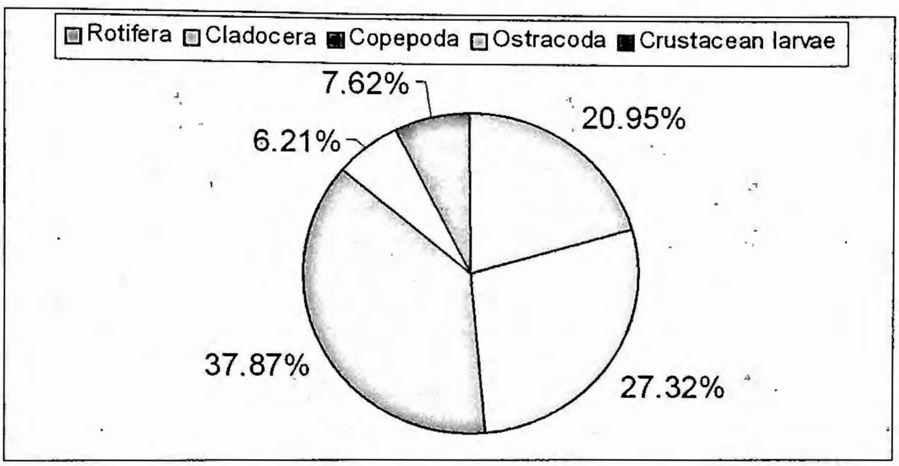


Figure 3.14
Percent composition of different groups of Zooplankton during the study period

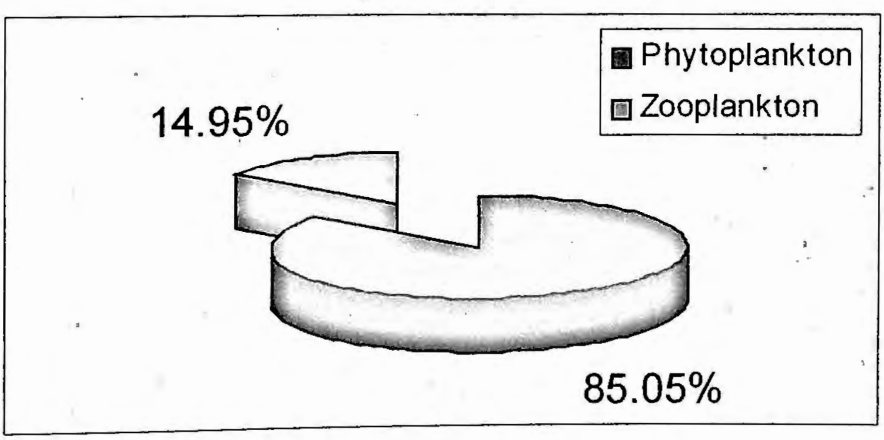


Figure 3.15
Percentage of total Phytoplankton and Zooplankton in the study area

3.8 Fisheries Diversity Monitoring

3.8.1 Fish Diversity Existing in the Posna Beel

A total of 63 fisheries species have been identified from the Posna beel. The piscine fauna included 48 species belong to 33 genera and 16 families 9 orders The non fisheries species comprised of 15 species belong to Crustacean (4), Mollusca (8), Reptilia (1), and Amphibia (1). Among piscine fauna 39 are self-recruiting, 4 exotic cultureable and 5 native culturable (Table 3.7).

Fin Fishes

Table 3.7
A list of fin- fish species existing in the Posna Beel during the study period

Order	Family	Local Name	Scientific Name	Status	IUCN Status	Beel Status
Beloniformes	Belonidae	Kakila	*Xenentodon cancila* (Hamil)	SRS	Vu	Vu
Channiformes	Channidae	Taki	*Channa punctatus* (Bloch)	SRS	C	C
		Tilo Taki	*Channa gachua* (Hamil)	SRS	Vu	En
		Shol	*C. striatus* (Bloch)	SRS	C	C
Cypriniformes	Cyprinidae	Dankina	*Rasbora danicunius* (Hamil)	SRS	En	C
		Tit puti	*Puntius tickto* (Hamilton)	SRS	Vu	C
		Futuni puti	*P. phutonio* (Hamilton)	SRS	C	C
		Jat puti	*P. sophore* (Hamilton)	EC	C	Vc
		Kanchan puti	*P. conchonius* (Hamilton)	SRS	C	Vc
		Baga puti	*P. stigma* (Hamilton)	SRS	C	Vu
		Shor puti	*P. sarana* (Hamilton)	NC	Cr	Vu
		Rui	*Labeo rohita* (Hamilton)	NC	C	Vu
		Catla	*Catla catla* (Hamilton)	NC	C	Vu
		Mrigel	*Cirhina mrigala* (Hamilton)	NC	C	Vu
		Raek	*Cirhina raba* (Hamilton)	NC	C	C
		Silver carp	*Hypothalmicthys molitrix* (Valeneienes)	EC	C	C
		Grass carp	*Ctenopharyngodon idella* (Valeneienes)	EC	C	C
		Common carp	*Cyprinus carpio* (Linnaus)	EC	C	Vu
		Chela	*Chela laubuca* (Hamil)	SRS	C	Vu
		Mola	*Amblyphyrngodon mola* (Hamilton)	SRS	En	Vu

Order	Family	Local Name	Scientific Name	Status	IUCN Status	Beel Status
	Cobitidae	Gutum	*Lepidocephalus guntea* (Hamil)	SRS	C	C
Clupiformes	Clupeidae	Chapila	*Gudusia chapra* (Hamil)	SRS	C	En
Siluriformes	Bagridae	Gulsha tengra	*Mystus bleekeri* (Day)	SRS	Vu	Vu
		Gunia tengra	*M. gulio* (Hamilton)	SRS	C	Vc
		Tengra	*M. vittatus* (Bloch)	SRS	C	C
		Batashi	*Batasio tengra* (Hamilton)	SRS	En	En
	Siluridae	Boal	*Wallago attu* (Bloch)	SRS	C	C
		Cheka	*Chaca chaca* (Hamilton)	SRS	En	En
		Madhu Pabdha	*Ompok pabda* (Hamilton)	SRS	En	En
		Kani Pabda	*Ompok bimaculatus* (Bloch)	SRS	En	En
	Claridae	Magur	*Clarius batrachus* (Bloch)	SRS	Vu	Vu
		Shing	*Hetropnuestes fossilis* (Bloch)	SRS	C	C
Perciformes	Centropomidae	Lal chanda	*Chanda ranga* (Hamilton)	SRS	C	C
		Chanda Nama	*C. nama* (Hamilton)	SRS	Vu	C
		Gool chanda	*Chanda baculis* (Hamil)	SRS	C	C
	Anabantidae	Koi	*Anabas testidineus* (Bloch)	SRS	C	C
	Pristolepidae	Naptei koi	*Badis badis* (Hamil)	SRS	En	C
		Meni	*Nandus nandus* (Hamil)	SRS	Vu	C
	Gobiidae	Baila	*Glossogobius guiris* (Hamilton)	SRS	C	C
	Osphrenemidae	Kholisha	*Colisa fasciatus* (Bloch)	SRS	C	C
		Lal Kholisha	*C. lalia* (Hmilton)	SRS	C	Vu
		Chuna Kholisha	*C. chuna* (Hamilton)	SRS	C	Vc
Mastacembeliformes	Mastacembelidae	Baro baim	*Mastacembelus armatus* (Lecepede)	SRS	En	Vu
		Guchi baim	*M. pancalus* (Hamilton)	SRS	C	C
		Tara baim	*Macrognathus aculeatus* (Bloch)	SRS	Vu	Vu
Tetradontiformes	Tetradontidae	Potka	*Tetradon potka* (Hamil)	SRS	C	En
Symbranchiformes	Amphipnoidae	Kuicha	*Ampipnous cuchia* (Hamillton)	SRS	Vu	Vu
Osteoglossiformes	Notopteridae	Foli	*Notopterus notopterus* (Pallas)	SRS	Vu	Vu

Table 3.8
Non-fin Fisheries Species of Posna Beel

Class/Order	Family	Common Name	Scientific Name
Class- Crustacea Order-Decapoda	Palaemonidae	1Thengua Icha	*Macrobrachium birmanicus* (Shenkel)
		2 Chotka Icha	*M. malcolmsonii* (H. Milne-Edwards)
		3 Dimua Icha	*M. villossimanus* (Tiwari)
		4 Gura Icha	*M. lammarrei* (H. Milne-Edwards)
	Potamonidae	5 Kakra	*Potamon wood-masoni* (Ruthbun)
Class-Gastropoda Order-Neogastropoda	Viviparidae	1	*Viviparus bengalensis* (Lamark)
		2	*Bellamya bengalensis* (Lamark)
		3	*Pila globossa* (Swainson)
Order-Basommatophora	Lymnaeidae	1	*Lymnaea luteola* (Lamark)
		2	*L. acuminata* (Lamark)
		3	*L. stagnalis* (linneaus)
	Planorbiidae	1	*Planorbis sp.*(Muller)
Class- Pelecypoda Order-Schizodonta	Uniodae	1	*Lamellidens marginalis* (Lamark)
Class-Reptilia Order-Chelonia	Chelonidae	1	*Tryonix gangeticus* (Cuvier)
Class-Amphibia Order-Anura	Ranidae	1	*R. tigrina* (Daudin)

Vc- Very common, C-Common, Vu- Vulnerable, En- Endangered, Cr- Critically endangered

SRS =Self-recruiting species, EC =Exotic culturable, NC =Native culturable

3.8.2 Fish Catch Assessment

During the 2-years fish harvesting study, a total of 37169 kg fish along with Ceridian prawns by different type of gears and traps was caught of which 17836 kg (47.99%) and 19333 kg (52.01%) were recorded in 2003 and 2004 respectively (Appendix Table VIII). The fish catch was varied from 138 kg to 3642 kg throughout the study period from the study area. The highest fish harvested was noted in December, which was 20.39% of the total catch followed by November, April and February while the lowest fish catch was recorded in the month of June

(2.16%). Monthly abundance and percent composition of fish catch are shown by figure 16 and 17 respectively. On an average 283.21 kg/ha/year catch was recorded throughout the study period (Table 3.9). Cypriniformes fishes were dominant which constituted 35.38% of the total fish catch followed by Perciformes (21.07%), Siluriformes (16.61%) and Channiformes (12.14%). Notably, the Ceridian prawns constituted 3.94% of the total catch (Figure 3.18). From the species-wise fish catch analysis, *Jat Puti* (*Puntius sophore*) was the dominant species in this beel which was 8.41% of the total fish catch followed by *Meni* (*Nandus nandus*), *Shol* (*Channa striatus*) and *Taki* (*Channa punctatus*) (Appendix table VIII).

Table 3.9
Seasonal Fish Catch in Posna Beel during the Study Period

Season	Area of beel (ha)	Total Fish Catch (Kg)		Total Fish Catch (kg/ha)	
		2003	2004	2003	2004
Monsoon	121.5	1914	1924	15.75	15.83
Post-monsoon	105.0	4859	5204	46.27	49.56
Winter	27.0	6082	8099	225.25	300.00
Summer	9.0	4981	4106	553.44	456.00
Yearly fish catch (Kg/ha)				271.80	294.62
Average fish catch during the study period (Kg/ha)				283.21	

3.8.3 Gears and Traps Use Pattern in Posna Beel

During the study period, a total of 12 different kinds of fishing gears and traps were found to be used by the surrounding villagers and fishermen of Posna beel (Table 3.10). Gill net and lift nets were the most frequently used gears. Gill net especially excessive Current Jal found round the year in the Posna beel. On the other hand, lift net was found in operation from July to December. Six gears, four spears like Chai, Doar, Koch and Teota, and two kinds of Hooks like Hath Borshi and Kathi Borshi had been found from the study area.

Table 3.10
Different types of Gears and Traps used in Posna Beel

	Bengali Name	English Name
Gears	Ber jal/Dhor jal	Seine net
	Current jal	Mono filament gill net
	Dharma jal	Lift net large
	Moshari jal	Seine net
	Jhaki jal/Urani jal	Cast net
	Thela Jal /Jali	Push net
Traps	Guli/Ghuni/Chai	Bamboo net
	Doar	Bamboo net
	Tenta/Teota	Spear
	Koch	Spear
	Hat borshi	Hook
	Kathi borshi	Hook

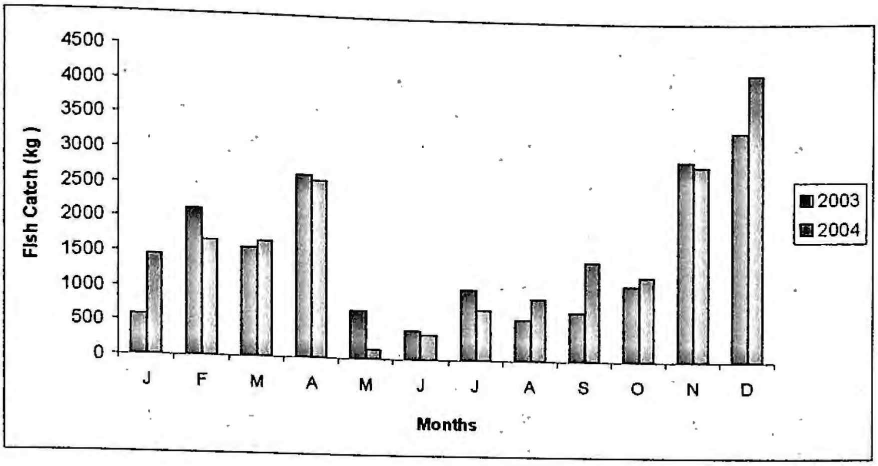


Figure 3.16
Monthly Variation of Fish Catch during the Study Period 2003 and 2004

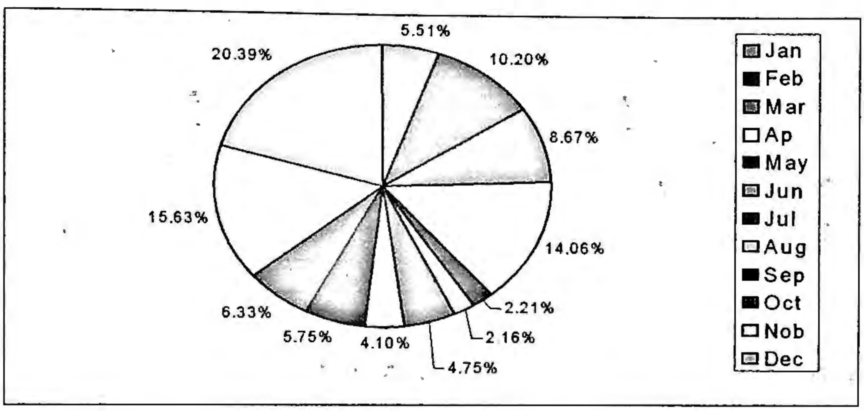


Figure 3.17
Percent Composition of Monthly Fish Catch during the Study Period 2003 and 2004

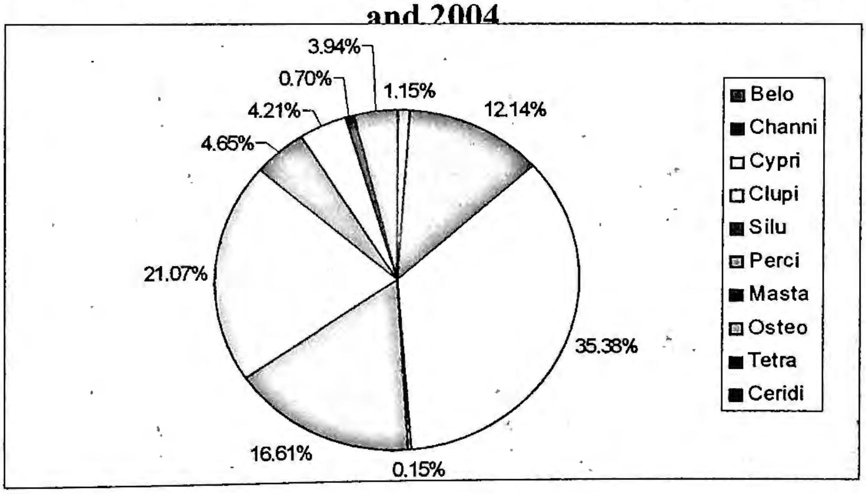


Figure 3.18
Percent Composition of Different Orders of Fish during the Study Period 2003 and 2004

Chapter 4
Discussion

4.1 Water Quality

All the vital function of fish like feeding, digestion, assimilation, growth, response to stimuli and reproduction are dependent on water. Water quality is the suitability of water for the survival and growth of fish and it is normally governed by only a few variables (Boyd, 1992). The aquatic environment in turn depends on a greater extend on the environmental characteristic of a particular geographical region. The quality of aquatic environment generally conditioned by three kinds of factors e.g. physical, chemical, and biological. A comparative discussion of the studied factors and biota of the sampling have been made. Besides, interrelationships between the physico-chemical conditions and plankton, soil characteristics and fish bio-diversity have been discussed.

Water Temperature

Temperature plays an important role in determining the quality of water of aquatic body because almost all the physical, chemical and biological factors are governed by it. For example, density, viscosity, surface tension, vapour pressure of water, the saturation values of solids and gases that are dissolved and other biological and biochemical activities such as photosynthesis, growth and death of micro organism are all dependant on water temperature. The water temperature, a catalyst, a depressant as activator, a restrictor, a stimulator, a controller, a killer is one of the most influenced water quality characteristics to life in water (FWPCA, 1967). Increased temperature accelerates biodegradation of the organic water, both at the bottom deposits and the overlying water, thus enhancing the BOD values. As temperature become higher oxygen becomes less soluble and in order to cope with biodegradation, demands on the increasingly scare resources results in oxygen depletion, leading to septic or obnoxious conditions, as demonstrated by Phelps (1944) and Velz (1970).

The range of water temperature of the study area Posna beel was ranged form 16.5°C to 34°C which is similar to the findings of Hussain *et al.* (1978), Openheimer *et al.* (1978), Islam *et al.* (1976), Khan *et al.* 1990, Bhuiyan and Nessa (1998) and Islam *et al.* (1998). From the study it is indicated that the variation of water temperature depend on seasonal weather.

Transparency

Water transparency is generally expressed on the level of productivity of a waterbody and it also indicates the presence or absence of fish food particles. Water transparency, i.e. the Secchi disk depth of investigated Posna beel ranged from 25.62 cm to 189.50 cm. The minimum transparency was recorded in the summer and post-monsoon and the maximum value was recorded winter (bed level visible). Factor affecting the transparency of water include various microscopic organism and types of suspended matter (McCombic, 1983). Boyd (1973) and Saran and Adoni (1982) stated that the low values of water transparency could be attributed to rich phytoplankton density and higher budgets of suspended and particulate matters due to heavy load by organic matter. Reid and Wood (1976) noted that the transparency of water is affected by the facts such as silting, microscopic organisms, suspended organic matters in different season of the years. Latitude and density of incident light, application of manure, grazing pressure and rainfall act as regulatory factors on transparency of water. In the Posna beel the range of transparency was relatively higher during winter and summer while lower transparency was observed during the post monsoon (Appendix table-I). The present finding of transparency of posna beel is nearly similar to the finding of Boyd (1973), Saran and Adoni (1982), and Rai and Rathore (1993). Boyd (1982) suggested that a transparency in between 15 to 40 cm is good for culture fish. The lower transparency in Posna beel during summer may be due to an increase of phytoplankton in the habitat and over fish catching in the season. Whereas in post-monsoon might be due to high water level which was chiefly affected by high turbidity condition with the presence of silt, clay and other matter run off from the catchment area. On the other hand, the higher value of transparency in winter season might be due to all soluble matter and particles were settled down. Even the bottom of the beel was visible in this season which revealed that the water quality of the study area was more clean and transparent.

In Practical operations, Secchi disk visibility often provides a rough estimate of plankton abundance (Almazan and Boyd, 1978). At identical levels of phytoplankton abundance, the soft water might have a Secchi disc visibility of less than 100 cm while the value for hard water might exceed 200 cm (Boyd, 1992). The observed mean values (89.23±58.87 cm) suggest that the Posna beel falls in the soft water category.

Total Solids

In natural water many minerals, salts and organic substances are present in dissolved form, known as dissolved solids. White silts, sand, clay etc. are present in suspended form, known as suspended solids. Total solids are a measure of dissolved and suspended impurities of water. Higher concentrations of these are much harmful to the biota of the water body and also to man when they use it for various purposes. Boyd (1992) stated that if the water has low concentration of volatile dissolved solid, the water is highly mineralized. On the other hand water with high concentrations of total solid and low concentration of total volatile and dissolved solids, contain large amount of suspended organic matter. Water from fishponds will varies in solid concentration depending upon the degree of mineralization, amount of the suspended clay and abundance of the existing plankton biota. The measurement of dissolved solids and particulate organic matter which indicate the total concentration of dissolved ions and the total concentration of suspended matter, respectively, are widely used in piscicultural habitats (Boyd, 1992).

The amount of total solid means total suspended solids and total dissolved solids. Throughout the study period, higher value (123.33 mg/l) of total solids was recorded in summer season. This might be due to the turbidity of water due to suspended materials during harvesting of fishes. Lower value (7 mg/l) of total solids of Posna beel recorded in winter that might be due to the stagnation of water when all soluble matter and particles were settle down.

Hydrogen Ion concentration (pH)

The pH of water is important factor in a fish habitat. It is called the productivity index of a water body. An acidic pH of water reduces the growth, metabolism and other physiological activities of fishes (Swingle, 1967). The pH range (6.83-8.00) recorded in the present study is (Posna beel) found within the limit of Bangladesh standard for fish culture and Bangladesh Standard for drinking water (Appendix table II). The Present finding agree with those of Mollah and Haque (1978), Ali *et al.* (1980) and Selvaraj *et al.* (1994) who found the similar fluctuation of pH in their studies. Ellis (1937) reported that a pH range of 6.7-8.4 is suitable for the growth of aquatic biota. Swingle (1967) reported that the pH values of 6.5 to 9.0 are suitable for pond fish culture and pH more than 9.5 is unsuitable because free CO_2 is not available under this situation. The acidic and alkaline death points for fish culture are about pH 4.0 and 11.0 respectively (Boyd, 1982). However, if water is more acidic than pH 6.5 or more alkaline than pH 9-9.5 for a long Period, reproduction and growth will diminish. (Swingle, 1961; Mount, 1973), such conditions had not been observed during the present investigation. The pH value of the study area was found to increase during the monsoon up to winter seasons. The peak in monsoon and post-monsoon seasons may be due to the rapid consumption of free carbon dioxide by the photosynthetic activity of phytoplankton. The lower values during the summer might be due to the decomposition of organic matter rapidly at higher temperature.

Free Carbon Dioxide (CO_2)

Biologically, free CO_2 has a great importance, as it is used to produce food by primary producer which are the main regulators of the food chain in an aquatic ecosystem. In natural water, the sources of CO_2 are: (i) atmosphere, (ii) respiration of biota (iii) bacterial decomposition of organic matter, (iv) inflowing ground waters that sweep into the ponds, swamp lakes and stream, and finally (v) from within the water itself in combination with other substance, chiefly, calcium and magnesium (Jhingran, 1975).

Schindler *et al.* (1971 and 1972), and Emerson *et al.* (1973) noticed that the demand of carbon dioxide can be fulfilled from atmosphere through invasion due to partial pressure in a condition of the low organic content.

According to Hutchinson (1957), free CO_2 occurs in water as the dissolved gas, carbonic acid, carbonate and bicarbonates of calcium and magnesium, and sometimes of iron. Further Hutchinson (1957) noticed that the vertical distribution of CO_2 reflects in a quantitative way, the distribution of oxygen deficit. Free CO_2 tend to disappear gradually when pH values begin to rise above 8.0 (Lakshminarayana, 1965; Welch, 1952; Hutchinson, 1957). This is similar to the present findings. Higher values of CO_2 during the summer season may be due to higher temperature associated with bright sunshine that accelerates the decay of organic matter. Lower values of CO_2 found during the winter season might be the result of increased rate of photosynthesis by the overwhelming aquatic weed population, which was also accelerated due to low rate of respiration of benthic fauna and decreased rate of decomposition of organic matter.

Alkalinity

Alkalinity refers to the amount of titrable bases in water expressed as Milligram per liter of equivalent calcium carbonate. The presence of carbonates, bicarbonates and hydroxide is the most common cause of alkalinity in natural waters. Alkalinity is expressed as phenolphthalein alkalinity or as total (Methyl orange)s alkalinity. Phenolphthalein alkalinity indicates the total hydroxide and one-half of the carbonate present. Total alkalinity indicates all carbonate, bio-carbonate and hydroxide alkalinity.

Natural waters exhibit wide variations in relative acidity and alkalinity, not only in actual pH value, but also in amount of dissolved materials producing acidity or alkalinity. The concentrations of these compounds and the ratio of one to another determine the actual pH and buffering capacity of a given water body.

In the present investigation only phenolphthalein alkalinity has been considered as the total alkalinity. Moyle (1946) designated the lakes with alkalinity values of 40 mg/l as 'soft' and 40-90 mg/l as hard type. The study area, Posna beel falls into the 'soft' type having the value of total alkalinity 37.76±8.58 mg/l. Therefore, the average alkalinity values during the study period represent the Posna beel water as productive.

Dissolved oxygen (DO) and Saturation of Oxygen

The oxygen content of the surrounding environment plays an important role in the metabolic activities of aquatic organisms. The oxygen supply of the inland water is a product of diffusion from the air at the surface (Interaction between surface water and air) and from the photosynthesis of aquatic phytoplankton or green plants. Water contains relatively little oxygen as compared to air. One litre of air at 15°C contains 209 ml of oxygen weighing approximately 1.2 mg while one litre of water contains 7.2 ml of oxygen (Satchell, 1971). So, oxygen concentration of surrounding environment of terrestrial organism is not a problem. On many accessions, it becomes a limiting factor for the proper growth and even survival of the aquatic organisms.

DO content is one of the most important factors in water quality assessment and it reflects the physical and biological processes prevailing in the natural water. Its presence is essential for maintaining the higher biological life in water.

Trivedy and Goel (1984) and Wetzel (1983) stated that the dissolved oxygen is obviously necessary for the metabolic activities of all aquatic organisms that possess aerobic respiratory biochemistry. DO of water of the Posna beel was measured from the surface level of water revealed an almost uniform trend throughout the study periods. The seasonal concentration varied from 6.66 mg/l to 9.66 mg/l.

Higher DO values were recorded during the winter and post monsoon season may be attributed mainly to photosynthetic activities of phytoplankton which were in much abundance with a lower abundance of zooplankton. On the other hand, high temperatures and water rich in organic matter, both of which reduce the dissolved oxygen content in the aquatic environment (Huet, 1977). In the case of present investigation higher DO content in water was recorded in winter while the water temperature was very lower than other seasons.

Banerjee (1967) considered that 5.0 to 7.0 mg/l DO content of water is fair or good in respect to productivity whereas water having less than 5.0 mg/l is unproductive.

Boyd (1992) concluded that dissolved oxygen < 1mg/l is lethal for fish biota if the exposure last longer than a few hours. At DO values of 1-5 mg/l, a fish survives, but reproduction is poor and growth is very slow if exposure is continuous and at DO > 5 mg/l, a fish reproduce and grows normally. In this regard, mean values of DO of Posna beel throughout the study periods was 8.08±0.90 mg/l, which is more satisfactory than the DO content in water within the limit of Bangladesh standard (>5.0 mg/l) for fish culture and drinking water which revealed that the Posna beel is productive.

Trivedy and Raj (1992) noticed that the optimum value for good quality water has been 4.6 mg/l DO which is suitable for maintaining aquatic life. Further, they added that DO value somewhat lower than this (4.6 mg/l) indicate water pollution. In the present study no such condition was observed. It is evident from the overall mean value of DO contents in the study beel water is always high which may be termed as unpolluted.

The rate of reservation of a water body with oxygen from the atmosphere depends on the rate of the solution (absorption) through the air-water interface and on the rate of dispersion within the body of water beneath the surface. The driving force of oxygen transfer is the difference between the dissolved oxygen, concentration at saturation and the actual concentration present in water (Walters, 1981 and Wetzel, 1983). During the study period in the studied water body, oxygen saturation is always high except in summer, winter season in 2003 and monsoon season in 2004, which dose not support with studies of Zaman (1991), Hasan (2000) and Hossain (2002) on the lentic and lotic water bodies. Khondaker and Parveen (1992) on the shallow hypertrophic lake (Dhanmondi Lake, Dhaka) reported that O_2 saturation ranged from 56.71 to 139% which is similar to the present findings.

Rappaport *et al.* (1976) reported that fish growth decrease when DO concentration in pond water is below 25% of saturation at the morning time. Such lower percentage of saturation of oxygen never found in the present study although it varied from 88.00 to 115.33% with a mean of 101.66±12.69 mg/l of O_2 saturation. McKee and Wolf (1963) reported the effect of O_2 super-saturation on fish and said that in pond carps exposed to 150% of O_2 saturation, had a greater chance of gas bubble disease than those exposed 100-125% of O_2 saturation. Fish die when super-saturation reaches 300% such condition have not been observed in the present study although super-saturation of O_2 was recorded in most of the times.

Biochemical oxygen demand (BOD_5)

BOD_5 may be defined as the amount of oxygen used for bio-chemical oxidation by microorganisms in a unit volume of water. The bio-chemical oxygen demand (BOD_5) is the quantity of oxygen in mg/l used in oxidation in water. BOD_5 represents the concentration of organic matter remaining in the water at anytime and DO (dissolved oxygen) shows the ability of the water body to purity itself through biochemical process (Trivedy and Raj, 1992). According to Khanna (1992), biochemical oxygen demand may be measured as the rate of removal of oxygen from natural water by microorganisms in aerobic degradation of the dissolved or even particulate organic matter in water. Palharya *et al.* (1993) noticed that seasonal variation in the value of BOD_5 appears to be a function of changes in the degree of dilution, quantity of organic matters and activities of microorganisms carrying out decomposition of carbonaceous and nitrogenous matter. The BOD_5 is used to characterize the state or health of a water body. Throughout the course of study, the highest values of BOD_5 were recorded in post-monsoon season and lowest in winter. The highest values of BOD_5 in post-monsoon may be due to maximum biological activities of micro-organisms. The lowest BOD_5 values indicate their lower biological activities at low temperature.

According to Trivedy and Raj (1992), BOD_5 status are: (i) 1 mg/l - very clean; 2 mg/l - fairly clean; 5 mg/l - doubtful and 10 mg/l - contaminated. They also stated that water with BOD_5 value ranging between 2.7-5.43 mg/l is excellent for drinking. On the other hand, 0.2 mg/l BOD_5 with water is permissible by Bangladesh standard (<6.0 mg/l for fish culture) for drinking water. Rai (1993) noticed that the high value of BOD_5 indicated very high degree of organic pollution. In the present study, the BOD_5 value as 4.15±0.88 mg/l was recorded.

Chemical oxygen demand (COD)

The COD is an important water quality parameter, which is an index of organic contents of water and oxygen demanding substance in the same (Trivedy and Raj, 1992). According to Jabanesan *et al.* (1992), COD estimates carbonaceous factor of organic matter. Throughout the study period, COD values were found to be of almost similar pattern of variation as in those of BOD_5. Higher values (8.15 mg/l) were recorded in summer season. The higher COD values in summer may be due to the increase of biodegradable and non-biodegrade matter in beel waterbody. Lower value of COD was recorded in winter season (5.20 mg/l) may be due to low temperature of water which inhibited the rate of decomposition of the organic matters. Arise in COD values due to allochthonous materials have been reported by Trivedy while working at Dhom reservoir in Maharastra. In the present study, the over all mean value of COD of Posna beel water was 6.78±0.99 mg/l, which is below the pollution level as natural water with COD value less then 20 mg/l indicate clean water. The COD also complies with Bangladesh standard (8.0 mg/l) for drinking water quality.

Oxidation Reduction Potential & Oxidation Reduction Index (Eh and rH_2)

In any aquatic ecosystem undergoing biological metabolism, these are a continuos change in the ratio between the materials in reduced form and the materials in oxidized form. In the ecosystem has organic material the concentration of reduced form is higher, which results in lower Eh and rH_2 values. When the materials degrade, the system start to come to its original form which is indicated by the rise of the Eh and rH_2 values consequently. The values of Eh and rH_2 will fall again when organic materials are added or accelerated again in the habitat (Gautam, 1990). The Eh and rH_2 values (Appendix table -I) indicate that the water of the beel under study has a moderate load of organic matter throughout the years of study. The organic load seems to be almost uniform as indicated by the approximately uniform values of Eh and rH_2 during this time and supported by the BOD_5 and COD values. The 'P' values (COD-BOD_5) indicated an uniformity which reveal that the amount of biodegradable and non-biodegradable matter were in uniform amount without significant variation. The natural condition and bottom organic deposits and continuous fertilization of water by the agricultural practices in the entire catchment zone may be attributed to the above findings as far as the redox characteristics are concerned (Appendix table -I). Moderately low Eh and rH_2, moderately high value of BOD_5 and COD, pH and uniform values of 'P' (COD-BOD_5), throughout the years of study showed a moderately slightly higher amount of organic matter in the water of beel. Alongside, higher values of DO and super saturation of oxygen in water indicate an unpolluted state. The redox characteristics indicate a eutrophic nature of the beel where suitable conditions for pisciculture and other biota prevail.

Total Hardness

Hardness of water refers to the concentration of divalent metal ion in water, expressed as mg/l of equivalent calcium carbonate or hardness results from the presence of bivalent metalic cations of which calcium and magnesium are the most dominant (Todd, 1980). Total Hardness is usually related to total alkalinity. Thresh *et al.* (1958) held that when the total hardness value is lesser than total alkalinity value, the hardness is due to carbonates. Water is classified according to its hardness (mg/l hardness $CaCO_3$) which is given in table 4.1.

Table 4.1
Quality Classification of Hardness of Water for Drinking (Sawyer and Catry, 1967)

Hardness mg/l $CaCO_3$	Water Class
0-75	Soft
75	Moderately hard
150-300	Hard
>300	Very hard

In the present study, the hardness of water ranged from 51.30 to 74.10 mg/l with an average of 61.40±7.45 mg/l. On the basis of the above classification of hardness, the water of the studied beel falls under the soft type and within the Bangladesh standard (200-500 mg/l) for drinking water or DWQS (Drinking Water Quality Standard).

The water for fish culture needs small amounts of Calcium and Magnesium, but the necessary quantities are apparently present if total hardness is above 20 mg/l (Boyd, 1992). In this regard, the water of Posna beel is suitable for fish culture.

Chloride (Cl^-) Contents

Chlorides in the form of ions are one of the majors inorganic anion present in natural waters. The water containing only 250 mg/l chloride and above may have a detectable salty taste .The chloride contains of beel water varied from 25.58 to 31.25 mg/l with the mean value as 29.15±2.05 mg/l. The peak chloride contents were in the winter and summers seasons. Which could be mainly attributed to input of highly soluble chloride salts through run off from the catchement area, high rates of evaporation and low depth of water, similar findings were made by Zafar (1964), Mishra and Yada (1978), Khanna *et al.* (1992) and Naz (1999). The summer increase of chloride ions corroborates with observations of Harshey *et al.* (1982).

Chloride concentration is not only an index of eutrophication, but also of pollution caused by Cattle, Sewage and other wastes (Mishra and Yadav, 1978). Sreenirvasan (1965) is of the opinion that chloride concentrations between 4 and 100 mg/l indicate purity of water. Dhakar (1979) reported that potable water has chloride contents between 45 and 122 mg/l, which indicate medium pollution and chloride contents between 60 and 200 mg/l indicate heavy pollution on the basis of above ideas. The water of Posna beel is not polluted because the average chloride content of water was 29.15 mg/l.

Ammonia

The presence of ammonia in water is due to natural fish metabolism and microbiological decay of organic matter. In water, ammonia nitrogen can exist in two forms, un-ionized ammonia (NH_3) and ammonium ion (NH_4^+). Un-ionized ammonia is toxic to fish, while the ammonium ion is non-toxic except at extremely high levels (HACH, 1999). Actually, the pH and temperature of water regulate the proportion of each form at high pH free NH_3 and its hydrolysis products are toxic in low concentration while at low pH, they are converted into ammonium ions (NH_4^+) which are comparatively non-toxic (Trivedy *et al.* 1997). The ammonium concentration in water (Posna beel) is slightly high but it does not exceed the Bangladesh standard (1.2 mg/l) for fish culture. Its concentration varied from 0.012 to 0.076 mg/l. The maximum value (0.076 mg/l) of ammonia was found in monsoon and minimum was in summer. The maximum amount ammonia in monsoon due to higher use of urea in HYV Boro field that washed away in beel waterbody during surface run-off.

Nitrate

Nitrogen (N_2) gas is the primary component of the earth's atmosphere and is extremely stable. Although a few biological species are able to oxidize nitrogen gas, nitrogen in the aquatic environment is derived primarily from sources other than atmospheric nitrogen. It is a constituent of proteins, chlorophyll, and many

Nitrate

Nitrogen (N_2) gas is the primary component of the earth's atmosphere and is extremely stable. Although a few biological species are able to oxidize nitrogen gas, nitrogen in the aquatic environment is derived primarily from sources other than atmospheric nitrogen. It is a constituent of proteins, chlorophyll, and many other biological compounds. After the death of plants or animals, complex organic matter is broken down to simple forms by bacterial decomposition.

Other sources of nitrogen in aquatic systems include animal wastes, chemical (particularly chemical fertilizers), and wastewater discharges. Nitrogen from these sources may be discharged directly into streams or may enter waterways through surface runoff or ground water discharge. Nitrogen compounds can be oxidized to nitrate by soil bacteria. The highest (0.40 mg/l) nitrogen concentration in water of Posna beel was found in monsoon'04 and post-monsoon'03 which may be due to HYV boro field around the beel where farmers use more nitrogenous fertilizer (field survey table-6). Rahman *et al.* (2004) observed the high concentration of Nitrogen in the Buriganganga River, which does not agree with the present findings. On the other hand, lowest was found in winter due to over growth of aquatic weeds. The mean value of nitrate was 0.26 ±0.12 mg/l which does not exceed the Bangladesh standard for fish culture. The present observed concentration of nitrogen of Posna beel comply within the Bangladesh standard (10.0 mg/l) for drinking water (Appendix table-II).

Phosphate

Phosphorus is essential to the growth of biological organisms, including both their metabolic and photosynthetic process. Phophorus occurs naturally in bodies of water mainly in the form of Phosphate (i.e. a compound of phosphorus and oxygen). Palharya et *al.* (1993) pointed out that phosphorus is essential for plants, because it form a constituent of many protein and unclean contents as much as 6% of the presence of phosphorus in aquatic system is of ecological interest. It performs a major role in biological metabolism and a small amount of phosphorus present in sufficient quantity and it may not be seen to be a limiting factor. This idea corroborates with the findings of Zaman (1991) and Naz (1999) while working in the tropical hard water bodies throughout the study period. The phosphate concentration was recorded comparatively little high. Its concentration was found to range between 2.68-6.39 mg/l with mean value as 4.20±0.95 mg/l. The highest concentration of phosphate was in summer seasons and post-monsoon.

The highest concentration of phosphate was recorded in summer (5.39 mg/l) seasons might be considered as due to high decomposition rate of aquatic weeds in the Beel. Blum (1956), Sreenivasan (1964), Lukshminarayana (1965) and Zaman (1991) held similar views. Besides, higher phosphorus contents in the water of the Posna beel in monsoon and post -monsoon may be due to HYV Boro fields where farmers applied TSP as fertilizer. The un-accumulated phosphate is washed away in the beel water during surface run off. On the other hand, the low concentration of phosphate was recorded in winter season which may be considered due to high accumulation of the aquatic weeds, which grown round the year in Posna beel. Though the amount of phosphate in water in Posna beel is high but it does not exceed the Bangladesh standard (8.0 mg/l) for drinking water (Appendix table II).

4.2 Pesticide Residue in Beel Water and Sediment

Pesticides (farm chemicals, agro-chemicals and agvet chemicals) are those substances which are used to control, destroy, repel or attract pests in order to minimize their detrimental effects. Pests are those organisms like weeds, insects, bacteria, fungi, virus and animals which adversely affect our way of life. The modern era of chemical pest control commenced during World War II. The much maligned DDT played a major role in the health and welfare of solders who used it to control body lice and mosquitoes which transmitted major illness. Further development of insecticides and herbicides followed with their relatively low cost, ease of use and effectiveness, they become the primary means of pest control. Protection of crops, animals and humans over extended periods became possible with corresponding increase in food production and improved standards of living (Hock, 1991).

The use of pesticides also constitutes an important aspect of modern agriculture, without chemicals to control various pests like insects, weeds, diseases, worms and rodents, our food supply would decreases and prices would increase. Unfortunately, pesticides are poisons and can be particularly dangerous when misused, reproductive failure in birds and acute illness in people have all been attributed to exposure to or ingestion of pesticides- usually as a result of misapplication or careless disposal of unused pesticides and pesticide containers. Pesticide losses from areas of application and contamination of non-target sites such as surface and groundwater represent a monetary loss to the farmer as well as a threat to the environment (Rao, *et al.* 2002).

Agriculture is the dominant sector in the economy of Bangladesh. But the fast growing population of the country is giving pressure upon the cultivable land for making homesteads, roads and urbanization etc. and the cultivable land is decreasing year after year. To meet the higher demand for food grains, HYV Boro is being cultivated extensively.

In Bangladesh, farmers are not using the recommended dose of fertilizer (Jabbar, 1991). Due to indiscriminate use of fertilizer and pesticides, the residual fertilizers and pesticides are washed away to the beel with surface run-off as a result the environment of the beel area is undergoing gradual change. Severe water pollution in the beel environment can cause physical, chemical or biological change in water quality that may adversely affect aquatic living organisms like fishes due to ecosystem disruption. Farmers use pesticides like basudin, diazinon, furadan etc. in rice fields around the beel that are toxic to aquatic animals (CPP, 1992).

The accumulation of DDE in American robins and Peregrine falcon was confirmed after several decades of the last use of DDT in Canada (Harris *et al.* 2000 and Blus, 2003). Jhingran (1989) illustrated the biomagnification of DDT in aquatic food chain in respect of the Hoogly estuary in West Bengal, India. DDT magnification in fish is 7,500 times while in gastropod it is 3,660 times and bivalve molluscs 15,800 times of the original. Cottam (1960) showed some of the acute toxic effects on fish, amphibia, crustacea and birds after use of DDT for insect control. Harrington and Bidlingmayer (1988) reported mortality of 25 tons of fish belong to 30 species of florida after dieldrin was applied. Keith (1966) observed the high mortality of fish eating birds due to toxaphene accumulated in fish. From agro-chemical use survey, it is found that the farmers around the Posna beel are not using organochlorine pesticides in HYV Boro field presently. Most of the pesticides used in crops under organophosphorus and organocarbamate groups have longevity 15-20 days. So, residual effects of pesticides under these two groups were not found during the study period. But very trace amount of organochlorine pesticides DDT, DDD and DDE was found in beel water and sediment but which is negligible in the context of water pollution. DDT breaks into DDE and DDD over the time. However, the presence of a trace amount of organochlorine pesticides in water and sediment samples may be for the past use of this pesticide for mosquito eradication in this area.

4.3 Nutrient in Beel Sediment

Soil act as a sink of pollutants, particularly heavy metals and pesticides. Both types of pollutants have a tendency to bind organic and inorganic solids and consequently eventually sink to the bottom. Thus the level of pollutants in soils can be used as an indicator of the occurrence of pollution. The accumulation of pollutants in sediments can reduce the productivity to benthic fish food organisms or have direct toxic effects on burrowing fish species. Polluted soils can release toxic substances back into the eater if disturbed, with harmful effects on fish and other aquatic organisms.

The pH and mineral concentration of soils have a direct effect on the acidity and presence of toxic metal ions in water supplies (BAFRU, 1990). The sediment reaction i.e. pH of Posna beel ranged from 4.33 to 5.33 with an average of 4.85±0.50 which is highly acidic in nature. This pH values agree with the findings of Hossain (1998). Mostly the acidic values of the soils is in favour of productivity of ponds as Karim (1975) reported that the bottom soil is oxidized by the overlying water thus leads to disappearance of alkaline condition and the appearance of acidic condition of the bottom soil. Benerjee (1967) has studied the ranges of pH of soil in relation to pond productivity in a number of ponds from the selected regions of India. He concluded that pH values of 6.5 to 7.5 are moderately acidic and may be considered as productive.

Organic matters are considered as the flesh while sand, silt and clay are known as the skeleton of a soil. A soil without organic matter is not considered as soil from the edaphilogical point of view (Alam *et al.* 1991). The organic matter status of the soil is linked to its fertility, thereby imparting its influences on its productivity.

The estimated organic matter of the Posna beel varied from 3.84 to 6.25% with an average of 4.75±1.30%. Content of organic matter in this beel is high. This result agree with the findings of Wahab *et al.* (1998) Almost all the life in the soil is dependent on the dead organic matter for energy and nutrients and the activities of various organisms result in the decomposition of compounds to different degrees.

Total nitrogen content of the bottom soil of the study area ranged from 0.24 to 0.26% with an average of 0.25±0.02%. It was found at medium level (Table 3.6). Rai (1994) noticed high amount nitrogen in non-drainable fish ponds. During the study period, almost same amount of total nitrogen was recorded in three seasons.

The beel sediment content available phosphorus ranged from 1.04 to 27.05 meq/100 gm with an average 10.47±14.40 meq/100 gm. Lower amount (1.04 meq/100 gm) of phosphorus found in winter season may be due to high accumulation by the aquatic weeds, which grew round the year. Whereas the highest amount (27.05 meq/100 gm) was recorded in the summer season. The higher amount of phosphorus in this season may be due to the result of high decomposition of aquatic weeds and run-off water from the surrounding Boro fields where inorganic fertilizers are applied.

Sulpher, copper, iron and manganese were recorded at very high level in Posna beel. Uddin *et al.* (20002) found near same result of Chalan beel. Zinc and Boron content in beel sediment was recorded at medium level. This finding confirms the findings of Singh *et al.*(1999) and Uddin *et al.* (2002).

4.4 Biological Conditions

4.4.1 Phytoplankton

The unity of organisms and their environment is a basic principle of ecology. Any organism's population or species lives at the expense of its environment. Without this interaction it ceases to exist (Nikolsky, 1963). Aquatic life is characterized in community and a complex web of natural composition forming a 'factor-complex' to keep a dynamic and operative ecosystem. Plankton are the heterogeneous assemblage of minute organisms which occur in the natural water and float about by the wave action and movement of water (Moss, 1982). Study of plankton is very useful tool for the assessment of water quality in any type of waterbody, and also it contributes to an understanding of the basic nature and general economy of the concerned habitats. Phytoplankton has been termed as the real grass of the water affording foodstuffs, which are directly or indirectly converted into food for fishes. In the present study, seasonal observation of phytoplankton has been made. The Posna beel is a lentic water ecosystem with a plankton biota differing in abundance, percentage composition and seasonal variation. A total of 47 genera were recorded from the study area of which 19 genera belonged to Chlorophyceae, 13 to Cyanophyceae, 10 to Bacillariophyceae, 3 to Euglenophyceae and 2 to Dinophyceae. Pandey *et al.* (1998) found similar result. This beel exhibit occurrence of the major classes of algae throughout the study period. Any planktonic genera were not found all around the year. Only one algal group (Dinophyceae) had been found to appear as a visual bloom formimg group during the study period. Zaman (1991) recorded a luxurious number of pytoplanktonic algal genera (90) in the Chalan beel, Bangladesh. Shastri *et al.* (1992) noticed that in the Indian fresh water ecosystem, the number of species and genera of Phytoplankton remain low as compared to temperate fresh waters. The present findings support this.

Chlorophyceae

The green algae group Chlorophyceae is represented by 19 genera, which contributes to 25.26% of the total bulk of Phytoplankton population. The generic diversity of Chlorophyceae is second dominant group. The peak abundance of Chlorophyceae was recorded during winter while low abundance was recorded in same season (winter). It might be due to the Dinoflagellates plankton bloom seen in winter'04. Besides, Chlorella's abnormal abundance found in the same season that has enhanced the peak abundance of Chlorophyceae in winter season. Dhakar (1979) opined that the green algae prefer water with higher concentrations of DO. In the case of Posna beel, a higher concentration of DO was always recorded throughout the study period with an average of 8.08 mg/l. The role of temperature in the growth and development of the green algae has been emphasized by many workers from time to time (Sing, 1960 and Hutchinson, 1957). According to Singh (1960) and Sharma (1983), high air or water temperatures along with bright sunshine were important factors in the periodicity of green algae. The present observation corroborates with the above mentioned physical factors.

Cyanophyceae

The blue green algae represent the third dominant group, which constituted 9.02% of the total phytoplankton. Cyanophyceae comprised of 13 genera of which *Oscillatoria* and *Aphanocapsa* were found to be the dominant genera but no visual bloom was seen. In the present study, Cyanophytes formed peaks during the monsoon and post-monsoon seasons with a maximum abundance of 3725 unit/l while the minimum was observed in summer (279 units/l). Similar findings have been reported by Zaman (1991), Naz (1999) and Hasan (2000). Naz (1999) stated that higher abundance of Cyanophyceae can be attributed to high concentrations of oxidizable organic matter with increased temperatures. Vyas and Kumar (1968) noticed an abundant growth of blue green algae under nutrients rich conditions. Although having all favourable conditions, in summer populations was found to be poor mostly due to turbid water caused by over fishing as well as low volume of water which affected not only the growth of Cyanophyceae but all forms of algae at this time.

Bacillariophyceae

The Bacillariophyceae were represented by 9 genera which covered 4.09 % of the total bulk of phytoplankton population. The dominant genera of this group were *Melosira*, *Fragilaria* and *Pinnularia*. The diatoms showed peaks in post-monsoon followed by summer and monsoon. Zafar (1964) stated that water with higher concentrations of calcium and moderate pH (7.5-8.1) favour the growth of diatoms. In the present study, calcium in sediment was high and the pH of water show alkaline condition. During the study period, the appearance of diatoms in winter'03 was totally absent because in this season the Dinophytes plankton bloom were observed.

Euglenophyceae

In the present study, the Euglenophyceae was consisted mainly of *Euglena, Phacus* and *Trachelomonus* genera and constituted 2.09% of the total Phytoplankton populations. This group showed the peak during the post-monsoon and summer season and the lowest abundance in winter season. Rao (1977) and Zafar (1964) reported that low iron contents and highly alkaline water are not favourable for euglenoid growth. The higher concentations of dissolved oxygen, low values of carbon dioxide limited the growth of euglenoid populations in the study area.

Dinophyceae

Dinophyceae represented the first dominant group with two genera which constituted the 57.60% of the total bulk of phytoplankton populations. The highest numbers of population was recorded in winter (79066 units/l). During the study period, most of the season the Dinophytes members were nil or very poor in number in the study area (Posna beel). Only *Ceratium* was found to be the most dominant genus and formed into plankton bloom in winter season (2004) during the course of the study. Winkelmann *et al.* (2004) found available *Ceratium* from June to September in their studies. Hutchinson (1957) stated that the dinoflagellates better developed in the sea than in fresh water, contain a number of genera exhibiting marked evolutionary euryhalinity. He also stated that the marine species usually outnumber the fresh water species. Hutchinson (1957) suggested that the *Ceratium* adapted to alkaline water, but often with fairly humic content and water containing more than 20 mg Ca per liter. In this respect, the water of Posna beel is neutral to alkaline and calcium content in beel sediment is high. These factors may be responsible for dinoflagellates plankton bloom in winter season in Posna beel. Ganf and Blazka (1974) stated that if zooplankton feeding rate is declined, phytoplanktonic bloom and crush occur. Agrawal (1999) opined that the increased number of aggregation of masses of cells, filaments or colonies of planktonic algae in surface water is involved in bloom formation.

4.4.2 Zooplankton

The zooplankton is almost universally distributed in all permanent bodies of water; whether fresh or salt. The wide distribution of plankton, and their frequent abundance, accounts for the great importance of this group as a major basic food maternal in the food cycle of aquatic environment (Bhouyain, *et al* 1992). Zooplankton plays a very important role in the food chain as they are in the second level as primary consumers and also contributes to the next trophic level (Quassim, 1977).

Zooplanktons are the very important foods for fish in aquatic habitats (Arora, 1966; and Mollah, and Haque 1978). In the freshwater ecosystem zooplankton forms an important groups as most of them feed upon and incorporate the primary producers into their bodies and make themselves available to other organism in food chain (Michael, 1973). They contribute significantly to the biological productivity of the freshwater ecosystem. The zooplankton contributes about 47.66% of the food items of *Catla* (*Catla catla*). 3.67% of the *Rui* (*Labeo rohita*); 24.19% of the *Oreochromis niloticus*; 82% of the *Anabas testudineus*; 32% of the *Notopterus notopterus*; 38.5% of the *Rohtee cotio* and 23% of the *Macrobrachium rosenbergi* (Shafi and Quddus, 1975), Tamot *et al.* (1997) suggested that zooplankton can be used as bio-indicators as they play a key role in the energy transfer to other trophic levels.

A total of 43 genera including 63 Species were recorded during of cause of study study from the Posna beel belonging to Rotifera, Cladocra, Copepoda and Ostracoda. The growth and development of zooplankton were inversely related to phytoplankton. This is supported by Bhattacharja and Moitra (1965) and Naz (1999). Harvey *et al.* (1935) proposed that the grazing effect of herbivorous plankton as sufficient to limit the phytoplankton population in quality as well as in quantity. Hardy and Gunther (1935) stated that the zooplankton avoided the areas of dense phytoplankton, presumably due to unfavorable chemical conditions produced by the phytoplankton population. Throughout the study period, the zooplankton population constituted 14.95% of the total bulk of plankton community in the Posna beel.

Copepoda

The present study revealed that the Copepods constituted the first dominant group and covered 37.87% of the total zooplankton population Pandey *et al.* (1998) observed the same result during study on the wetlands of Durbhangai. *Cyclops* was the most dominant number followed by *Diaptomus, Heliodiaptomus* and *Mesocyclops* during the study period. Copepoda showed similar variation of their abundance with Cladocerans abundance throughout the study period. Pennak (1955) and Welch (1952) observed the occurrence of copepods in similar food habitat, and their migration behaviour was governed by approximately the same habitat conditions. The Copepods were abundant throughout the study period with highest density in monsoon and post-monsoon respectively, and the lowest density was in winter. Krishnamurthy and Visweswara (1965) and George (1966) made similar findings. Hasan (2000) observed the minimum abundance of Copepods in winter seasons in the Chalan beel, which is similar to the present findings.

Cladocera

The Cladocerans cover 27.32% of the total zooplankton. The Cladocerans comprised of 13 genera e.g. *Alona, Bosmina, Ceriodaphnia, Chydorus, Daphnia, Diaphanosoma, Kurzia, Leydigia, Moina, Macrothrix, Oxyurella, Simocephalus and Scapholoberis.* The Cladocerans were the second dominant group of zooplankton. This group reached their peaks during the monsoon and post-monsoon. Hasan (2000) observed the similar result. According to Edmonsons (1965) zooplankton hatching rates are dependant on temperature. This might have caused different peaks in different seasons in the Posna beel with varying temperature ranges. The Cladocerans were found in monsoon and post-monsoon which might be due to more phytoplankton abundance during two seasons. Brooks (1959) and Frey (1971) investigated that Cladocerans form an important component of zooplankton and important group of fish food organism.

Rotifera

The Rotifera were represented by 13 genera and constituted 20.95% of the total zooplankton and ranks as third dominant group. Rotifers were found throughout the study period. This findings support by the findings of George (1966) and Sharma (1992). Among the 13 genera *Keratella* was dominant, followed by *Brachionus, Notholca, Filinia* and *Trichocerca.*

The occurrence of a large numbers of Rotifer; indicate the eutrophic nature of wetland. In the case of Posna beel the abundance of Rotiferans is quite significant. But the highest number of species was recorded in this group. The oxygen regime of Posna beel was indicative of its biologically unpolluted nature. It has been observed that the beel water was enriched with nutrients with biological significance. The abundance of Rotifera populations may not fit as an index of polluted water in that habitat while the importance of rotifers as water in quantity indicators had been established by Pejler (1957), Fuller *et al.* (1977) and Sladecek. In this regard Posna beel show eutrophic nature. The rotifers were much more in abundance in the noon sample where as the Cladocerans and copepods were found in large scale in the evening sample. Which indicates that the rotifers prefer direct sunlight and the other two groups choose darkness. It reveals that the different groups of zooplanktons become activated depending on the physical environmental conditions of the same habitat for accommodating themselves in the single habitat.

Crustacean Larvae

Crustacean larvae had the low abundance in all seasons during the course of study. Most of the seasons crustacean larvae were recorded higher than Ostracoda. Bhuiyan and Nessa (1998), Hossain (2002) and Hasan (2000) observed lower abundance of crustacean as zooplankton in their studies.

4.5 Fish Species Diversity and Catch Assessment

Regarding fresh water (open water) fish species abundance in Bangladesh there are a considerable number of published reports of which some are as follows:

Ahmed (1953) recorded 107 fresh water fish species from the then East Pakistan. Sandercoek (1968) and Mahmood (1986), 58 species (Kaptai reservoir); Bhuiyan (1964), 71 species from (Dhaka District); Doha (1973), 106 species from (Mymensingh and Tangail); Ahmed and Hasan (1981), 27 fish species from (Karanaphuli reservoir); Islam and Hossain (1983), 110 fish species (Padma river at Rajshahi); Rahman (1989), 260 species (Bangladesh); Hasan *et al.*(1998), 50 species (Chalan beel); Karim (1997) ,25 species (Schitani beel) , 26 species (Godadanga beel) and 27 species (Maragangi beel) in Melandha thana (Jamalpur District); Kumar *et al.*(2001), 55 species (Chikashi beel, Bogra); Ehsan *et al.*(2000), 40 species (Chanda beel); Ali *et al.* (2000), 42 fish species (Bhaga dighi at Rajshahi); Ahmed (2003), 35 species (Titas floodplain area in Bhrahmanbaria district);. Hossain (2002), 55 species (Altadhigi in Naogaon); Saha and Hossain (2002), 40 species (Saldu beel at Delduwar in Tangail) and Ahmed *et al.* (2004), 39 species (Baila beel of Maljeekangsa floodplain) reported from their studied areas.

Presently, 48 piscine faunas were recorded from the perennial Posna beel. Among them 4 exotic fishes (*P. sophore, H. molitrix, C. idella*, and *C. carpio*) , 4 Culturabe fishes (*P. sarana, L. rohita, C. catla* and *C. mrigala*) and rest are Self Recruiting. Large amount consisting of maximum fish species harvested in December revealed that generally catch diversity was related with the harvest time and quantity.

Annual fish production was 271.80 kg/ha/year in 2003 while in 2004 it was 294.62 kg/ha/year. On an average fish production during the total study period was recorded as 283.21 kg/ha/year from the Posna beel. Throughout the study period 8.40% of fish production has been increased, especially major carp was increased dramatically in 2004. As in the year, 2004 the beel was inundated by flood along with the adjacent cultivable fishponds, and the culturable fish might have entered into this beel raised the catch. Of the 16 species of cypriform from the beel only 2 species (*P. tickto and R. danicunius*) were marked as vulnerable in the red data book of ICUN (2000) but presently more 8 species (*P. stigma, P. sarana, L. rohita, C. catla, L. mrigala, C. carpio, C. laubuca and A. mola*) are in vulnerable state. It seems that the breeding of this species is mostly dependent on running water which has been obstructed due to construction of roads surrounding this beel. As well as frequent low level flood restricts the fish migration.

Cyprinids and perch are dominant groups of fish in the Posna beel. Among the Major carps *Rui* (*L. rohita*), *Catla* (*C. catla*) and *Mrigel* (*C. mrigala*) were found. The production of major carps from this beel is not well enough. Harvest of minor carps is much higher than the major carps. The minor carp had the highest abundance during the study period. Among the minor carps, the abundance of *Jat Puti* and *kanchan Puti* is higher in this beel.

The catfishes were the next dominant group. The dominant fishes are *Boal* (*Wallago attu*), *Tengra* (*M. gulio*), *Shingi* (*H. fossilis*), *Magur* (*C. batrachus*) and *Cheka* (*C. chaca*) etc. It is noticed that the abundance of perch fishes especially *Koi* (*A. testudineus*) and *Meni* (*N. nandus*) were most dominant throughout the period of observation almost uniformly. Snakehead *Taki* (*C. punctatus*) and carnivorous shoal were also highly abundant in the beel and small miscellaneous fishes consists of *Kakila* (*X. cancila*), *Baila* (*G. guiris*), *Baim* (*M. armatus, M. pancalus* and *M. aculeatus*), *Kholisa* (*C. fasciatus, C. lalia, C. chuna*) and *Chanda* (*C. baculis*) , *Chapila* (*G. chapra*) and other small fishes are recorded throughout the study period. Small ceridian prawns is also widely distributed in the beels in Bangladesh. A total of 4 species of ceridian prawns were recorded in the Posna beel. Sagir (2003) has found similar results; Saha and Hossain (2002) reported 3 species of prawn from the Saldu beel in Tangail. The non-fin fisheries fauna of the Posna beel were Mollusca constituted the first group; these were represented by *Viviparus bengalensis, Pila globossa, Lymnaea luteola, L. acuminata, L.*

stafnalis, Planorbis sp. Bellamya bengalensis and lamellidens marginalis. The Chelonid reptiles such as *Tryonix hurun* and *Chitra indica* were found in this beel. These findings agree with the reports of Jahan (1993), Rahman (2000), Saha and Hossain (2002). Only one species of Amphibia (*Rana tigrina*) and one species of Potamon (*.Potamon sp.)* were found.

According to IUCN (2000) red data book 28 species like *Taki* (*C. punctatus*), *Shol* (*C. striatus*), *Futuni Puti* (*P. phutonio*), *Jat Puti* (*P. sophore*), *Kanchan Puti* (*P. conchonius*), *Baga Puti* (*P. Stigma*), *Rui* (*L. rohita*), *Catla* (*C. catla*), *Mrigel* (*C. mrigala*), *Raek* (*C. raba*), *Silver Carp* (*H. molitrix*), *Grass Carp* (*C. idella*), *Common Carp* (*C. carpio*), *Chela* (*C. laubuca*), *Gutum* (*L. guntea*), *Chapila* (*G. chapra*), *Gunia Tengra* (*M. gulio*), *Boal* (*W. attu*), *Shing* (*H. fossilis*), *Lal Chanda* (*C. ranga*), *Gool Chanda* (*C. baculis*), *Koi* (*A. testidineus*), *Baila* (*G. guiris*), *Kholisha* (*C. fasciatus*), *Lal Kholisha* (*C. lalia*), *Chuna, Kholisha* (*C. chuna*), *Guchi Baim* (*M. pancalus*), *Potka* (*T. potka*) are common; 12 species like *Kakila* (*X. cancila*), *Tilo Taki* (Raga) (*C. gachua*), *Dankina* (*R. danicunius*), *Tit Puti* (*P. tickto*), *Gulsha Tengra* (*M. bleekeri*, *Magur* (*C. batrachus*), *Nama Chanda* (*C. nama*), *Meni* (*N. nandus*), *Tara Baim* (*M. aculeatus*) and *Foli* (*N. notopterus*) are vulnerable ; 7 species like *Mola* (*A. mola*), *Batashi* (*B. tengra*), *Checka* (*C. chaca*), *Madhu Pabda* (*O. pabda*), *Kani Pabda* (*O. bimaculatus*) and *Baro Baim* (*M. armatus*) are endangered. Only one species like *Shor Puti* (*P. sarana*) is critically endangered.

According to present status 21 species like *Taki* (*C. punctatus*), *Shol* (*C. striatus*), *Dankina* (*R. danicunius*), *Tit Puti* (*P. tickto*), *Futuni Puti* (*P. phutonio*), *Raek* (*C. raba*), *Silver Carp* (*H. molitrix*), *Grass Carp* (*C. idella*), *Gutum* (*L. guntea*), *Tengra* (*M. vittatus*), *Boal* (*W. attu*), *Shing* (*H. fossilis*), *Lal chanda* (*C. ranga*), *Chanda Nama* (*C. nama*) , *Gol Chanda* (*C. baculis*), *Koi* (*A. testidineus*), *Naptei Koi* (*B. badis*), *Meni* (*N. nandus*), *Baila* (*G. guiris*), *Kholisha* (*C. fasciatus*) and *Guchi Baim* (*M. pancalus*) were common; 4 species like *Jat Puti* (*P. sophore*), *Kanchan Puti* (*P. conchonius*), *Gunia Tengra* (*M. gulio*), and *Chuna Kholisha* (C.

chuna) were very common; 16 species like *Kakila* (*X. cancila*), *Baga Puti* (*P. stigma*), *Shor Puti* (*P. sarana*), *Rui* (*L. rohita*), *Catla* (*C. catla*), *Mrigrl* (*C. mrigala*), *Common Carp* (*C. carpio*), *Chela* (*C. laubuca*), *Mola* (*A. mola*), *Magur* (*C. batrachus*), *Gulsha tengra* (*M. bleekeri*), *Lal Kholisha* (*C. lalia*), *Baro Baim* (*M. armatus*), *Tara Baim* (*M. aculeatus*), *Kuchia* (*A. cuchia*) and *Foli* (*N. notopterus*) were vulnerable, and 7 species like *Tilo Taki* (Raga) (*C. gachua*), *Checka* (*C. chaca*), *Batashi* (*B. tengra*), *Madhu Pabda* (*O. pabda*), *Kani Pabda* (*O. bimaculatus*) and *Chapila* (*G. chapra*) were found endangered.

From fish catch analysis, it is found that *Jat Puti* (*P. sophore*), *Kanchan Puti* (*P. conchonius*), *Tengra* (*M. vitatus*), *Kholisha* (*C. fasciatus*) and *Gura Icha* (*M. lammarrei*) are very common and *Koi* (*A. testudineus*), *Meni* (*N. nandus*), *Chanda* (*C. baculis*), *Taki* (*C. punctatus*) and *Shing* (*H. fossilis*) are moderately common in Posna beel. Some national endangered fish species like *Napti Koi* (*B. badis*), and *Dankina* (*R. danicunius*) are found vulnerable level in this beel. However, *Tilo Taki* (*C. gachua*) is vulnerable and *Potka* (*T. potka*) is common nationally but both are endangered in Posna beel. According to IUCN Red Data Book (2000), *Tilo Taki* (Raga) (*C. gachua*) is vulnerable and *Potka* (*T. potka*) is common considering the country status of Bangladesh but both are endangered in Posna beel.

Moreover, from the above statements it is clear that some of the species have been able to change their position such as *Dankina* (*R. danicunius*), *Mola* (*A. mola*), *Baro Baim* (*M. armatus*) and *Tit Puti* (*P. ticto*) endangered to vulnerable ; *Chanda Nama (C. nama)* and *Meni (N. nandus)* vulnerable to common . This change in status of specific fish species might be due to the alteration of the micro-or macro habitat which is to be investigated for sustainable management of our depleting fish species diversity.

The fish production in the inland open water has declined during the last three decades. Increase in land use intensity, flood control and drainage projects (FCD) and flood control, drainage and irrigation projects are the major causes of decline of common property resources. Intervention to control floods, adoption of new agricultural technologies and construction of road networks in the last thirty years has altered the ecology of flood plains significantly (Khan, 1993 and Ali, 1991). On the other hand, destruction of habitats and loss of many of the natural breeding and nursing grounds have caused fish stocks to reach at a critical low level and recruitment at a low level for many of the important species such as major carps (Tsai and Ali, 1985; Rahman, 1993). Tsai and Ali (1987) found that within two years of completion of the Chandpur irrigation project, fish production was reported to have declined by 35%. An annual decline of 2.4-2.9% over the last 4-5 years has been recorded in fish production from flood plain and beels. Paul (1997) found that many groups of fishes namely Murrels, Catfishes, Perch, local prawn, minor carps etc. spawn in flood plains/beels and grow in there. In the most of the cases river to flood plain channels have been blocked by the construction of flood protection embankment and sluices causing catastrophic effects on major carps. Flood creates a vast productive expanse into which the fish migrate seasonally for feedings and reproduction. Whereas sixty percent of the known fresh water fish species in Bangladesh are flood plains dependent.

In the case of Posna beel, the fish fauna seems to be poor. But the existing of poor fish fauna in this study area is not due to water pollution because the water quality of Posna beel is found to be unpolluted and, more suitable for fish culture. Besides, the beel is disconnected from neighbouring beels canal and river resulting in fish fry and eggs can not enter into the beel in the early monsoon. The main sources of water of this beel are surface drainage, rainfall, ground water as well as occasionally overflowing from neighboring wetlands due to high flood.

Jhingran (1991) observed that a correlation exists between the flood regime and the total catch of flood plains. Fish population increases through the flood season touching the minimum just before the advent of next flood. In the case of Posna beel the fish catch period does not thoroughly agree with above authors, because the beel is not directly connected with neighboring beels and river, except for certain time in the rains causing a short flood period.

Rahman *et al.* (1993) stated that most of the beels are full of organic debris, mud and aquatic weeds due to the lack of proper management. The annual yield/production from these water bodies is only 450 kg/ha (BBS, 1986). Bayley (1988) suggests that maximum potential yield from tropical flood plains are of 110-160 kg/ha/year. Payne (1997) reported that baseline productivity from flood plains of the 3rd fisheries project in Bangladesh ranged from 86kg/ha/year. This is not the optimum level. The current low level of production is caused by the inability of existing fish stokes to fully utilize the fish food. Fish stocks are depleted and species composition is unbalanced, because the natural production of fish has been disturbed by overfishing caused by population pressure and poverty and by expanding water (flood) control infrastructure. Zaman and Ali (1989) found that the flood control and drainage projects (FCP) on flood plain effects loss and flood plain fish production in Bangladesh. Paul (1997) reported that land reclamation of flood plain and beels for paddy cultivation is the primary source of conflict between fisheries and agricultural in the beel areas. Land reclamation results in a reduction of water areas for fish production. In the early 1960s the flood plain (app-28, 37, 792 ha) contributed about 90% of the total fish production. In recent years the production has dropped down to 50-55% due to man made alterations in fish habitats caused by flood protection measures, overfishing, irrigation, dam and reservoir construction, and improper use of insecticides, herbicides and fungicides without discrimination.

4.6 Correlation co-efficients (r)

Analysis of correlation co-efficients among the different physico-chemical variables of water revealed that:

The correlation coefficient (r) among the different physico-chemical variables of water have been calculated (Appendix table-IX).

The water temperature showed a positive statistically significant relation with total solids and COD. It showed a negative but statistically significant correlation with alkalinity and dissolved oxygen. The Secchi disk showed negative statistically significant correlation with BOD_5 and COD. The pH had negative statistically correlation with Eh, Cl^- and PO_4. The alkalinity had a negative statistically significant correlation with temperature and total solids. The dissolved oxygen showed a negative significant correlation with temperature. The biochemical oxygen demand (BOD_5) had a positive significant with COD and negative significant with transparency. The chemical oxygen demand (COD) had a positive and statistically significant correlation with temperature and BOD_5. It showed a negative but statistically significant correlation with transparency. The oxidation-reduction potential (Eh) showed a negative but statistically significant correlation with pH. The oxidation-reduction index (rH_2) showed a negative but statistically significant correlation with total hardness. The chloride had a positive significant correlation with phosphate. It had a negative significant relation with pH. The phosphate concentration in water showed a positive statistically significant correlation with chloride. It showed a negative but statistically significant relation with pH (Table 4.2).

Table 4.2
Correlation co-efficient (r) Significance of Physico-chemicals Variables of Water at Different level

Water's variables	Positive significant		Negative significant	
	1% level	5% level	1% level	5% level
Temp	TS	COD	Alka	DO
Trans				BOD_5, COD
TS			Alka	
pH				Eh, Cl^-, PO_4
Alka			Temp, TS	
DO				Temp
BOD_5		COD, Temp.		Trans
COD		BOD_5		Trans
Eh				
rH_2				TH
TH				rH_2
Cl^-	PO_4			pH
PO_4	Cl^-			pH

Correlation Co-efficient (r) Among Phytopankton Abundance, zooplankton Abundance and Physico-chemical Variables of Water:

From the obtained data of two years the phytoplankton abundance showed a positive non-significant correlation with carbondioxide, alkalinity, BOD_5, COD, Eh, rH_2, Cl^-, $N0_3$, PO_4 while negative but non- significant correlation with temperature, transparency, total solids, pH, DO, saturation of dissolved oxygen, total hardness and NH_3. On the other hand, the zooplankton abundance had a positive but non- significant correlation with temperature, total solid, pH, CO_2, saturation of dissolved oxygen, BOD_5, COD, rH_2, NH_3 and NO_3. It had a negative but non-significant correlation with transparency, alkalinity, DO, Eh, total hardness, Cl^- and PO_4 (Table 4.3).

Table 4.3
Correlation Coefficient (r) Among Phytoplankton Abundance, Zooplankton Abundance and Physico-chemical Variables of Water at Different Level

Plankton	Positive			Negative		
	1% level	5% level	Non-significant	1% level	5% level	Non-significant
Phytoplankton			CO_2, Alk, BOD_5, COD, Eh, rH_2, Cl^-, NO_3, PO_4			Temp, Trans, TS, pH, DO, Sat. O_2, TH, NH_3
Zooplankton			Temp, TS, pH, CO_2, Sat. O_2, BOD_5, COD, rH_2, NH_3, NO_3			Trans, Alk, DO, Eh, TH, Cl^-,PO_4

Correlation Coefficients among the Physico-chemical Variables of Sediment, Phytoplankton and Zooplankton

The correlation coefficients(r) among different physico-chemical variables, phytoplankton and zooplankton have been calculated. These analysis reveal a generalized pattern of relationships among the soil physico-chemical variables, phytoplankton and zooplankton (Appendix table-X). The pH of sediment showed a positive and significant correlation with Calcium. Phosphorus showed a positive and significant correlation with Boron. The Magnesium content had a positively significant correlation with Phytoplankton. The rest sediment components are not correlated significantly either positively or negatively.

Chapter 5
Conclusion and Recommendations

From the two years of intensive study of the perennial water body Posna beel, it has been observed that the physical characters of water such as water temperature, transparency and total solid are mostly found within the Bangladesh standard for fish culture. The chemical and biochemical parameters such as DO, BOD_5 and COD observed revealed slightly high organic content of biodegradable and non-biodegradable nature which did not reach the pollution level. pH value showed a neutral to alkaline nature, suitable for fish culture. Lower concentration of ammonia and nitrate were found during the study period while phosphate concentration was comparatively high. Enrichment of phosphate concentration in water may lead to increased growth of algal and macrophyte vegetation. Eventually which may result into a deleterious condition for fish and other biota. At present, levels of concentration of the parameters concerned are within Bangladesh standard for fish culture and are also within the Bangladesh drinking water quality standard (DWQS).

Qualitative and quantitative study of plankton revealed that the Posna beel is considerably productive. The phytoplankton- zooplankton ratio (**5.2:1**) is also indicative of the productive nature. The phytoplankton populations indicate that the Posna beel to be eutrophic. During the study period, some pollutant tolerant zooplankton species like *Keratella* and *Brachionus* have been identified from the study area. Besides, algal forms like *Chlorella, Navicula, Nitzschia* and *Synedra* were encountered in the beel which are regarded as most pollution tolerant genera in the world (Palmer, 1969).

The pH range of this beel sediment is medium acidic (4.33 - 5.33) which did not show a significant impact on fish production. The beel sediment has a high content of organic matter (3.84-6.25 %). Exchangeable calcium (6.26±1.08 meq/100gm), available phosphorus (10.47±14.40 meq/100 gm) and total nitrogen (0.24-0.26%)

are all in favour in fish production, although some factors (sulphur, iron, copper, manganese) are very high.

Pesticides residue from water and sediment of Posna beel during the study period, revealed that most of the pesticides were in untraceable amount or nil. Only very trace (not quantifiable) amount of organochlorine pesticides DDT, DDE, DDD, Heptachlor and Dieldrin, were found in water and sediment while organophosphorus and carbamate, pesticides were totally absent both in water and in sediment. Therefore, the residual pesticides impact on the fisheries resources and aquatic environment of posna beel is very negligible.

During the study period, a total of 63 fisheries (48 fishes and 15 non-fin fisheries species) species recorded from the posna beel, which may be indicative poor fish diversity in comparison to other beels and flood plain areas. But in respect of Posna beel's location, its area and environmental condition, the fish population in this beel is considerably high. Some nationally endangered fish species like *Napit Koi* (*Badis badis*), *Mola* (*Amplyphyrngodon mola*) and *Dankina* (*Rasbora danicunius*) are found to occur in vulnerable condition in this beel. However, *Potka* (*Tetradon potka*) is common nationally but is under stress in Posna beel.

Some statistically significant correlation co-efficient was obtained between water physico-chemical conditions and biotic components; water physico-chemical conditions between sediment nutrient components. This correlation indicated that there are inter-relation, interactions and interdependence of various physico-chemical and biological factors (phytoplankton and zooplankton) of both water and sediment. It was found that the variables are dependent on each other either positively or negatively with different levels of significance. The findings of the present study suggest that further specific but intensive investigation on fish production, density, and growth rate of fish is necessary.

Bangladesh possess vast wetland areas of diverse nature and variable dimension. Wetlands are invaluable components of the environment. Wetlands play a significant role on the lives of adjoining human beings and biotic components acting as resource base. It has great ecological, economic, commercial and socio-economic importance and values. Besides, it is providing income and high protein for the increasing number of rural families in Bangladesh, but these resources have suffered considerably from the impact of a burgeoning human population. It is the best time to conserve the wetland including Posna beel against the environmental degradation by sustainable development and proper management, prevention of unbalanced fishing activities, enforcement of rules and regulations and by undertaking proper stocking programs of indigenous fisheries species. Loss of fish habitat by any type of anthropogenic activities should be brought under strict control enacting regulations. Alongside, public awareness and participating environmental as well as ecosystemological knowledge based development activities should be undertaken by the GO and NGOs immediately.

Information for Community Dissemination

From this research work, some important findings have been identified for community dissemination for better management of Posna beel, these are

i. Excessive uses of agro-chemicals increase the HYV Boro production along with increase the risk of water pollution of beel.

ii. Judicious use of agro-chemicals as per DAE recommendation increased rice production.

iii. Water quality of Posna beel is suitable for open water fisheries.

iv. Beel sediment is rich with nutrient matters, suitable for producing the fish food (phytoplankton and zooplankton)

v. Vulnerable condition of some locally endangered fish species in Posna beel is not due to water pollution. Because a low level of water pollution is found during the water quality monitoring. Prevention of free emigration and immigration of fish species may be the main cause of reduction of fish population in the beel.

vi. The indiscriminate catch of fish from this beel by complete removal of water from beel-bed ditches results in destruction of the entire population of brood fish.

vii. The use of Current Jal should be banned and fishing by dewatering should be prohibited.

viii. The use of Current Jal. Puti Jal, Fash Jal and Traps should be restricted from July to September/October.

ix. Community should take immediate measure to connect the Posna beel with neighbouring Zoloi beel, Catra beel and Balla river, which will help free migration of fishes round from the beel, and simultaneously the beel water will be enriched with nutrients due to water movements, Which can improve the fisheries resources of Posna beel.

x. A co-operative society consisting of the fisherman and dwellers of the beel catchment zone should be formed and entrusted with the entire management of this wetland.

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Appendix table I: Seasonal Variation of Phisico-chemical Conditions of Water of Posna Beel during the Study Period.

Parameters	2003-2004				2004-2005				Min	Max	Mean	±SD
	Monsoon	Post-monsoon	Winter	Summer	Monsoon	Post-monsoon	Winter	Summer				
Temperature °C	31 ±0	30 ±0	16.50 ±0.00	30 ±0	32 ±0	30.66 ±0.57	20.66 ±.57	33.33 ±.57	16.50	32.66	28.01	5.46
Transparency, cm	148.33 ±15.06	50.66 ±8.32	189.50 ±5.40	25.62 ±2.86	120.56 ±36.79	44.37 ±1.25	92.30 ±17.98	42.50 ±4.33	25.62	189.50	89.23	58.87
Total solids (mg/l)	70 ±5	119.66 ±17.47	7 ±0	100.66 ±10.40	123.33 ±20.81	106.66 ±5.77	16.66 ±11.54	110 ±10	7.00	123.33	81.53	46.14
pH	7.66±0.28	7.90±0.36	7.50±0.00	7.2±0.20	8±0	7.50±0.00	7.33±0.28	6.83±1.04	6.83	8.00	7.39	0.49
Free CO_2 (mg/l)	10±0	11.66±2.88	5±0	11.66±0.00	5±0	10±0	10±0	13.33±2.88	5.00	13.33	9.58	3.05
Alka (mg/l)	34.20±0.00	28.50±9.87	51.30±0.00	34.2±0.00	34.20±0.00	34.20±0.00	51.30±0.00	34.20±0.00	28.50	51.30	37.76	8.58
DO (mg/l)	6.66±0.57	8.20±1.70	9.66±0.57	8.33±.57	8.00±0.50	8.66±0.57	8.0±0.5	7.16±1.04	6.66	9.66	8.08	0.90
% sat O_2 (mg/l)	88.86±3.97	104.16±19.62	98±5.29	107.68±3.73	109.46±4.19	115.33±8.08	88.0±4.0	101.92±13.40	88.00	115.33	101.66	12.69
BOD_5 (mg/l)	4.08±1.10	5.43±0.70	2.70±0.36	4.36±0.79	4.31±0.82	4.19±1.28	3.50±0.32	4.7±2.73	2.70	5.43	4.15	0.80
COD	6.90±1.35	7.53±1.15	5.20±0.78	8.15±0.95	6.85±1.40	6.73±1.20	5.80±0.30	7.8±3.44	5.20	8.15	6.87	0.99
'P'COD-BOD (mg/l)	2.75±0.22	2.1±0.45	3.10±1.20	3.79±0.17	2.50±0.20	2.09±0.04	2.30±0.30	3.1±0.44	2.09	3.10	2.70	0.05
Eh (mv.)	0.51±0.05	0.48±0.04	0.50±0.05	0.59±0.10	0.45±0.057	0.49±0.01	0.52±0.01	0.25±0.11	0.25	0.59	0.470	0.098
rH_2	29.31±4.14	32.18±1.94	32.62±0.30	32.28±0.66	31.71±0.37	32.11±0.27	32.80±0.30	32.23±1.90	29.31	32.80	31.90	1.20
Total Hard (mg/l)	60.31±0.95	51.30±1.12	58.33±0.66	68.40±0.44	65.43±0.80	58.38±24.06	55.0±1.08	74.10±9.87	51.30	74.10	61.40	7.45
Cl^- (mg/l)	26.80±0.90	29.16±0.92	30.15±1.15	31.25±.43	25.58±1.15	28.91±1.52	30.15±2.02	31.25±0.70	25.58	31.25	29.15	2.05
NH_3 (mg/l)	0.066 ±0.07	0.056 ±0.04	0.026 ±0.05	0.012 ±0.01	0.073 ±0.005	0.039 ±0.044	0.015 ±0.001	0.038 ±0.054	0.012	0.076	0.04	0.02
NO_3. N (mg/l)	0.48 ±0.11	0.25 ±0.03	0.22 ±0.11	0.15 ±0.13	0.40 ±0.10	0.20 ±0.03	0.15 ±0.31	0.26 ±0.02	0.15	0.48	0.26	0.12
PO_4. P (mg/l)	4.85 ±0.30	4.30 ±0.68	2.68±0.41	5.39 ±1.23	4.7 0±0.58	4.60 ±0.17	2.87 ±0.17	4.25 ±0.18	2.68	5.39	4.20	0.95

Appendix Table II: Water Quality of Posna Beel with Comparison to Bangladesh Standard for Fish Culture and Drinking Water.

	Water Temp. °C	Trans. cm	Total Solid mg/l	pH	f. CO_2 mg/l	Alkali mg/l	T. Hard mg/l	DO mg/l	BOD_5 mg/l	COD mg/l	Cl^- mg/l	NH_3 mg/l	NO_2 mg/l	NO_3 mg/l	PO_4 mg/l
Existing Water Quality of Posna Beel	28.01	89.23	81.53	7.39	9.58	37.76	61.40	8.08	4.15	6.87	29.15	0.04	0.00	0.26	4.20
Bangladesh Std. for Fish Culture	-	-	-	6.5-8.5	-	-	-	>5.0	<6.0	-	-	1.2	-	-	-
Bangladesh Std. for Drinking Water	20-30	-	-	6.5-8.5	-	-	200-500	6.0	0.2	8.0	150-600	0.5	<1.0	10.0	8.0

ECR, 1997

Appendix Table III : Seasonal Variation and Percent Composition in Parenthesis of Phytoplankton of Posna Beel (August 2003-April 2005).

CHLOROPHYCEAE	Monsoon'03	Post-monsoon'03	Winter'03	Summer'04	Monsoon'04	Post-monsoon'04	Winter'04	Summer'05	Total	% of the class	% of total Phyto
Cosmarium	418 (7.20)	173 (2.21)	230 (8.21)	173 (8.65)	83 (1.84)	0	33 (0.34)	193 (1.34)	1267	3.55	0.92
Chlorella	167 (2.87)	880 (11.28)	0	0	310 (6.88)	1875(17.54)	13667 (14.65)	12143(84.91)	29042	81.44	20.61
Bulbochaete	58 (1.00)	0	0	0	0	0	0	16 (0.11)	74	0.20	0.06
Euastrum	175 (3.01)	100 (1.28)	95 (3.93)	97 (4.85)	72 (1.60)	84 (0.78)	0	0	623	1.74	0.43
Pediastrum	101 (1.74)	100 (1.280	83 (2.93)	0	104 (2.31)	19 (0.17)	100 (0.10)	93	600	1.68	0.60
Scenedesmus	89 (1.53)	85 (1.08)	34 (1.21)	244 (12.2)	54 (1.20)	0	67 (0.07)	0	573	1.60	0.24
Micrasterias	35 (0.60)	28 (0.35)	25 (0.89)	305 (10.89)	81 (1.80)	0	0	0	474	1.32	0.27
Microspora	58 (1.00)	71 (0.91)	24 (0.85)	0	23 (0.5)	110 (1.02)	0	0	286	0.80	0.20
Oedogonium	21 (0.30)	0	20 (0.75)	0	0	0	0	0	41	0.11	0.02
Zygnema	210 (3.62)	41 (0.52)	47 (1.67)	0	53 (0.51)	0	0	0	351	0.98	0.25
Stuarastrum	0	132 (2.27)	67 (2.39)	0	84 (1.85)	303 (2.83)	0	0	586	1.64	0.41
Pluerodina	0	28 (0.35)	0	0	0	0	0	0	28	.07	0.02
Mougeotia	137 (2.36)	96 (1.23)	0	0	115 (2.55)	133 (1.24)	0	0	481	1.34	0.24
Actinastrum	0	110 (1.41)	42 (1.5)	0	0	0	0	0	152	0.42	0.12
Closterium	0	186 (2.38)	0	95 (4.75)	0	0	33 (0.03)	0	314	0.88	0.20
Pandorina	0	0	0	96 (4.76)	0	0	0	0	96	0.27	0.06
Volvox	0	0	0	0	212 (4.71)	0	0	0	212	0.60	0.15
Crucigenia	0	0	0	0	39 (0.86)	19 (0.17)	0	0	58	0.16	0.04
Spirogyra	137 (2.36)	0	205 (7.32)	0	0	0	0	60 (0.40)	402	1.12	0.28
Total	**1465**	**2030**	**875**	**1061**	**1149**	**2543**	**13833**	**12505**	**35660**		**25.26**
CYANOPHYCEAE											
Oscillatoria	1696 (29.21)	664 (8.51)	48 (1.71)	0	1181 (26.24)	893 (8.34)	0	0	4482	35.16	3.06
Nostoc	144 (2.48)	150 (1.92)	0	0	128 (2.84)	0	0	0	422	3.31	0.30
Anabaena	36 (0.62)	35 (0.44)	0	0	161 (3.75)	264 (2.46)	0	0	496	3.90	0.35
Lyngbya	134 (2.31)	213 (2.73)	117 (4.17)	0	14 (0.31)	0	0	0	478	3.75	0.33
Aphanocapsa	433 (7.46)	1280 (16.41)	190 (6.78)	79 (3.95)	0	1214 (11.34)	0	121 (0.82)	3317	26.02	2.35
Gleocapsa	72 (1.24)	42 (0.53)	308 (11.0)	102 (5.10)	64 (1.42)	837 (7.82)	0	177 (1.20)	1602	12.57	1.13
Ravularia	47 (0.80)	58 (0.74)	0	0	0	0	0	0	105	0.83	0.07
Microcystis	99 (1.70)	433 (5.55)	46 (1.64)	0	286 (6.35)	251 (2.34)	0	0	1115	8.74	0.79

	Monsoon'03	Post-monsoon'03	Winter'03	Summer'04	Monsoon'04	Post-monsoon'04	Winter'04	Summer'05	Total	% of the class	% of total Phyto
Choleochaete	0	32 (0.41)	70 (2.50)	0	0	0	0	0	102	0.80	0.02
Cylindrospermum	0	0	23 (0.82)	0	0	0	0	0	23	0.18	0.01
Merismopedia	0	0	0	98 (4.90)	0	0	0	0	98	0.76	0.07
Aphanothece	0	0	0	0	100 (2.22)	266 (2.48)	0	0	366	2.87	0.25
Anabeanopsis	0	0	0	0	138 (3.06)	0	0	0	138	1.08	0.09
	2661	**2743**	**732**	**279**	**2072**	**3725**	**0**	**298**	**12744**		**9.02**
BACILLARIOPHYCEAE											
Gomphonema	227 (3.91)	0	0	0	0	0	0	0	227	3.95	0.19
Navicula	134 (2.31)	42 (0.53)	161 (5.75)	103 (5.51)	0	0	0	397 (2.77)	876	12.51	0.62
Fragilaria	143 (2.46)	250 (3.21)	0	0	151 (3.51)	183 (1.71)	0	0	727	10.39	0.81
Melosira	145 (2.5)	850 (10.65)	0	20 (1.00)	271 (6.02)	1420 (13.27)	0	464 (3.24)	3191	45.60	1.93
Nitzchia	58 (1.0)	55 (0.70)	70 (2.5)	32 (1.60)	52 (1.15)	0	0	26 (0.18)	293	4.18	0.22
Cymbella	160 (2.75)	33 (0.42)	169 (6.03)	29 (1.45)	0	0	0	41 (0.28)	432	6.17	0.40
Pinnularia	135 (1.32)	195 (2.50)	260 (9.28)	0	32 (0.7)	0	0	179 (1.25)	801	11.44	0.44
Rhiziclonium	23 (0.39)	31 (0.39)	27 (0.96)	52 (2.60)	14 (0.3)	0	0		147	2.10	0.25
Gyrosygma	11 (0.18)	134 (1.71)	21 (0.75)	0	0	0	0	121 (0.84)	287	4.10	0.10
Synedra	0	16 (0.20)	0	0	0	0	0	0	16	0.22	0.01
Total	**1095**	**1606**	**717**	**237**	**520**	**1603**	**0**	**1180**	**6997**		**4.95**
EUGLENOPHYCEAE											
Euglena	148 (2.55)	433 (5.55)	62 (2.21)	131 (6.55)	31 (0.7)	254 (2.37)	0	102 (0.71)	1161	39.26	1.26
Phacus	119 (2.05)	276 (3.53)	103 (3.67)	169 (8.45)	0	170 (1.580	67(0.07)	0	903	30.53	0.52
Trachelomonus	117 (2.01)	48 (0.61)	26 (0.92)	163 (8.15)	165 (3.66)	374 (3.49)	0	0	893	30.19	0.63
Total	**384**	**757**	**191**	**463**	**196**	**798**	**67**	**102**	**2957**		**2.09**
DINOPHYCEAE											
Peridinium	0	0	51 (1.82)	0	0	0	0	0	51	0.06	0.04
Ceratium	0	0	100 (3.57)	0	322 (7.15)	1767 (16.51)	79066(84.80)	0	81255	99.94	57.66
Total	**0**	**0**	**151**	**0**	**322**	**1767**	**79066**	**0**	**81306**		**57.60**
Unidentified	104	500	27	47	160	374	0	57	1269		0.89
Grand Total	**5800**	**7800**	**2800**	**2000**	**4500**	**10700**	**93233**	**14300**	**141133**		**100.00**

Appendix Table IV: Seasonal Abundance and Percent Composition in Parenthesis of Zooplankton of Posna Beel (August 2003-April 2005).

ROTIFERA	Monsoon'03	Post-monsoon'03	Winter'03	Summer'04	Monsoon'04	Post-monsoon'04	Winter'04	Summer'05	Total	% of the class	% of total zoo
Brachionus	174 (4.8)	240 (5.58)	0	140 (0.53)	349 (10.5)	389 (8.45)	0	11 (0.52)	1303	25.06	5.25
Keratella	110 (3.0)	146 (3.39)	0	576 (22.15)	180 (5.45)	358 (7.78)	383 (17.41)	209 (9.95)	1962	37.74	7.91
Notholca	14 (0.33)	73 (1.69)	50 (2.38)	56 ((2.15)	120 (3.63)	283 (6.15)	217 (9.86)	55 (2.61)	868	16.69	3.5
Lecane	0	115 (2.67)	12 (0.57)	28 (1.07)	0	0	0	0	155	2.98	0.62
Polyarthra	0	29 (0.67)	0	0	0	0	0	0	29	0.55	0.11
Pomphodyx	6 (0.16)	0	0	0	0	0	0	0	6	0.07	0.02
Squantinella	4 (0.11)	0	0	0	0	0	0	0	4	0.07	0.01
Platiyias	0	61 (1.41)	0	0	0	16 (0.34)	0	0	77	1.48	0.31
Rotaria	0	0	0	14 (0.53)	0	0	0	0	14	0.26	0.05
Filinia	0	0	0	43 (1.65)	120 (3.63)	216 (4.70)	17 (0.77)	0	396	7.61	1.59
Trichocecra	0	0	20 (0.95)	28 (1.07)	30 (0.90)	17 (0.36)	100 (4.54)	0	195	3.75	0.78
Monostyla	4 (0.11)	0	0	0	62 (1.87)	50 (1.08)	0	0	116	2.23	0.46
Polyarthra	0	0	0	0	30 (0.90)	18 (0.39)	0	0	48	0.92	0.19
Total	**312**	**664**	**82**	**911**	**891**	**1346**	**717**	**275**	**5198**		**20.96**
CLADOCERA											
Alona	9 (0.25)	129 (3.0)	0	0	0	0	0	0	138	2.03	0.55
Bosmina	112 (3.11)	93 (2.16)	0	0	186 (5.63)	466 (10.13)	300 (13.63)	76 (3.61)	1233	18.19	4.97
Ceriodaphnia	164 (4.55)	63 (1.46)	146 (6.95)	128 (4.92)	325 (9.840	300 (6.25)	100 (4.54)	121 (5.76)	1347	19.87	5.43
Chydorus	0	36 (0.83	0	0	0	41 (0.90)	0	0	77	1.13	0.31
Daphnia	20 (0.55)	90 (2.09)	0	0	98 (2.96)	0	0	0	208	3.06	0.83
Diaphanosoma	190 (5.27)	677 (15.74)	104 (4.93)	72 (2.76)	404 (12.24)	466 (10.13)	100 (4.54)	423 (20.14)	2436	35.94	9.82
Kurzia	0	98 (2.27)	19 (0.90)	0	0	16 (0.35)	0	22 (1.04)	155	2.28	0.62
Leydigia	48 (1.33)	38 (0.88)	0	0	244 (7.39)	16 (0.35)	0	33 (1.57)	379	5.59	1.52
Moina	31(0.86)	145 (3.37)	0	147 (5.65)	150 (4.540	0	0	0	473	6.97	1.90
Macrothrix	0	33 (0.76)	36 (1.71	0	0	0	0	0	69	1.01	0.27
Oxyurella	0	19 (0.44)	0	0	0	0	0	0	19	0.28	0.07
Simocephalus	0	0	0	32 (1.23)	96 (2.90)	50 (1.08)	0	0	178	2.62	0.71
Schapholeberis	0	19 (0.44)	0	0	30 (0.90)	16 (0.35)	0	0	65	0.95	0.26

ROTIFERA	Monsoon'03	Post-monsoon'03	Winter'03	Summer'04	Monsoon'04	Post-monsoon'04	Winter'04	Summer'05	Total	% of the class	% of total zoo
Total	574	1440	305	379	1537	1371	500	675	6777		27.32
COPEPODA											
Diaptomus	573 (15.9)	165 (3.83)	177 (8.42)	73 (2.80)	180 (5.45)	116 (2.5)	433 (19.68)	140 (6.66)	1857	19.77	7.56
Heliodiaptomus	439 (12.19)	435 (12.0)	156 (7.42)	62 (2.38)	213 (6.45)	316 (6.86)	67 (3.04)	110 (5.2)	1798	19.14	7.25
Neodiaptomus	416 (11.5)	116 (3.22)	113 (5.38)	43 (1.60)	62 (1.87)	116 (2.5)	133 (6.04)	44 (2.09)	1043	11.10	4.20
Specodiaptomus	87 (2.41)	0	24 (1.14)	0	61 (1.84)	0	0	0	172	1.83	0.69
Cyclops	657 (18.25)	194 (4.50)	239 (11.38)	241(9.26)	196 (6.0)	368 (8.0)	0	260 (12.38)	2155	22.94	8.68
Mesocyclops	244 (6.77)	401 (11.13)	147 (7.93)	382 (14.70)	31 (0.93)	134 (2.91)	0	164 (7.80)	1503	16.00	6.06
Macrocyclops	84 (2.33)	341 (7.93)	85 (4.04)	114 (4.38)	0	100 (2.17)	0	0	724	7.70	2.91
Microcyclops	0	30 (0.70)	0	104 (4.0)	0	0	0	0	134	1.42	0.54
Total	2500	1682	941	1019	749	1150	633	718	9392		37.87
OSTRACODA											
Cypris	42 (1.16)	15 (0.340)	150 (7.14)	50 (1.92)	10 (0.30)	0	125 (5.68)	22 (1.04)	414	26.86	1.66
Heterocypris	0	0	50 (2.38)	0	0	0	25 (1.13)	30 (1.42)	105	6.81	0.42
Centrocypris	18 (0.50)	0	0	25 (0.96)	0	15 (0.23)	0	145 (6.90)	203	13.17	0.81
Stenocypris	0	8(0.18)	0	0	0	0	25(1.31)	0	33	2.14	0.13
Cypria	10 (0.27)	0	32 (1.52)	0	0	0	0	0	42	2.72	0.16
Eucypris	0	40 (0.95)	322 (15.06)	174 (6.68)	20(0.60)	15(0.23)	25 (1.13)	125 (5.94)	741	48.06	2.97
Total	90	63	554	249	30	30	200	322	1541		6.21
CRUSTACEAN LARVAE	124 (3.44)	445 (10.34)	218 (10.38)	42 (1.61)	97 (2.93)	700 (15.2)	150 (6.81)	110 (5.23)	1892		7.62
Grand Total	3600	4300	2100	2600	3300	4600	2200	2100	24800		100.00

CHLOROPHYCEAE	Monsoon'03	Post-monsoon'03	Winter'03	Summer'04	Monsoon'04	Post-monsoon'04	Winter'04	Summer'05	Total	% of the class	% of total Phyto
Choleochaete	0	32 (0.41)	70 (2.50)	0	0	0	0	0	102	0.80	0.02
Cylindrospermum	0	0	23 (0.82)	0	0	0	0	0	23	0.18	0.01
Merismopedia	0	0	0	98 (4.90)	0	0	0	0	98	0.76	0.07
Aphanothece	0	0	0	0	100 (2.22)	266 (2.48)	0	0	366	2.87	0.25
Anabeanopsis	0	0	0	0	138 (3.06)	0	0	0	138	1.08	0.09
	2661	**2743**	**732**	**279**	**2072**	**3725**	**0**	**298**	**12744**		**9.02**
BACILLARIOPHYCEAE											
Gomphonema	227 (3.91)	0	0	0	0	0	0	0	227	3.95	0.19
Navicula	134 (2.31)	42 (0.53)	161 (5.75)	103 (5.51)	0	0	0	397 (2.77)	876	12.51	0.62
Fragilaria	143 (2.46)	250 (3.21)	0	0	151 (3.51)	183 (1.71)	0	0	727	10.39	0.81
Melosira	145 (2.5)	850 (10.65)	0	20 (1.00)	271 (6.02)	1420 (13.27)	0	464 (3.24)	3191	45.60	1.93
Nitzchia	58 (1.0)	55 (0.70)	70 (2.5)	32 (1.60)	52 (1.15)	0	0	26 (0.18)	293	4.18	0.22
Cymbella	160 (2.75)	33 (0.42)	169 (6.03)	29 (1.45)	0	0	0	41 (0.28)	432	6.17	0.40
Pinnularia	135 (1.32)	195 (2.50)	260 (9.28)	0	32 (0.7)	0	0	179 (1.25)	801	11.44	0.44
Rhiziclonium	23 (0.39)	31 (0.39)	27 (0.96)	52 (2.60)	14 (0.3)	0	0		147	2.10	0.25
Gyrosygma	11 (0.18)	134 (1.71)	21 (0.75)	0	0	0	0	121 (0.84)	287	4.10	0.10
Synedra	0	16 (0.20)	0	0	0	0	0	0	16	0.22	0.01
Total	**1095**	**1606**	**717**	**237**	**520**	**1603**	**0**	**1180**	**6997**		**4.95**
EUGLENOPHYCEAE											
Euglena	148 (2.55)	433 (5.55)	62 (2.21)	131 (6.55)	31 (0.7)	254 (2.37)	0	102 (0.71)	1161	39.26	1.26
Phacus	119 (2.05)	276 (3.53)	103 (3.67)	169 (8.45)	0	170 (1.580	67(0.07)	0	903	30.53	0.52
Trachelomonus	117 (2.01)	48 (0.61)	26 (0.92)	163 (8.15)	165 (3.66)	374 (3.49)	0	0	893	30.19	0.63
Total	**384**	**757**	**191**	**463**	**196**	**798**	**67**	**102**	**2957**		**2.09**
DINOPHYCEAE											
Peridinium	0	0	51 (1.82)	0	0	0	0	0	51	0.06	0.04
Ceratium	0	0	100 (3.57)	0	322 (7.15)	1767 (16.51)	79066(84.80)	0	81255	99.94	57.66
Total	**0**	**0**	**151**	**0**	**322**	**1767**	**79066**	**0**	**81306**		**57.60**
Unidentified	**104**	**500**	**27**	**47**	**160**	**374**	**0**	**57**	**1269**		**0.89**
Grand Total	**5800**	**7800**	**2800**	**2000**	**4500**	**10700**	**93233**	**14300**	**141133**		**100.00**

Appendix Table IV: Seasonal Abundance and Percent Composition in Parenthesis of Zooplankton of Posna Beel (August 2003-April 2005).

ROTIFERA	Monsoon'03	Post-monsoon'03	Winter'03	Summer'04	Monsoon'04	Post-monsoon'04	Winter'04	Summer'05	Total	% of the class	% of total zoo
Brachionus	174 (4.8)	240 (5.58)	0	140 (0.53)	349 (10.5)	389 (8.45)	0	11 (0.52)	1303	25.06	5.25
Keratella	110 (3.0)	146 (3.39)	0	576 (22.15)	180 (5.45)	358 (7.78)	383 (17.41)	209 (9.95)	1962	37.74	7.91
Notholca	14 (0.33)	73 (1.69)	50 (2.38)	56 ((2.15)	120 (3.63)	283 (6.15)	217 (9.86)	55 (2.61)	868	16.69	3.5
Lecane	0	115 (2.67)	12 (0.57)	28 (1.07)	0	0	0	0	155	2.98	0.62
Polyarthra	0	29 (0.67)	0	0	0	0	0	0	29	0.55	0.11
Pomphodyx	6 (0.16)	0	0	0	0	0	0	0	6	0.07	0.02
Squantinella	4 (0.11)	0	0	0	0	0	0	0	4	0.07	0.01
Platiyias	0	61 (1.41)	0	0	0	16 (0.34)	0	0	77	1.48	0.31
Rotaria	0	0	0	14 (0.53)	0	0	0	0	14	0.26	0.05
Filinia	0	0	0	43 (1.65)	120 (3.63)	216 (4.70)	17 (0.77)	0	396	7.61	1.59
Trichocecra	0	0	20 (0.95)	28 (1.07)	30 (0.90)	17 (0.36)	100 (4.54)	0	195	3.75	0.78
Monostyla	4 (0.11)	0	0	0	62 (1.87)	50 (1.08)	0	0	116	2.23	0.46
Polyarthra	0	0	0	0	30 (0.90)	18 (0.39)	0	0	48	0.92	0.19
Total	**312**	**664**	**82**	**911**	**891**	**1346**	**717**	**275**	**5198**		**20.96**
CLADOCERA											
Alona	9 (0.25)	129 (3.0)	0	0	0	0	0	0	138	2.03	0.55
Bosmina	112 (3.11)	93 (2.16)	0	0	186 (5.63)	466 (10.13)	300 (13.63)	76 (3.61)	1233	18.19	4.97
Ceriodaphnia	164 (4.55)	63 (1.46)	146 (6.95)	128 (4.92)	325 (9.840	300 (6.25)	100 (4.54)	121 (5.76)	1347	19.87	5.43
Chydorus	0	36 (0.83	0	0	0	41 (0.90)	0	0	77	1.13	0.31
Daphnia	20 (0.55)	90 (2.09)	0	0	98 (2.96)	0	0	0	208	3.06	0.83
Diaphanosoma	190 (5.27)	677 (15.74)	104 (4.93)	72 (2.76)	404 (12.24)	466 (10.13)	100 (4.54)	423 (20.14)	2436	35.94	9.82
Kurzia	0	98 (2.27)	19 (0.90)	0	0	16 (0.35)	0	22 (1.04)	155	2.28	0.62
Leydigia	48 (1.33)	38 (0.88)	0	0	244 (7.39)	16 (0.35)	0	33 (1.57)	379	5.59	1.52
Moina	31(0.86)	145 (3.37)	0	147 (5.65)	150 (4.540	0	0	0	473	6.97	1.90
Macrothrix	0	33 (0.76)	36 (1.71	0	0	0	0	0	69	1.01	0.27
Oxyurella	0	19 (0.44)	0	0	0	0	0	0	19	0.28	0.07
Simocephalus	0	0	0	32 (1.23)	96 (2.90)	50 (1.08)	0	0	178	2.62	0.71
Schapholeberis	0	19 (0.44)	0	0	30 (0.90)	16 (0.35)	0	0	65	0.95	0.26

ROTIFERA	Monsoon'03	Post-monsoon'03	Winter'03	Summer'04	Monsoon'04	Post-monsoon'04	Winter'04	Summer'05	Total	% of the class	% of total zoo
Total	**574**	**1440**	305	379	**1537**	**1371**	500	675	**6777**		27.32
COPEPODA											
Diaptomus	573 (15.9)	165 (3.83)	177 (8.42)	73 (2.80)	180 (5.45)	116 (2.5)	433 (19.68)	140 (6.66)	1857	19.77	7.56
Heliodiaptomus	439 (12.19)	435 (12.0)	156 (7.42)	62 (2.38)	213 (6.45)	316 (6.86)	67 (3.04)	110 (5.2)	1798	19.14	7.25
Neodiaptomus	416 (11.5)	116 (3.22)	113 (5.38)	43 (1.60)	62 (1.87)	116 (2.5)	133 (6.04)	44 (2.09)	1043	11.10	4.20
Specodiaptomus	87 (2.41)	0	24 (1.14)	0	61 (1.84)	0	0	0	172	1.83	0.69
Cyclops	657 (18.25)	194 (4.50)	239 (11.38)	241(9.26)	196 (6.0)	368 (8.0)	0	260 (12.38)	2155	22.94	8.68
Mesocyclops	244 (6.77)	401 (11.13)	147 (7.93)	382 (14.70)	31 (0.93)	134 (2.91)	0	164 (7.80)	1503	16.00	6.06
Macrocyclops	84 (2.33)	341 (7.93)	85 (4.04)	114 (4.38)	0	100 (2.17)	0	0	724	7.70	2.91
Microcyclops	0	30 (0.70)	0	104 (4.0)	0	0	0	0	134	1.42	0.54
Total	**2500**	**1682**	**941**	**1019**	**749**	**1150**	**633**	**718**	**9392**		**37.87**
OSTRACODA											
Cypris	42 (1.16)	15 (0.340)	150 (7.14)	50 (1.92)	10 (0.30)	0	125 (5.68)	22 (1.04)	414	26.86	1.66
Heterocypris	0	0	50 (2.38)	0	0	0	25 (1.13)	30 (1.42)	105	6.81	0.42
Centrocypris	18 (0.50)	0	0	25 (0.96)	0	15 (0.23)	0	145 (6.90)	203	13.17	0.81
Stenocypris	0	8(0.18)	0	0	0	0	25(1.31)	0	33	2.14	0.13
Cypria	10 (0.27)	0	32 (1.52)	0	0	0	0	0	42	2.72	0.16
Eucypris	0	40 (0.95)	322 (15.06)	174 (6.68)	20(0.60)	15(0.23)	25 (1.13)	125 (5.94)	741	48.06	2.97
Total	**90**	**63**	**554**	**249**	**30**	**30**	**200**	**322**	**1541**		**6.21**
CRUSTACEAN LARVAE	124 (3.44)	445 (10.34)	218 (10.38)	42 (1.61)	97 (2.93)	700 (15.2)	150 (6.81)	110 (5.23)	1892		7.62
Grand Total	**3600**	**4300**	**2100**	**2600**	**3300**	**4600**	**2200**	**2100**	**24800**		**100.00**

Appendix Table V: Seasonal Abundance, Minimum, Maximum and Mean of Different Phytoplankton (units/l) Classes in the Posna Beel during the Investigation Period from August 2003 to April 2005.

Phytoplankton Classes	2003-2004				2004-2005				Mini	Maxi	Mean ±SD	Range
	Monsoon'3	Post-. monsoon'03	Winter'03	Summer'04	Monsoon'04	Post-monsoon'04	Winter'04	Summer'05				
Chlorophyceae	1606	2030	872	1010	1230	2433	13900	12615	872	13900	5712±5847	17,172
Cyanophyceae	2661	279	802	279	2072	3725	200	298	200	3725	1289±1356	3947
Bacillariophyceae	1045	1606	758	237	520	1603	0	1228	00	1606	875±601	2053
Euglenophyceae	381	757	190	463	196	798	67	102	67	798	370±285	929
Dinophyceae	0	0	150	0	322	1767	79066	0	00	79066	12699±27713	67,016
Unidentified	104	500	27	47	160	374	0	57.	00	500	159±182	516
Grand Total	**5800**	**7800**	**2800**	**2000**	**4500**	**10700**	**93233**	**14300**	**200**	**93233**	**17642±30818**	**78,045**

Appendix Table VI: Seasonal Abundance, Minimum, Maximum and Mean of Different Zooplankton (units/l) Group in the Posna Beel during the Investigation Period from August 2003 to April 2005.

Zooplankton Group	2003-2004				2004-2005				Mini	Maxi	Mean ±SD	Range
	Monsoon'03	Post-monsoon' 03	Winter'03	Summer'04	Monsoon'04	Post-monsoon' 04	Winter' 04	Summer' 05				
Rotifera	312	664	82	911	891	1346	717	275	82	1346	650±413	1460
Cladocera	574	1440	305	374	1533	1371	500	675	305	1533	847±513	1852
Copepoda	2500	1682	941	1019	749	1150	633	718	633	2500	1174±630	2408
Ostracoda	90	63	554	249	30	33	200	322	30	554	193±181	548
Crustacean larvae	124	451	218	42	97	700	150	110	42	700	237±225	678
Grand Total	3600	4300	2100	2600	3300	4600	2200	2100	2100	4600	3100±1003	5066

Appendix Table VII: Total Plankton in the Posna Beel during the Study Period from August 2003 to April 2005.

Plankton	Seasonal Abundance								Total	%	PP : ZP
	Monsoon' 03	Post-monsoon'03	Winter'03	Summer'04	Monsoon'04	Post-monsoon'04	Winter' 04	Summer'05			
Phytoplankton	5800	7800	2800	2000	4500	10700	93233	14300	141133	85.05	5.7: 1
Zooplankton	3600	4300	2100	2600	3300	4600	2200	2100	26800	14.95	

Appendix table VIII: Species and Month-wise Fish Catch (Kg) of Posna Beel during the Year 2003 and 2004.

Scientific Name	2003												2004													
	Jan	Feb	Mar	Ap	May	Ju	Jy	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Ap	May	Ju	Jy	Aug	Sep	Oct	Nov	Dec	Total	% of total catch
Xenentodon cancila (Hamil)	0	10	34	27	10	3	16	7	7	18	12	7	48	81	42	68	0	5	0	33	0	0	0	3	431	1.16
Channa punctatus (Bloch)	88	233	101	289	65	46	137	53	59	89	404	160	159	164	147	205	9	52	19	8	0	0	49	219	2755	7.41
C. striatus (Bloch)	103	80	49	259	91	0	0	0	9	14	208	83	1485	128	93	108	0	7	15	0	0	0	48	348	3128	8.41
Rasbora danicunius (Hamil)	0	20	56	10	2	7	15	11	12	11	9	10	0	7	17	0	6	0	24	16	0	0	0	8	241	0.65
Puntius tickto (Hamilton)	0	99	29	38	0	0	0	0	0	0	0	30	3	23	35	38	3	11	0	14	4	0	0	35	362	0.97
P. sophore (Hamilton)	14	85	66	110	51	47	75	55	60	56	221	1132	106	138	96	181	12	32	102	60	139	164	174	216	3392	9.12
P. conchonius (Hamilton)	11	61	36	104	50	24	55	53	48	61	139	63	0	0	30	0	0	0	0	0	142	40	215	79	1211	3.25
P. stigma (Hamilton)	9	12	7	3	0	0	0	8	1	2	9	17	54	52	50	65	0	0	19	24	50	69	65	116	362	0.92
P. sarana (Hamilton)	0	0	6	5	9	0	38	22	33	31	0	4	0	0	0	0	0	0	0	0	0	164	426	220	958	2.57
Labeo rohita (Hamilton)	0	21	0	8	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	320	163	388	635	1553	4.17
Catla catla (Hamilton)	0	39	61	16	9	10	14	9	8	11	13	10	53	10	11	0	0	0	0	0	0	0	196	276	746	2.00
Cirhina mrigel (Hamilton)	0	43	37	17	2	14	14	10	11	14	14	11	59	72	44	16	0	0	44	106	117	60	280	207	1192	3.20
Hypothalmicthys molitrix (Valeneienes)	0	0	0	15	0	0	0	0	16	58	0	52	31	0	0	6	0	0	0	117	0	0	0	0	295	0.80
Ctenopharyngodon idella (Valeneienes)	0	71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	71	0.19
Cyprinus carpio (Linnaeus)	159	0	0	0	0	0	0	0	0	0	0	60	0	0	0	0	0	0	0	0	0	0	256	219	694	1.86

Scientific Name	2003												2004													
	Jan	Feb	Mar	Ap	May	Ju	Jy	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Ap	May	Ju	Jy	Aug	Sep	Oct	Nov	Dec	Total	% of total catch
Chela laubuca (Hamil)	0	0	0	0	4	0	3	4	0	9	0	9	0	0	0	0	0	0	0	7	0	0	0	16	52	0.14
Amplyphyrngodon mola (Hamilton)	0	0	0	11	6	0	22	7	5	18	11	14	3	0	0	4	0	0	9	7	0	0	0	34	151	0.40
Lepidocephalus guntea (Ham)	0	22	46	78	12	14	47	16	10	29	17	19	1	26	47	51	8	23	22	12	0	0	0	30	530	1.42
Cirrhina raba (Hamilton)	31	172	124	156	0	0	48	0	40	46	7	91	107	50	23	20	0	0	28	30	0	0	0	0	973	2.61
Gudusia chapra (Hamil)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	42	50	0.13
Mystus bleekeri (Day)	2	10	31	28	4	51	9	0	0	14	4	211	45	96	22	69	10	4	32	1	13	0	15	47	718	1.93
M. vittatus (Bloch)	11	15	12	57	19	0	39	3	19	10	69	614	15	29	22	19	10	4	32	1	13	0	15	47	1053	2.83
Wallago attu (Bloch)	0	23	41	95	0	0	0	0	0	0	0	42	9	90	13	0	0	0	0	0	0	0	87	55	455	1.21
Chaca chaca (Hamilton)	0	0	0	5	4	0	3	4	0	9	0	9	0	0	298	0	0	0	0	0	0	0	0	4	336	0.90
Ompok pabda (Hamilton)	0	5	9	26	23	0	38	22	33	31	0	0	5	5	11	61	0	6	4	0	0	0	1	8	288	0.77
Ompok bimaculatus (Bloch)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Clarias batrachus (Bloch)	0	0	49	61	0	0	0	0	0	0	134	5	0	15	0	0	10	0	0	0	0	0	0	20	294	0.80
Hetropnuestes fossilis (Bloch)	91	283	129	211	41	26	68	78	83	113	400	45	65	38	125	199	17	49	45	51	133	61	101	141	2591	6.97
Batasio tengra (Hamilton)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5	0.01
Chanda ranga (Hamilton)	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0.01
C. nama (Hamilton)	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	10	0.01
C. baculis (Hamilton)	0	11	38	35	9	10	18	12	2	21	7	24	7	21	37	34	5	4	28	36	4	8	5	21	397	1.06
Anabas testidineus (Bloch)	43	146	64	116	69	0	44	38	85	81	405	82	154	65	124	204	0	0	0	13	92	36	151	212	2224	5.98
Badis badis (Hamilton)	0	6	18	10	0	3	3	3	10	5	10	68	0	6	6	2	1	6	7	0	0	0	0	14	128	0.34
Nandus nandus (Hamilton)	41	94	76	211	66	49	7	66	80	135	389	81	182	188	149	196	1	18	91	78	120	175	165	165	2823	7.60
Glossogobius guiris (Hamil)	0	8	61	84	28	20	48	3	15	48	21	25	5	19	69	92	10	8	33	0	0	0	0	47	644	1.73
Colisa fasciatus (Bloch)	14	44	23	78	8	27	13	24	34	11	75	12	35	48	38	59	0	15	22	30	55	23	76	91	855	2.30
C. chuna (Hamilton)	0	47	42	48	11	12	14	8	9	12	9	22	2	18	34	49	6	13	19	12	6	18	2	34	447	1.20
Mastacembelus armatus	0	0	0	10	15	0	0	0	0	0	0	0	10	25	35	0	0	0	0	0	0	0	0	0	95	0.25

Scientific Name	2003												2004													
	Jan	Feb	Mar	Ap	May	Ju	Jy	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Ap	May	Ju	Jy	Aug	Sep	Oct	Nov	Dec	Total	% of total catch
(Lecepede)																										
M. pancalus (Hamilton)	2	48	91	125	0	15	22	30	55	23	76	91	6	22	59	75	18	34	54	19	17	34	25	37	978	2.63
Macrognathus aculeatus (Bloch)	11	4	0	0	0	0	12	38	0	30	169	0	0	0	12	175	0	0	0	49	37	0	0	4	541	1.45
Tetradon potka (Hamilton)	0	0	0	1	5	17	9	0	0	14	4	183	12	28	19	32	3	8	9	0	0	2	2	30	378	1.01
Notopterus notopterus (Pallas)	116	166	108	242	57	0	37	0	13	40	82	78	103	46	66	15	0	0	28	103	0	0	0	0	1300	3.50
Macrobrachium birmanicus (Shenkel)	0	25	48	43	14	11	15	8	21	21	23	19	103	46	66	15	0	0	0	28	103	0	0	0	609	1.63
M. villossimanus (Tiwari)	0	25	26	25	0	8	15	10	12	21	11	11	0	0	2	30	0	0	0	0	0	0	0	10	215	0.57
M. malcomsonii (H.edwards)	0	51	54	46	0	0	0	10	0	11	0	11	0	10	19	12	5	10	21	10	6	39	0	39	344	0.92
M. lammarei (H.edwards)	0	0	0	0	0	0	0	0	0	0	0	0	0	9	16	10	4	9	11	15	4	26	0	16	120	0.32
Monthly total with	746	1981	1585	2703	693.	414	898	602	790	1117	2952	3355	2885	1575	1855	2110	138	318	726	880	1380	1082	2742	3642	37169	100%
% of fish catch	2.00	5.33	4.26	7.27	1.86	1.11	2.41	1.61	2.12	3.01	7.94	9.02	7.76	4.23	5.00	5.67	0.37	0.85	1.92	2.36	3.71	2.91	7.37	9.79		
Annual fish catch	17836												19333													
% of annual fish catch	47.99%												52.01%													

Appendix Table IX: Correlation Coefficient (r) among Physico- Chemical Variables of Water, and Plankton (both phytp and zoo)

Parameters	T°C	Trans	TS	pH	CO_2	Alk.	DO	Sat. O_2	BOD_5	COD	Eh	rH_2	TH	Cl^-	NH_3	NO_3	PO_4	PP	ZP
T°C	1.000	-.626	.929**	-.005	.366	-.915**	-.713*	.462	.556	.708*	-.202	-.195	.531	-.296	.103	-.047	.198	-.426	.461
Trans		1.000	-.685	.325	-.361	.592	.379	-.592	-.723*	-.819*	.006	.127	-.412	-.307	-.143	-.121	-.648	-.018	-.260
TS			1.000	.168	.214	-.948**	-.475	.689	.519	.633	-.450	-.277	.429	-.288	.291	.104	.166	-.525	.549
pH				1.000	-.308	-.216	.119	.124	-.129	-.338	-.888*	.154	-.546	-.792*	.341	.490	-.834*	-.224	.615
CO_2					1.000	-.297	-.612	-.206	.682	.404	.219	.461	-.003	.169	.020	-.298	.290	.269	.220
Alk						1.000	.533	-.557	-.485	-.623	.386	.042	-.293	.299	-.211	.110	-.095	.591	-.653
DO							1.000	-.053	-.459	-.453	-.122	-.072	-.421	.358	-.118	.083	.027	-.018	-.489
Sat. O_2								1.000	.027	.173	-.419	-.640	.513	-.097	.695	.239	.124	-.552	.467
BOD_5									1.000	.819*	-.112	.357	-.050	.122	-.174	.190	.438	.367	.194
COD										1.000	.129	.156	.267	.259	-.378	-.069	.652	.059	.072
Eh											1.000	.084	.340	.675	-.486	-.636	.575	.257	-.591
rH_2												1.000	-.771*	.103	-.432	-.254	-.081	.390	.155
TH													1.000	.089	.210	-.152	.403	-.353	-.098
Cl^-														1.000	-.351	-.457	.857**	.231	-.601
NH_3															1.000	.303	-.358	-.307	.623
NO_3																1.000	-.351	.397	.170
PO_4																	1.000	.117	-.481
PP																		1.000	-.337
ZP																			1.000

** = Correlation is significant at the 0.01% level.
* = Correlation is significant at the 0.05% level.

Appendix Table X: Correlation coefficients among the Physico-chemical Variables of Sediment and Plankton (both phyto and zoo).

Parameters	pH	Organic Matter	Total Nitrogen	Phosphorus	Potassium	Sulfur	Sodium	Calcium	Magnesium	Boron	Copper	Iron	Manganese	Zinc	Phytoplankton	Zooplankton
PH	1.00															
Organic mat	-.046	1.00														
Total Nitrogen	.903	.387	1.00													
Phosphorus	.159	.979	.567	1.00												
Potassium	-.856	-.476	-.995	-.646	1.00											
Sulfur	.666	.715	.921	.843	-.955	1.00										
Sodium	-.769	-.604	-.969	-.754	.989	-.989	1.00									
Calcium	.999*	-.097	.880	.108	-.829	.627	-.735	1.00								
Magnesium	.676	-767	.295	-.620	-.198	-.100	-.048	.713	1.00							
Boron	.102	.989	.519	.998*	-.601	.810	-715	.051	-.664	1.00						
Copper	-.453	-.870	-.791	-.952	.848	-.967	.918	-.406	.351	-.933	1.00					
Iron	.316	.933	.692	.987	-.761	.918	-.850	.267	-.485	.976	-.989	1.00				
Manganese	.863	.465	.996	.637	1.00**	.952	-.987	.836	.210	.591	-.841	.753	1.00			
Zinc	-.250	.979	.189	.916	-.286	.556	-.427	-.300	-.883	.938	-.750	.839	.274	1.00		
Phytoplankton	.693	-.752	.317	-.602	-.221	-.077	-.071	.976	1.00*	-.646	.329	-.465	.233	-.871	1.00	
Zooplankton	.964	-.311	.756	-.111	-.687	.442	-.569	.729	.848	-.167	-.198	.051	.696	-.500	.861	1.00
Fish Production	-.995	-.058	-.943	.261	.905	-.740	.831	-.988	-.596	-.205	.543	-.413	-.911	.148	.572	-.255

** = Correlation is significant at the 0.01% level.
* = Correlation is significant at the 0.05% level.

Appendix XI

Questionnaire for Agro-chemical Use

Posna Beel Project under CBFM-2

1. Name: **2. Age:** **3. Profession:**
4. Village: **5. UP** **6.Thana:**
7. Interviewer's name: **8.Interview date:**
9.Cultivated land (acre): **10. HYV Boro Field (Acre):**

11. Fertilizer use:

(a) Urea (Kg./Acre)
(b) Potas (Kg./Acre)
(c) TSP. (Kg./Acre)
(d) Gypsum (Kg./Acre)
(e) Others

12. Organic manure:

(a) Cow dung (Kg./Acre)
(b) Compost (Kg./Acre)
(c) Others

13. Pesticide use (Kg. or L /Acre):

(a) Dimecron
(b) Diazinon
(c) Basudin
(d) Carbaryl
(e) Others

14. Do you know about the proper application and dosing of agrochemicals?

Yes / No

15. Do you interested to learn the proper application and dosing the agrochemicals?

Yes/ No.

16. Do you know about the integrated pest management (IPM)?

Yes/ No.

17. Do you interested to learn the integrated pest management technique (IPM)?

Yes/ No.

18. What are the causes of water pollution of the Posna Beel?

(a) Fertilizer
(b) Pesticide
(c) Household wastes
(d) Decomposition of organic matters
(e) Decomposition of organic weeds
(f) Others