ENVIRONMENTAL IMPACT ASSESSMENT STUDY REPORT ON RABINDRA SAROBAR LAKE PREMISES, KOLKATA

FINAL REPORT

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Acknowledgement

The West Bengal Pollution Control Board wishes to thank the Hon'ble NGT (EZ) for constituting a five member committee consisting of eminent scientists and engineers to study and submit a report on the probable impact of the activities in the Rabindra Sarovar stadium during the nights, connected with ISL matches, on "physical environment", "biodiversity of the lake environment" and on the survivability scope of the migratory birds and required preventive measures.

The West Bengal Pollution control Board extends heartiest thanks to the expert committee members, constituted to undertake Rapid EIA study in the Rabindra Sarovar: Dr. A.K. Sanyal, Chairman, WBBB (Chairman of the Expert Committee), Dr. Ujjal Kumar Mukhopadhyay, Chief Scientist, WBPCB, Dr. Anirban Roy, Research Officer, WBBB , Dr. Rajib Gogoi, Scientist-D, BSI, Kolkata, Dr. Rita Saha, Scientist-D, CPCB, Kolkata Regional Office, Dr. Deepanjan Majumdar, Sr. Scientist, NEERI, Dr. S.I. Kazmi, Scientist, ZSI, Kolkata and Mr. Ashoke Kumar Das, Secretary, KIT, Kolkata (Convenor).

The background information and Literature survey provided by West Bengal Biodiversity Board and Botanical Survey of India were intently helpful to prepare this " EIA Report of Rabindra Sarovar, Kolkata ". This could not have been possible to prepare and publish this without their great help.

We are also thankful to the team from the West Bengal Biodiversity Board for visiting Rabindra Sarobarlake and premises and contributed their effort & energy to prepare general biodiversity documentation, one of the essential source for this report, with their expertise.

The West Bengal Pollution Control Board wishes to acknowledge the assistance provided by the Kolkata Improvement Trust For providing boat to collect water samples; CAL Herbarium for identification of aquatic macrophytes; Central National Herbarium (CNH, BSI, Howrah) for Macromorphological characterization; Zoological Survey of India, Kolkata for identification of insects; CSIR-NEERI for first initiation of the noise monitoring exercise and the team of West Bengal pollution Control Board for sound monitoring exercise.

Dr.Kalyan Rudra

Chief Editor

1.0. INTRODUCTION

1.1. Background of the rapid EIA study

With reference to the case no. O.A. 136/2016/EZ filed by Subhash Dutta-Vs-State of West Bengal & Ors., the Hon'ble NGT (EZ) constituted a five member committee consisting of eminent scientists and engineers to study and submit a report on the probable impact of the activities in the Rabindra Sarovar stadium during the nights connected with ISL matches, on physical environment, biodiversity of the lake environment and the migratory birds and the preventive measures. In compliance to the above, the committee submitted its report on 26.09.2016. The committee in the report agreed with the applicant that an Environmental Impact Assessment study in the lake area would be needed to frame regulations in respect of ISL matches in the Sarovar Stadium. The Hon'ble NGT in its order mentioned, "However, whether or not such event should be allowed in future shall be finally decided after we receive further inputs and report of the EIA studies which we shall direct later".

In pursuance of the order of the Hon'ble Tribunal passed in O.A. No. 136/2016/EZ dated 12.01.2017 as mentioned above, the Registrar NGT (EZ) convened a consultative meeting on 16.01.2017 with the Chairman West Bengal Biodiversity Board; Chairman, West Bengal Pollution Control Board; Director, Zoological Survey of India; Director, Botanical Survey of India; Head, Regional Office, Central Pollution Control Board; Head, Regional Office, National Environmental Engineering Research Institute, Kolkata; Secretary, Kolkata Improvement Trust, Kolkata and Mr. Subhash Dutta. In view of the above, an expert committee was constituted to undertake Rapid EIA study in the Rabindra Sarovar, with the following members.

1. Dr. A.K. Sanyal, Chairman, WBBB (Chairman of the Expert Committee)
2. Dr. Ujjwal Kumar Mukhopadhyay, Chief Scientist, WBPCB
3. Dr. Anirban Roy, Research Officer, WBBB
4. Dr. Rajib Gogoi, Scientist-D, BSI, Kolkata
5. Dr. Rita Saha, Scientist-D, CPCB, Kolkata Regional Office
6. Dr. Deepanjan Majumdar, Sr. Scientist, NEERI
7. Dr. S.I. Kazmi, Scientist, ZSI, Kolkata
8. Mr. Ashoke Kumar Das, Secretary, KIT, Kolkata (Convenor)

1.2. The terms of Reference

(I) The area of studies has been set out as under:

1. Listing of plant and animal species from the aquatic body (both from primary and secondary sources).
2. List of plant (Tree, shrub and herbs) and animal species from the land (both from primary and secondary sources).
3. Listing of migratory birds and animals (both from primary and secondary sources).

4. Classification of existing animals and plants according to "schedule" under Wild Life Protection Act, 1972.
5. Ambient Air Quality monitoring including noise level.
6. Water quality based on CPCB classification of "designated best use".
7. Nutrients (Phosphate, Nitrate) and heavy metals (Hg, As, Cd, Pb) quantity in the water.
8. Lake sediment characteristics including (Phosphate, Nitrate) lead and heavy metals (Hg, As, Cd, Pb) quality.
9. Trophic status of the lake (to find out whether the lake is in Oligotrophic, Mesotrophic or Eutrophic stage based on qualitative (colour, presence of hydrophytes) and quantitative (oxygen profile, algal diversity and dominance) studies.
10. Methodology for collection of samples (minimum No. of samples and sampling locations) and analysis will be decided by the Committee.

(II) Impact Assessment:

Probable impact on ecology, biodiversity and pollution of the Rabindra Sarobar lake environment due to anthropogenic activities undertaken in Rabindra Sarobar lake and stadium, such as organization of mega events like cricket and football matches with bursting of fire crackers and emission of high intensity noise, night lighting, organizing Chat Puja and picnic parties, activities of various clubs existing in the premises, movement of large number of vehicles in the park area etc.

2.0. STUDY AREA

❖ Rabindra Sarobar

Rabindra Sarobar, a lake of national importance is the second largest water body in Kolkata and situated in the southern part of the city (22°30′.30″ -22°30′.42″ N, 88°21′-88°22′ E). Rabindra Sarobar and its vicinity is a heaven for floristic diversity, both aquatic and terrestrial that provides a natural CO_2 sink of the metropolitan city, aparts from its pristine beauty and aesthetic value. It also serves as suitable habitat for a variety of amphibians, fishes, reptiles, waterfowls and migratory birds.

Rabindra Sarovar

The story of the gradual transition of the Dhakuria Lakes park and recreation grounds from a malarious marshy jungle, is too long to recount in detail here, but it is of great interest nevertheless, and is outstanding evidence of the success that can be made of any site, however unattractive and seemingly impossible of improvement it may appear in its original state. The excavations here were carried out to a pre-conceived plan with the object of creating ornamental lakes after the excavation works was finished. While this work was in progress the sections reserved for park land and playing fields were being raised and leveled and extensive tree planting, under the supervision of the Director of the Calcutta Horticultural Society, was simultaneously undertaken. Blocks of earth were left undisturbed in the centre of the excavations and the tops were raised and planted with trees and flowering shrubs. These earth blocks are now islands, and are extremely attractive features in the Lakes. Another form of ornamentation has been the mounting of old cannon found during the course of the Trust's operations thorough out Calcutta. A tablet has been fixed at each emplacement giving details of the sites where these ancient weapons were discovered.

The area around this excavated lake was later developed to build recreational complexes, which included children' parks, gardens and auditoria.

Today the lake and its surrounding areas are one of the most popular recreational areas in Kolkata. Around 38% of the total area (73 acres) constitutes the water body while the residual area comprises of varieties of plant/tree species some of which are century old. It is surrounded by Southern Avenue to the north, Russa Road to the west, Dhakuria to the east, and the Kolkata Sub-urban Railway track to the south. The area has a humid tropical climate with a maximum temperature of 40˚C and a minimum temperature of 10˚C. There are four islands inside the lake, one of which is connected to the shore by a hanging bridge and harbours a Masjid. Rest of the three islands are uninhabited and forms important roosting and nesting grounds for resident water birds like Cormorants, Egrets, Night Herons, Pond Herons, Painted Storks, Asian Openbill, etc. A partial tree census in 2012 recorded 50 different species. In the winter, one can spot some migratory birds around the lake, though the numbers are dwindling because of the rise in pollution level. Some parts of the wetland have emergent and floating vegetation like Lotus (*Nelumbo nucifera*), Sushnishak (*Marsilea minuta*), Hingcha (*Enhydra fluctuans*), Water Chestnut

(*Trapa natans*), Borati (*Panicum paludosum*), Kachu (*Colocasia esculenta*), *Hydrilla verticillata, Vallisneria spiralis, Pistia stratiotes, Lemna perpusilla, Salvinia molesta, Spirodela polyrhiza, Azolla pinnata* etc. There is seasonal invasion of Water-hyacinth (*Eichhornia crassipes*) as well that has to be removed every year.The lake itself is home to many varieties of fish. Fishing is strictly prohibited. In 2012 an abandoned water house in the premises of lake turned into a museum run by Kolkata Improvement Trust as a gallery for installation art, locally called as "thakur-der gallery" - a place for some of the award-winning Durga idols of Kolkata.

A number of people come for a walk around the lake in the mornings to enjoy the fresh air. Many visit the sunrise point to offer their prayers to the sun. During the day, it is visited by families on a picnic, tourists, young lovers and joggers.

The transition of Dhakuria lakes to parks and recreation grounds from a situation seemingly impossible of improvement being malariously marshy to its present state of sylvan retreat represented sustained supervision and maintenance: known as Rabindra Sarobar, today it represents the lungs of South Calcutta with massive environmental fillip of extensive tree planting carried out under the supervision of the Calcutta Horticultural Society.

The provision made for sport and recreation at the Dhakuria Lakes includes a large open air swimming pool ,three full size football grounds and an athletic ground laid out and equipped for high and long jumps, running track, and 'Putting the shot'. Two playgrounds for children have also been laid out and are equipped with shelters, swings, sides and so on, but the most popular feature in the summer time in these children's grounds are the bathing pools.

The present scenerio of the Recreation space is as follows:

- A Stadium with a seating capacity of 30,000 persons enclosing a football ground as well as Athletic and Cycle tracks together.
- Land on the banks of the main Lake leased out from as far back as 1937 to several rowing clubs e.g. Calcutta, Lake, University, Bengal Club, N.C.C. Naval Cadets.
- Land leased to different swimming clubs, viz, Indian Life Saving Society, Calcutta Sports Association, Lake Friends to promote swimming besides a public swimming pool of the C.I.T.
- Two Children's Parks within the area providing for seesaws, swings, etc. besides a Lily Pool on the south bank including a miniature zoo.
- Two football grounds and one hockey ground in addition to the football ground within the Stadium.
- A fish sanctuary under the hanging bridge leading to the Mosque.
- An auditorium with 625 seats.
- Open air Theatre being constructed with funds being provided by 'Bengal Chamber of Commerce'.

In pre-Independence days with less than one acre per one thousand populations the city fell far below the standard of 7 acres per one thousand populations for public open space and recreation grounds. The maidan which was the main lungs of the city served at that time only a very limited population. Recreation space outside the city proper was then being represented by

Shibpur gardens and a portion of Barrackpore Park. After Independence the objectives of C.I.T. were therefore identified, among other things, as:

(i) Construction of parks and playgrounds within the municipal area;
(ii) Provision for public resort or picnic spots with planned landscape outside the municipal area (if feasible by extending the provisions of the Act under Sections 1(3) & 147 of the C.I. Act.)

For the first objective, schemes were framed for combining bustees clearance and rehousing with provision of playgrounds being made on bustee sites. The C.I.T. was in fact adding one or two small playgrounds almost every year prior to the outbreak of the Second World War. But the need for looking further afield in the neighbourhood of Calcutta for creation of spots of scenic beauty was clearly urgent.

The following gradual developments shaped the site into what now is known as Rabindra Sarobar:

- 1926: The cable suspended bridge erected by Burn & Co., Howrah to connect the mosque island with the mainland & strengthened in 1962 by the same Company.
- May 1958: Dhakuria Lakes identified as CIT Scheme LXXIV and renamed as *Rabindra Sarobar* after Kabiguru Rabindra Nath Tagore.
- May 1960: Construction of 26,000 capacity Stadium at the N-W corner
- 1980: Construction of 3,500 capacity OAT.
- 1985-89: Installation and operation of the Toy Train, the tracks of which still circumscribe the lake.
- 1991: Conversion of the OAT into a covered auditorium for the 10th International Film Festival in Kolkata, and named *Nazrul Mancha.*

3.0. Floral Diversity of Rabindra Sarobar and its premises

Flora, the collective plant life naturally occurring in a particular region, is very significant for sustaining ecosystem functioning and maintaining diversity of life as well. Flora includes different taxonomic groups of plants starting from algae to angiosperms and also encompasses the fungi as fungal flora. Actually plant species are the main productive units of the ecosystem and they contribute largely in the functional aspect of the wetlands.

3.1. Materials and Methods

A. Background information/ Literature survey

The background history of undertaking the present study is given above. In this connection, the West Bengal Biodiversity Board and Botanical Survey India were assigned the following works:

1. Listing of plant from aquatic body (both from primary and secondary sources).
2. Listing of plant (tree, shrub and herbs) from the land (both from primary and secondary sources).
3. Classification of existing plants according to "Schedule" under Wild life Protection act, 1972.

Besides, WBBB and BSI have also studied algal diversity in the Lake and macrofungal diversity of the Rabindra Sarobar lake premises. Literature was surveyed for works related to the biodiversity of Rabindra Sarobar lake and its premises through various published digital sources and printed documents.

B. Details of Visits

Team from WBBB visited Rabindra Sarobar lake and premises for general biodiversity documentation on 11th and 12th February, 2017. The tree census was conducted during 16th, 17th and 19th February, 2017, whereas, phytoplankton sampling were conducted on 23rd February, 2017 and 06th March, 2017. The team members of BSI visited Rabindra Sarobar Lake in four occasions' *viz*., 19.01.2017, 28.01.2017, 01.02.2017 and 28.02.2017 to conduct the floristic exploration and survey in the area. On 28.02.2017 the team visited the Island areas and different parts of lake areas. For collection of samples from water, boat was provided by Kolkata Improvement Trust.

Table 3. 1. Area or site wise survey to document the "Floral Diversity in Rabindra Sarobar"

Name of the area/site	Latitude & Longitude	Altitude, a.s.l.
	19.01.2017	
Site 1- Near Stadium	22°30.627'N 88°21.039'E	18 m
Site 2- Towards Railway tract from Stadium	22°30.538'N 88°20.892'E	19 m
Site 3- South end of the stadium	22°30'37.19"N 88°21'9.15"E	20 m

Site 4- Near Railway tract from Stadium	22°30.513'N 88°20.859’E	18 m
Site 5- Near water fountain side	22°30.497'N 88°20.906’E	18 m
28.01.2017		
Site 6- East of Lake garden Flyover side	22°30.517'N 88°21.224’E	15 m
Site 7- Lake garden bridge side	22°30.532'N 88°21.147’E	17 m
Site 8- Railway station side	22°30.506'N 88°21.037’E	17 m
01.02.2017		
Site 9- CSIR Guest house entrance and nearby area	22°30.675'N 88°21.894’E	16 m
Site 10- Side of Najrul Manch	22°30'47.94"N 88°21'48.02"E	17 m
Site 11- East of Lotus Pond area	22°30.686'N 88°21.772’E	17 m
Site 12- Lotus Pond	22°30.729'N 88°21.671’E	18 m
Site 13- Southern bank side	22°30'35.73"N 88°21'38.27"E	17 m
Site 14- Bengal Rowing Club side	22°30'32.21"N 88°21'20.96"E	18 m.
28. 02.2017		
Site 15- 1st Island from Stadium side	22°30.547'N 88°21.045’E	20 m
Site 16- 2nd Island from Stadium side	22°30.671'N 88°21.635’E	19 m
Site 17- 3rd Island from Stadium side	22°30.601'N 88°21.425’E	21 m
Site 18- Northen bank side	22°30'45.29"N 88°21'27.89"E	20 m
Site 19- North western side of Lotus pond	22°30'47.65"N 88°21'36.61"E	20 m

3.2. Algae/ Phytoplankton

a. Sampling sites

Seven sampling sites in various parts of the lake were demarcated from where the samples were collected for qualitative and quantitative estimation of phytoplankton. The periphytic algae on different aquatic macrophytes and other substrata were also collected from various parts of the lake.

b. Quantitative assessment

For quantitative assessment 1 ml concentrated sample was transferred to Sedgwick Rafter Counter and counted the number of individuals/cells of each species in every quadrat. Finally the number of individuals of each species in per liter was calculated. Data analysis was performed in MS Excel.

3.3. Aquatic macrophytes

a. Collection and identification

Aquatic macrophytes were collected randomly during period of study with respective photographs. Specimens were identified with standard literature (Cook, 1996; Prain, 1981) or with consultation in CAL Herbarium.

3.4. Terrestrial plants including macrofungi

a. Collection and identification

***i) Qualitative assessment of* Vascular Plants**

The specimens of terrestrial plants (Pteridophytes, Gymnosperms and Angiosperms) including macrofungi were collected following standard techniques (Jain and Rao, 1977).

Plant specimens are deposited at Central National Herbarium (CAL). The specimens were identified according to standard literature.

***ii) Qualitative assessment of* Macrofungi**

Survey and collection trips were undertaken during dry winter season (January end to mid March-2017). Macromorphological characterization was made based on fresh fruiting bodies both in the field (Rabindra Sarobar) and in the Central National Herbarium (CNH, BSI, Howrah).

***iii) Quantitative assessment :* Tree Census and Mapping**

Quantitative assessment was done by WBBB to prepare species wise numerical distribution map of trees of Rabindra Sarobar. GPS locations were taken on field for demarcating quadrats of size and plotting using Garmin Etrex-20 GPS machine. Subsequently, whole Rabindra Sarobar lake and its premises were marked into 35 sampling areas. Islands were marked separately in order of 1-5. The number of individual(s) of each tree species was/were counted in each sampling area. Mapping was

done with QGIS version 2.14.3 and DIVA GIS version 7.5. Digital image were processed in Photoshop CS5 extended.

3.5. Identification of Scheduled species

Classification of existing plants according to "schedule" under Wild life Protection act, 1972 was verified from website of Ministry of Environment, Forest and Climate Change (http://www.moef.nic.in/legis/wildlife/wildlife2s6.pdf). Rare, Endangered and Threatened (RET) plants available in the study area were checked from "**The IUCN Red List of Threatened species"** (http://www.iucnredlist.org/).

3.6. Observation and Discussion

i) Algae/Phytoplankton

Phytoplankton, photosynthesizing microscopic free-floating organisms that inhabit the upper layer of all ocean and fresh water, is accounted for half of all photosynthetic activity on the earth. Phytoplankton and other algal components are the key sources of primary productivity that maintains the diversity of other animal life and overall health of the lake. The more diversity of phytoplankton in the aquatic system suggests its healthier condition. On the other hand dominance of opportunistic taxa with their blooming indicates the deterioration of the system. In freshwater, the phytoplankton constitutes the members of Cyanophyceae and Chlorophyceae, Euglenophyceae and the groups with siliceous skeletons, such as diatoms. Dinoflagellates, Xanthophytes and Chrysophytes are rather feeble in number in the fresh waters.

Table: 3.2. List of Phytoplankton and algal components of Rabindra Sarobar; (+) indicates presence

Sl. No.	Name	Family	Class	Earlier report	Present study
1	*Achnanthes* sp.	Achnanthaceae	Bacillariophyceae	Khan and Sinha (2002)	(+)
2	*Achnanthidium minutissimum* (Kütz.) Czarnecki	Achnanthaceae	Bacillariophyceae		(+)
3	*Actinastrum hantzschii* Lagerheim	Chlorellaceae	Trebouxiophyceae		(+)
4	*Agmenellum* sp.	Merismopediaceae	Cyanophyceae	Roy et al. (2009)	
5	*Anabaena* sp.	Nostocaceae	Cyanophyceae	Roy et al. (2009); Khan and Sinha (2002)	
6	*Anacystis* sp.	Microcystaceae	Cyanophyceae	Roy et al. (2009); Khan and Sinha (2002)	
7	*Ankistrodesmus convolutus* Corda	Selenastraceae	Chlorophyceae		(+)
8	*Ankistrodesmus* sp.	Selenastraceae	Chlorophyceae	Roy et al. (2009); Khan and Sinha (2002)	
9	*Aphanocapsa conferta* (West & G.S. West) Komárkova –Legnerová & Cronberg	Merismopediaceae	Cyanophyceae		(+)
10	*Aphanocapsa* sp.1	Merismopediacea	Cyanophyceae		(+)

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11	*Aphanocapsa* sp.2	Merismopediaceae	Cyanophyceae		(+)
12	*Aphanocapsa castagnei* (Kützing) Rabenhorst	Merismopediaceae	Cyanophyceae		(+)
13	*Aphanothece* sp.	Aphanothecaceae	Cyanophyceae		(+)
14	*Calothrix* sp.	Rivulariaceae	Cyanophyceae	Roy et al. (2009)	
15	*Caloneis* sp.	Naviculaceae	Bacillariophyceae	Khan and Sinha (2002)	
16	*Characiopsis columnaris* Pascher	Characiopsidaceae	Xanthophyceae		(+)
17	*Chara* sp.	Characeae	Charaophyceae	Khan and Sinha, 2002	
18	*Chlorella* sp.	Chlorellaceae	Trebouxiophyceae		(+)
19	*Chlorococcum* sp.	Chlorococcaceae	Chlorophyceae		(+)
20	*Chlamydomonas* sp.	Chlamydomonadaceae	Chlorophyceae		(+)
21	*Chodatella* sp.	Oocystaceae	Trebouxiophyceae		(+)
22	*Chodatella ciliata* (Lagerheim) Lemmermann	Oocystaceae	Trebouxiophyceae		(+)
23	*Chroococcus* sp.	Chroococcaceae	Cyanophyceae		(+)
24	*Cladophora glomerata* (L.) Kütz.	Cladophoraceae	Chlorophyceae		(+)
25	*Closteriopsis* sp.	Chlorellaceae	Trebouxiophyceae	Roy et al. (2009)	
26	*Closterium* sp.	Desmidiaceae	Conjugatophyceae (Zygnematophyceae)		
27	*Cosmarium* sp.	Desmidiaceae	Conjugatophyceae (Zygnematophyceae)	Roy et al. (2009); Khan and Sinha (2002)	(+)
28	*Crucigenia* sp.	Trebouxiophyceae incertae sedis	Trebouxiophyceae		(+)
29	*Cocconeis* sp.	Cocconeidaceae	Bacillariophyceae	Roy et al. (2009); Khan and Sinha (2002)	
30	*Coscinodiscus* sp.1	Coscinodiscaceae	Coscinodiscophyceae		(+)
31	*Coscinodiscus* sp. 2	Coscinodiscaceae	Coscinodiscophyceae		(+)
32	*Coscinodiscus* sp. 3	Coscinodiscaceae	Coscinodiscophyceae		(+)
33	*Cyclotella* sp.	Stephanodiscaceae	Mediophyceae	Khan and Sinha (2002)	(+)
34	*Denticula* sp.	Bacillariaceae	Bacillariophyceae	Khan and Sinha (2002)	
35	*Diatoma* sp.	Tabellariaceae	Bacillariophyceae	Roy et al. (2009)	
36	*Dispora* sp.	Coccomyxaceae	Chlorophyceae		(+)
37	*Encyonema caespitosum* Kütz.	Gomphonemataceae	Bacillariophyceae		(+)
38	*Encyonema minutum* (Hilse) D.G. Mann	Gomphonemataceae	Bacillariophyceae		(+)
39	*Euglena* sp. 1	Euglenaceae	Euglenophyceae	Roy et al. (2009); Khan and Sinha (2002)	(+)

40	*Euglena* sp. 2	Euglenaceae	Euglenophyceae		(+)
41	*Euglena* sp. 3	Euglenaceae	Euglenophyceae		(+)
42	*Euglena* sp. 4	Euglenaceae	Euglenophyceae		(+)
43	*Fragilaria* sp.	Fragilariaceae	Bacillariophyceae	Khan and Sinha (2002)	(+)
44	*Golenkinia* sp.	Neochloridaceae	Chlorophyceae		(+)
45	*Gloeocapsa* sp.	Microcystaceae	Cyanophyceae		(+)
46	*Gomphonema clavatum* Ehrenb.	Gomphonemataceae	Bacillariophyceae		(+)
47	*Gomphonema olivaceum* (Hornemann) Bréb.	Gomphonemataceae	Bacillariophyceae		(+)
48	*Gomphonema* sp.	Gomphonemataceae	Bacillariophyceae		(+)
49	*Gonium* sp.	Goniaceae	Chlorophyceae		(+)
50	*Grammatophora* sp.	Grammatophoraceae	Bacillariophyceae	Khan and Sinha (2002)	
51	*Heteroleibleinia epiphytica* Komárek	Heteroleibleinaceae	Cyanophyceae		(+)
52	*Hydrodictyon reticulatum* (Linnaeus) Bory	Hydrodictyaceae	Chlorophyceae	Roy and Banerjee (1998); Roy et al. (2009)	(+)
53	*Kirchneriella* sp.	Selenastraceae	Chlorophyceae		(+)
54	*Korshikoviella limnetica* (Lemmermann) P.C.Silva	Characiaceae	Chlorophyceae		(+)
55	*Lyngbya majuscula* Harvey ex Gomont	Oscillatoriaceae	Chlorophyceae		(+)
56	*Lyngbya* sp.	Oscillatoriaceae	Cyanophyceae	Roy et al. (2009); Khan and Sinha (2002)	(+)
57	*Merismopedia punctata* Meyen	Merismopediaceae	Cyanophyceae		(+)
58	*Merismopedia convoluta* Brébisson ex Kützing	Merismopediaceae	Cyanophyceae		(+)
59	*Merismopedia elegans* A.Braun ex Kützing	Merismopediaceae	Cyanophyceae		(+)
60	*Merismopedia glauca* (Ehrenberg) Kützing	Merismopediaceae	Cyanophyceae		(+)
61	*Melosira* sp.	Melosiraceae	Coscinodiscophyceae		(+)
62	*Mougeotia* sp.	Zygnemataceae	Conjugatophyceae (Zygnematophyceae)	Roy et al. (2009)	
63	*Navicula digitulus* Hust.	Naviculaceae	Bacillariophyceae		(+)
64	*Navicula* sp.	Naviculaceae	Bacillariophyceae	Roy et al. (2009); Khan and Sinha (2002)	(+)
65	*Nitzschia sigmoidea* (Nitzsch) W. Sm.	Bacillariaceae	Bacillariophyceae		(+)
66	*Nitzschia* sp.	Bacillariaceae	Bacillariophyceae	Roy et al. (2009); Khan and Sinha (2002)	
67	*Nostoc* sp.	Nostocaceae	Cyanophyceae	Roy et al. (2009); Khan and Sinha (2002)	
68	*Oscillatoria* sp.	Oscillatoriaceae	Cyanophyceae	Datta and Banik, 1987; Roy et al. (2009); Khan and Sinha (2002)	
69	*Oedogonium varians* Wittrock & Lundell ex Hirn	Oedogoniaceae	Chlorophyceae		(+)

70	*Oedogonium* sp.	Oedogoniaceae	Chlorophyceae	Datta and Banik, 1987; Roy et al. (2009); Khan and Sinha (2002)	
71	*Pediastrum tetras* (Ehrenberg) Ralfs	Hydrodictyaceae	Chlorophyceae		(+)
72	*Pediastrum duplex* Meyen	Hydrodictyaceae	Chlorophyceae		(+)
73	*Pediastrum* sp.	Hydrodictyaceae	Chlorophyceae	Khan and Sinha (2002)	
74	*Peridinium* sp.	Peridiniaceae	Dinophyceae	Roy et al. (2009)	(+)
75	*Phacus* sp.	Phacaceae	Euglenophyceae		(+)
76	*Phormidium* sp.	Oscillatoriaceae	Cyanophyceae	Roy et al. (2009); Khan and Sinha (2002)	
77	*Planktothrix suspensa* (Pringsh.) Anagnostidis & Komárek	Microcoleaceae	Cyanophyceae		(+)
78	*Pleurocapsa minor* Hansgirg	Hyellaceae	Cyanophyceae		(+)
79	*Pseudanabaena biceps* Böcher	Pseudanabaenaceae	Cyanophyceae		(+)
80	*Pseudanabaena limnetica* (Lemmerm.) Komárek	Pseudanabaenaceae	Cyanophyceae		(+)
81	*Rhizoclonium tortuosum* (Dillwyn) Kütz.	Cladophoraceae	Chlorophyceae		(+)
82	*Rhodochytrium* sp.	Endosphaeraceae	Chlorophyceae		(+)
83	*Rhopalodia* sp.	Rhopalodiaceae	Bacillariophyceae	Khan and Sinha (2002)	
84	*Schroederia planctonica* (Skuja) Philipose	Schroederiaceae	Chlorophyceae		(+)
85	*Schroederia setigera* (Schröder) Lemmermann	Schroederiaceae	Chlorophyceae		(+)
86	*Scenedesmus* sp.	Scenedesmaceae	Chlorophyceae	Roy et al. (2009); Khan and Sinha (2002)	(+)
87	*Scenedesmus abundans* (O.Kirchner) Chodat	Scenedesmaceae	Chlorophyceae		(+)
88	*Scenedesmus acuminatus* (Lagerheim) Chodat	Scenedesmaceae	Chlorophyceae		(+)
89	*Scenedesmus armatus* (Chodat) Chodat	Scenedesmaceae	Chlorophyceae		(+)
90	*Scenedesmus brasiliensis* Bohlin	Scenedesmaceae	Chlorophyceae		(+)
91	*Scenedesmus carinatus* (Lemmermann) Chodat	Scenedesmaceae	Chlorophyceae		(+)
92	*Scenedesmus dimorphus* (Turpin) Kützing	Scenedesmaceae	Chlorophyceae		(+)
93	*Scenedesmus opoliensis* P.G.Richter	Scenedesmaceae	Chlorophyceae		(+)
94	*Scenedesmus quadricauda* Chodat	Scenedesmaceae	Chlorophyceae		(+)
95	*Scenedesmus perforatus* Lemmermann	Scenedesmaceae	Chlorophyceae		(+)
96	*Scenedesmus protuberans* F.E.Fritsch & M.F.Rich	Scenedesmaceae	Chlorophyceae		(+)
97	*Spirogyra hyalina* Cleve	Zygnemataceae	Chlorophyceae		(+)
98	*Spirogyra* sp.	Zygnemataceae	Conjugatophyceae (Zygnematophyceae)	Datta and Banik, 1987; Roy et al. (2009); Khan and Sinha (2002)	(+)
99	*Spirulina* sp.	Spirulinaceae	Cyanophyceae	Roy et al. (2009); Khan and Sinha (2002)	(+)
100	*Stigeoclonium* sp.	Chaetophoraceae	Chlorophyceae	Datta and Banik, 1987	

101	*Synedra* sp.	Fragilariaceae	Bacillariophyceae	Roy et al. (2009)	(+)
102	*Tetraëdron regulare* Kützing	Hydrodictyaceae	Chlorophyceae		(+)
103	*Tetraëdron trigonum* (Nägeli) Hansgirg	Hydrodictyaceae	Chlorophyceae		(+)
104	*Tetraëdron* sp.	Hydrodictyaceae	Chlorophyceae	Roy et al. (2009)	
105	*Trachelomonas volvocina* (Ehrenb.) Ehrenb. var. punctata Playfair	Euglenaceae	Euglenophyceae		(+)
106	*Trachelomonas* sp.	Euglenaceae	Euglenophyceae		(+)
107	*Tetrastrum heteracanthum* (Nordstedt) Chodat	Scenedesmaceae	Chlorophyceae		(+)
108	*Tetrastrum punctatum* (Schmidle) Ahlstrom & Tiffany	Scenedesmaceae	Chlorophyceae		(+)
109	*Tetrastrum staurogeniiforme* (Schröder) Lemmermann	Scenedesmaceae	Chlorophyceae		(+)
110	*Thalassiosira* sp.	Thalassiosiraceae	Mediophyceae	Roy et al. (2009)	
111	*Uronema confervicola* Lagerh.	Uronemataceae	Chlorophyceae		(+)
112	*Volvox* sp.	Volvocaceae	Chlorophyceae	Roy et al. (2009); Khan and Sinha (2002)	

b) Quantitative assessment

Table 3.3. Frequency class (Fc) distribution of different phytoplankton class collected during present study

Class	**Fc% Classes (no. of species)**				**Total Species**
	A (1--25)	**B (26--50)**	**C (51--75)**	**D (76--100)**	
Bacillariophyceae	2	1	1	1	5
Chlorophyceae	9	16	4	1	30
Conjugatophyceae (Zygnematophyceae)	1	1	0	0	2
Coscinodiscophyceae	1	2	0	1	4
Cyanophyceae	4	6	0	2	12
Euglenophyceae	5	1	0	0	6
Mediophyceae	0	1	0	0	1
Trebouxiophyceae	4	1	0	0	5
Total	26	29	5	5	65

B) Aquatic macrophytes

Table 3.4. List of macrophytes of Rabindra Sarobar; (+) indicates presence

Sl. No.	Name of the species	Common Name	Family	Earlier report	Present study
1	*Alternanthera philoxeroides* (Mart.) Griseb.	Alligator Weed	Amaranthaceae	Ghosh, 2010	(+)
2	*Alternanthera sessilis* (L.) R.Br. ex DC.	Sessile joyweed	Amaranthaceae	Ghosh, 2010	(+)
3	*Azolla pinnata* R. Br.	Water velvet	Azollaceae	Roy et al. 2010; Khan, 2002	(+)
4	*Brachiaria mutica* (Forssk.) Stapf	Para grass	Poaceae	Roy et al. 2010	(+)
5	*Ceratophyllum demersum*	Horn wort	Ceratophyllaceae	Roy et al. 2010; Khan, 2002	(+)
6	*Colocasia esculenta* (L.) Schott	Taro	Araceae		(+)
7	*Commelina benghalensis* L.	bengal dayflower	Commelinaceae	Roy et al. 2010	(+)
8	*Commelina diffusa* Burm.f.	Climbing dayflower	Commelinaceae	Roy et al. 2010	(+)
9	*Crinum asiaticum* L.	Spider lily	Amaryllidaceae	Roy et al. 2010	(+)
10	*Cyperus alopecuroides* Rottb.	Purple nutsedge	Cyperaceae	Roy et al. 2010	(+)
11	*Eichhornia crassipes* (Mart.) Solms	Water hyacinth	Pontederiaceae	Khan, 2002; Ghosh, 2010; Roy et al. 2010	(+)
12	*Enhydra fluctuans* Lour.	Water Cress	Asteraceae		(+)
13	*Hydrilla verticillata* L.f. (Royle)	Hydrilla	Hydrocharitaceae	Chaudhuri and Sharma, 1978; Khan, 2002; Roy et al. 2010	(+)
14	*Hydrocharis dubia* (Blume) Backer (Syn. *Hydrocharis cellulosa* Buch.-Ham. ex Prain)	Frogbit	Hydrocharitaceae	Khan, 2002	
15	*Hygrophila auriculata* (Schumach.) Heine	March Barbel	Acanthaceae	Roy et al. 2010	
16	*Ipomoea aquatica* Forssk.	Water morning glory	Convolvulaceae	Roy et al. 2010	(+)
17	*Lemna perpusilla* Torry	Duckweed	Lemnaceae	Roy et al. 2010; Khan, 2002	(+)
18	*Limnophila* sp.	Marshweed	Scrophulariaceae	Khan, 2002	
19	*Ludwigia adscendens* (L.) H.Hara	Water Primerose	Onagraceae	Ghosh, 2010; Roy et al. 2010	(+)
20	*Najas* sp.	Waternymph	Najadaceae	Khan, 2002	
21	*Nelumbo nucifera* Gaertn.	Lotus	Nelumbonaceae	Roy et al. 2010	(+)
22	*Nymphaea pubescens* Willd.	Kumuda	Nymphaeaceae	Roy et al. 2010; Khan, 2002	(+)
23	*Nymphoides indica* (L.) Kuntze	Water Snowflake	Menyanthaceae	Khan, 2002	(+)
24	*Panicum paludosum* Roxb.	Panicum grass	Poaceae	Roy et al. 2010	(+)
25	*Persicaria hydropiper* (L.) Delarbre	Water-pepper	Polygonaceae	Roy et al. 2010	(+)
26	*Persicaria orientalis* (L.) Spach	Prince's feather	Polygonaceae	Roy et al. 2010	(+)
27	*Pistia stratiotes* L.	Water Lettuce	Araceae	Khan, 2002; Ghosh, 2010;	(+)

				Roy et al. 2010	
28	*Rumex maritimus* L.	Golden dock	Onagraceae		(+)
29	*Salvinia natans* (L.) Allioni	Floating fern	Salviniaceae		(+)
30	*Spirodela polyrrhiza* (L.) Schleid.	Duckweed	Lemnnaceae	Khan, 2002; Roy et al. 2010	(+)
31	*Trapa* sp.	Water Chestnut	Trapaceae	Khan, 2002	
32	*Utricularia* sp.	Bladderwort	Lentibulariaceae	Khan, 2002	
33	*Vallisneria spiralis* L.	Tape Grass	Hydrocharitaceae	Khan, 2002; Chaudhuri and Sharma, 1978; Roy et al. 2010	(+)
34	*Wolffia arrhiza* (L.) Hork. Ex Wimm.	Watermeal	Lemnaceae		(+)
35	*Wolffia* sp.	Watermeal	Lemnaceae	Khan, 2002	

C) Terrestrial vascular plants

Life cycle of terrestrial plants mainly completes in land. Besides the water spread area, the open space of the lake vicinity (cachment area or bank) and the island like elevated land mass within the lake harbours a wide array of diversity of terrestrial vascular flora containing trees, shrubs, climbers & lianas and herbs. The dense canopy of trees and lianas is significant for ecological security of the city Kolkata.

i) Earlier reports

The earlier works on the terrestrial flora of Rabindra Sarobar (IWMED, 2001; Ghosh, 2010; Roy et al. 2010) reveals the occurrence record of a total of 152 species of vascular terrestrial plants of which 73 species were trees, 66 species were herbs, 7 species were shrubs, 4 species were climbers and 2 species were lianas. These species were reported under 127 genera and 53 families.

ii) Present scenario

In the present study, a total of 366 species of terrestrial vascular plants in the life form of 162 trees, 8 lianas, 14 climbers, 46 shrubs and 136 herbs have been identified from Rabindra Sarobar and its premises. The 366 species were distributed under 277 genera and 43 families. The terrestrial flora of Rabindra Sarobar consists of 2 species of Pteridophytes, 3 species of Gymnosperms, and 361 species of Angiosperms. The most diverse genera include *Ficus* (11 species) followed by *Acacia* (5 species); *Alternanthera*, *Bauhinia*, *Dalbergia*, *Euphorbia*, *Ipomoea*, *Ixora*, *Phyllanthus*, *Senna*, *Sida* and *Syziygium* (4 species each) while, 10 genera had 3 species each, 25 genera had 2 species each and 230 genera had single species each.

The most diverse families include Fabaceae (43 species, 27 genera), Asteraceae (21 species, 20 genera), Euphorbiaceae (17 species, 11 genera), Poaceae (17 species, 14 genera), Moraceae (16 species, 4 genera), Arecaceae (15 species, 14 genera), Apocynaceae (13 species, 11 genera), Bignoniaceae (11 species, 10 genera), Acanthaceae (10 species, 7

genera), Rubiaceae (10 species, 6 genera), Malvaceae (9 species, 7 genera), Myrtaceae (8 species, 4 genera), Rutaceae (8 species, 4 genera), Verbenaceae (8 species, 7 genera), Amaranthaceae (7 species, 3 genera), Convolvulaceae (7 species, 3 genera), Cucurbitaceae (7 species, 4 genera), while, Meliaceae and Solanaceae were represented by 6 species each, Araceae, Commelinaceae, Sapindaceae and Sterculiaceae had representation of 5 species each, similarly other 6 families had 4 species each, 6 families had 3 species each and 12 families had 2 species each and rest 41 families had single species each.

Some potential medicinal plants viz. *Aegle marmelos*, *Aloe vera*, *Andrographis paniculata*, *Azadirachta indica*, *Catharanthus roseus*, *Hemidesmus indicus*, *Mucuna pruriens*, *Oldenlandia corymbosa*, *Ocimum tenuiflorum*, *Phyllanthus emblica*,*Phyllanthus niruri*, *Rauvolfia tetraphylla*, *Ricinus communis*, *Saraca asoca*, *Senna sophera*, *Sida cordata*, *Sphagneticola calendulacea*, *Solanum americanum*, *Terminalia arjuna*, *Terminalia bellirica*, *Tiliacora racemosa*, *Tinospora sinensis*, *Woodfordia fruticosa* etc. were documented in the premises of Rabindra Sarobar both as introduced or as naturally growing species.

D) Trees

Table 3.5. List of Trees of Rabindra Sarobar; (+) indicates presence

Sl. No.	Tree species	Common Name	Family	Earlier report	Present study	Note/importance
1	*Acacia auriculiformis* Benth.	Akashmoni; Ear-leaf Acacia	Fabaceae	IWMED, 2001; Ghosh, 2010	(+)	Ornamental
2	*Acacia catechu* (L.f.) Willd.	Cutch Tree	Fabaceae	Ghosh, 2010	(+)	Medicinal
3	*Acacia leucophloea* (Roxb.) Willd.	White Bark Acacia	Fabaceae		(+)	Edible, medicinal and fodder
4	*Acacia mangium* Willd.	Black Wattle	Fabaceae		(+)	Ornamental
5	*Acacia nilotica* (L.) Delile	Babla	Fabaceae	IWMED, 2001	(+)	Medicinal
6	*Adansonia digitata* L.	African Baobab Tree	Bombacaceae	Ghosh, 2010	(+)	Medicinal & ornamental
7	*Adenanthera pavoniana* L.	Barbados pride	Fabaceae	Ghosh, 2010	(+)	Economic
8	*Aegle marmelos* (L.) Corrêa	Atha Bel; Wood Apple	Rutaceae	IWMED, 2001	(+)	Edible & medicinal
9	*Ailanthus excelsa* Roxb.	Gokul; Indian tree of heaven	Simaruboiaceae		(+)	Medicinal
10	*Albizia lebbeck* (L.) Benth.	Sirish	Fabaceae	Ghosh, 2010	(+)	Economic
11	*Albizia saman* (Jacq.) Merr.	Khirish; Rain Tree	Fabaceae	IWMED, 2001; Ghosh, 2010	(+)	Ornamental
12	*Alstonia macrophylla* Wall. ex G.Don	Hard Alstonia	Apocynaceae		(+)	Economic

13	*Alstonia scholaris* (L.) R. Br.	Chhatim	Apocynaceae	Ghosh, 2010	(+)	State tree of West Bengal
14	*Annona reticulata* L.	Nona	Annonaceae		(+)	Edible and medicinal
15	*Anogeissus acuminata* (Roxb. ex DC.) Wall. Ex Guillem. & Perr.	Button tree	Rhamnaceae		(+)	Economic
16	*Araucaria luxurians* (Brongn. & Gris) de Laub.	Coast Araucaria	Araucariaceae		(+)	Ornamental
17	*Areca catechu* L.	Supari; Betel palm	Arecaceae		(+)	Ornamental and edible
18	*Artocarpus heterophyllus* Lam.	Jack fruit	Moraceae		(+)	Edible
19	*Artocarpus integer* (Thunb.) Merr.	Kanthal	Moraceae	IWMED, 2001; Ghosh, 2010	(+)	Edible
20	*Artocarpus lacucha* Buch.-Ham.	Monkey fruit; Deo	Moraceae		(+)	Edible
21	*Averrhoa carambola* L.	Kamranga	Oxalidaceae		(+)	Edible
22	*Azadirachta indica* A.J uss.	Neem	Meliaceae		(+)	Medicinal
23	*Barringtonia acutangula* (L.) Gaertn.	Hijol; Indian Oak	Lecythidaceae	IWMED, 2001; Ghosh, 2010	(+)	Economic
24	*Bauhinia acuminata* L.	White orchid-tree	Fabaceae		(+)	Ornamental
25	*Bauhinia blakeana* Dunn	Hong Kong Orchid Tree	Fabaceae		(+)	Ornamental
26	*Bauhinia purpurea* DC. ex Walp.	Rakta Kanchan	Fabaceae		(+)	Medicinal
27	*Bauhinia variegata* L.	Orchid Tree	Fabaceae	Ghosh, 2010	(+)	Ornamental
28	*Bombax ceiba* L.	Lal Shimul; Cotton tree	Bombacaceae	IWMED, 2001; Ghosh, 2010	(+)	Economic
29	*Borassus flabellifer* L.	Taal; Palmyra palm	Arecaceae	IWMED, 2001; Ghosh, 2010	(+)	Edible
30	*Butea monosperma* (Lam.) Taub.	Palash; Flame of the forest	Fabaceae	Ghosh, 2010	(+)	Ornamental & economic
31	*Caesalpinia pulcherrima* (L.) Sw.	Peacock flower	Fabaceae	IWMED, 2001	(+)	Ornamental and medicinal
32	*Calliandra haematocephala* Hassk.	Red powder puff	Fabaceae		(+)	Ornamental
33	*Callistemon brachyandrus* Lindl.	Bottle Brush	Myrtaceae		(+)	Ornamental
34	*Callistemon lanceolatus* (Sm.) Sweet	Lemon bottlebrush	Myrtaceae		(+)	Ornamental
35	*Calophyllum inophyllum* L.	Alexandrian laurel balltree	Clusiaceae	IWMED, 2001; Ghosh, 2010	(+)	Ornamental
36	*Carica papaya* L.	Papaya	Caricaceae		(+)	Edible
37	*Caryota urens* L.	Fishtail palm	Arecaceae		(+)	Ornamental & edible
38	*Cascabela thevetia* (L.)	Kolke	Apocyn		(+)	Ornamental

	Lippold (Syn. *Thevetia peruviana* (Pers.) K. Schum.)		aceae			
39	*Casearia elliptica* Willd.	Toothed Leaf Chilla	Flacourtiaceae		(+)	Economic
40	*Cassia fistula* L.	Bandarlathi; Golden Rain Tree	Fabaceae	IWMED, 2001; Ghosh, 2010	(+)	Ornamental
41	*Cassia javanica* subsp. *nodosa* (Roxb.) K.Larsen & S.S.Larsen	Java Cassia	Fabaceae		(+)	Ornamental
42	*Castanospermum australe* A.Cunn. & C.Fraser	Black Bean; Moreton Bay Chestnut	Fabaceae	Ghosh, 2010	(+)	Ornamental
43	*Casuarina equisetifolia* L.	She-oak	Casuarinaceae	IWMED, 2001; Ghosh, 2010	(+)	Ornamental
44	*Toona ciliata* M.Roem	Tun	Meliaceae		(+)	Timber yielding tree
45	*Ceiba pentandra* (L.) Gaertn.	Sada Shimul; Java cotton	Bombacaceae	Ghosh, 2010	(+)	Economic
46	*Citrus lemon* (L.) Osbeck	Lebu	Rutaceae		(+)	Edible and medicinal
47	*Citrus maxima* (Burm.) Merr.	Batabi lebu; Pommelo	Rutaceae		(+)	Edible
48	*Cocos nucifera* L.	Narkel; Coconut	Arecaceae	IWMED, 2001; Ghosh, 2010	(+)	Edible
49	*Colvillea racemosa* Bojer	Pitchura; Colville's Glory	Fabaceae	Ghosh, 2010	(+)	Ornamental
50	*Cordia sebestena* (Willd.) ex Spreng.	Scarlet Cordia	Boraginaceae		(+)	Ornamental
51	*Couroupita guianensis* Aubl.	Nagalingam; Cannon Ball Tree	Lecythidaceae	Ghosh, 2010	(+)	Ornamental
52	*Crescentia cujete* L.	Belaiti Bel; Begger's Bowl	Bignoniaceae	Ghosh, 2010	(+)	Ornamental
53	*Dalbergia assamica* Benth.		Fabaceae	Ghosh, 2010	(+)	Economic
54	*Dalbergia lanceolaria* L.f.	Takoli	Fabaceae		(+)	Economic
55	*Dalbergia pinnata* (Lour.) Prain (Syn. *Derris pinnata* Lour.)		Fabaceae	IWMED, 2001	(+)	Medicinal
56	*Dalbergia sissoo* DC.	Sisoo	Fabaceae	Ghosh, 2010	(+)	Economic
57	*Delonix regia* (Hook.) Raf.	Gulmohor	Fabaceae	IWMED, 2001; Ghosh, 2010	(+)	Ornamental
58	*Dillenia indica* Balanco	Chalta	Dilleniaceae		(+)	Medicinal
59	*Dimocarpus longan* Lour.	Aans Fal	Sapindaceae		(+)	Edible and medicinal
60	*Diospyros ebenum* Koenig ex Retz.	Gaab	Ebenaceae	Ghosh, 2010	(+)	
61	*Diospyros malabarica* (Desr.) Kostel.	Indian persimmon	Ebenaceae	Ghosh, 2010	(+)	Edible

62	*Dolichandrone spathacea* (L.f.) Seem.	Mangrove Trumpet	Bignoniaceae		(+)	Ornamental
63	*Dypsis lutescens* (H.Wendl.) Beentje & J.Dransf.	Golden Cane Palm	Arecaceae		(+)	Ornamental
64	*Erythrina arborescens* Roxb.	Madar	Fabaceae	IWMED, 2001	(+)	Ornamental
65	*Eucalyptus globulus* Labill.	Potash	Myrtaceae		(+)	Medicinal
66	*Euphorbia neriifolia* L.	Mansa	Euphorbiaceae		(+)	Ornamental and medicinal
67	*Ficus benghalensis* L.	Bot; Banyan	Moraceae	IWMED, 2001; Ghosh, 2010	(+)	Economic
68	*Ficus benjamina* L.	Weeping fig	Moraceae	IWMED, 2001; Ghosh, 2010	(+)	Ornamental
69	*Ficus elastica* Roxb. ex Hornem.	Rubber fig	Moraceae		(+)	Ornamental
70	*Ficus geniculata* Kurz	Dotted fig	Moraceae		(+)	Medicinal
71	*Ficus hispida* L.f.	Dumur; Hairy Fig	Moraceae		(+)	Edible
72	*Ficus longifolia* Schott	Alii Fig	Moraceae		(+)	Ornamental
73	*Ficus racemosa* L. (Syn. *Ficus glomerata* Roxb.)	Joggo Dumur; Cluster Fig tree	Moraceae	IWMED, 2001; Ghosh, 2010	(+)	Edible
74	*Ficus religiosa* L.	Ashattha; Peepal	Moraceae	IWMED, 2001	(+)	Economic
75	*Ficus rumphii* Bl.	Pakur; Mock Peepul tree	Moraceae	IWMED, 2001	(+)	Ornamental
76	*Ficus virens* Aiton (Syn. *Ficus infectoria* (Miq.) Miq.)	White fig	Moraceae	IWMED, 2001	(+)	Edible
77	*Gardenia jasminoides* J.Ellis	Gandhoraj; Cape jasmine	Rubiaceae		(+)	Ornamental
78	*Gelonium multiflorum* A.Juss.	False lime	Euphorbiaceae		(+)	Medicinal
79	*Gliricidia sepium* (Jacq.) Walp.	Quick stick	Fabaceae	IWMED, 2001; Ghosh, 2010	(+)	Ornamental
80	*Gmelina arborea* Roxb.	Beech wood; Gamar	Verbenaceae		(+)	Economic
81	*Grevillea robusta* A. Cunn. Ex R.Br.	Silver oak	Proteaceae		(+)	Ornamental
82	*Grewia asiatica* L.	Falsa	Tiliaceae		(+)	Edible and medicinal
83	*Hamelia patens* Jacq.	Scarlet bush	Rubiaceae		(+)	Ornamental
84	*Handroanthus chrysanthus* (Jacq.) S.O.Grose	Yellow Ipe	Bignoniaceae	IWMED, 2001	(+)	Ornamental
85	*Heritiera fomes* Buch.-Ham.	Sundari	Sterculiaceae		(+)	Ornamental
86	*Holarrhena pubescens*	Kurchi	Apocyn		(+)	Medicinal

	Wall. & G. Don		aceae			
87	*Hyophorbe lagenicaulis* (L.H.Bailey) H.E.Moore	Bottle Palm	Arecaceae		(+)	Ornamental
88	*Jacaranda mimosifolia* D.Don	Jacaranda	Bignoniaceae		(+)	Ornamental
89	*Khaya senegalensis* (Desv.) A.Juss.	African mahogany	Meliaceae		(+)	Economic
90	*Kigelia africana* (Lam.) Benth. (Syn. *Kigelia pinnata* (Jacq.) DC.)	Sausage Tree	Bignoniaceae	Ghosh, 2010	(+)	Ornamental & medicinal
91	*Kleinhovia hospita* L.	Guest tree	Sterculiaceae	IWMED, 2001	(+)	Medicinal
92	*Lagerstroemia javanica* Thunb.	Crepe myrtle	Lythraceae	IWMED, 2001; Ghosh, 2010	(+)	Ornamental
93	*Lagerstroemia speciosa* (L.) Pers.	Jarul; Queen's crepe-myrtle	Lythraceae		(+)	Ornamental
94	*Lannea coromandelica* (Houtt.) Merr.	Jiol	Anacardiaceae		(+)	Medicinal
95	*Lepisanthes tetraphylla* Radlk.	Kannada	Sapindaceae	IWMED, 2001	(+)	Economic
96	*Leucaena leucocephala* (Lam.) de Wit	Subabul	Fabaceae	IWMED, 2001; Ghosh, 2010	(+)	Leaves used for animal feed
97	*Licuala grandis* H.Wendl.	Ruffled Fan Palm	Arecaceae		(+)	Ornamental
98	*Limonia acidissima* Houtt.	Koth Bel	Rutaceae		(+)	Edible and medicinal
99	*Litchi chinensis* Sonn.	Lichu	Sapindaceae		(+)	Edible
100	*Litsea glutinosa* (Lour.) C.B.Rob.	Ledachhal; Indian laurel	Lauraceae		(+)	Economic
101	*Livistona saribus* (Lour.) Merr. ex A.Chev.	Taraw Palm	Arecaceae		(+)	Ornamental
102	*Madhuca longifolia* var. *latifolia* (Roxb.) A.Chev.	Indian Butter Tree; Mahua	Sapotaceae	IWMED, 2001; Ghosh, 2010	(+)	Edible
103	*Mangifera indica* L.	Aam; Mango	Anacardiaceae	IWMED, 2001; Ghosh, 2010	(+)	Edible
104	*Manilkara hexandra* Dubard	Khir Kul	Sapotaceae		(+)	Edible and medicinal
105	*Manilkara zapota* (L.) Royen	Sabeda	Sapotaceae		(+)	Edible and medicinal
106	*Melia azedarach* L.	Chinaberry tree	Meliaceae		(+)	Economic
107	*Michelia champaca* L.	Champa	Magnoliaceae		(+)	Ornamental & medicinal
108	*Millettia peguensis* Ali	Moulmein Rosewood	Fabaceae	Ghosh, 2010	(+)	Ornamental
109	*Millingtonia hortensis* L.f.	Parijat	Bignoniaceae		(+)	Ornamental

110	*Mimusops elengi* L.	Bakul; Spanish cherry	Sapotaceae	IWMED, 2001; Ghosh, 2010	(+)	Ornamental
111	*Moringa oleifera* Lam.	Sajina; Drumstick tree	Moringaceae		(+)	Edible and medicinal
112	*Morus alba* L.	Tunt; White mulberry	Moraceae		(+)	Edible
113	*Murraya exotica* L.	Kamini	Rutaceae		(+)	Ornamental & medicinal
114	*Neolamarckia cadamba* (Roxb.) Bosser	Kadam; Cadamba	Rubiaceae	IWMED, 2001; Ghosh, 2010	(+)	Economic
115	*Nyctanthes arbor-tristis* L.	Siuli; Night-flowering Jasmine	Oleaceae		(+)	Ornamental & medicinal
116	*Peltophorum pterocarpum* (DC.) K.Heyne	Radhachura	Fabaceae	IWMED, 2001; Ghosh, 2010	(+)	Economic
117	*Phoenix roebelenii* O'Brien	Pygmy Date Palm	Arecaceae		(+)	Ornamental
118	*Phoenix sylvestris* (L.) Roxb.	Khejur; Date Palm	Arecaceae	Ghosh, 2010	(+)	Ornamental & edible
119	*Phyllanthus emblica* L.	Indian gooseberry	Phyllanthaceae		(+)	Edible and medicinal
120	*Pithecellobium dulce* (Roxb.) Benth.	Jilabi; Manilla Tamarind	Fabaceae	IWMED, 2001; Ghosh, 2010	(+)	Ornamental
121	*Plumeria alba* L.	White fragipani	Apocynaceae	IWMED, 2001	(+)	Ornamental
122	*Plumeria rubra* L.	Tagar	Apocynaceae		(+)	Ornamental
123	*Polyalthia angustifolia* A.C.Sm.	Debdaru	Annonaceae		(+)	Ornamental
124	*Polyalthia longifolia* (Sonn.) Thwaites	Debdaru	Annonaceae	IWMED, 2001; Ghosh, 2010	(+)	Ornamental
125	*Pongamia pinnata* (L.) Pierre	Karanja; Indian beech	Fabaceae	Ghosh, 2010	(+)	Economic & medicinal
126	*Psidium guajava* L.	Peara; Guava	Myrtaceae		(+)	Edible
127	*Pterocarpus marsupium* Roxb.	Indian kino tree	Fabaceae	Ghosh, 2010	(+)	Economic
128	*Pterospermum acerifolium* (L.) Willd.	Muchkunda; Kanak Champa	Sterculiaceae	IWMED, 2001; Ghosh, 2010	(+)	Medicinal
129	*Pterygota alata* (Roxb.) R. Br.	Buddha Coconut	Sterculiaceae	Ghosh, 2010	(+)	Ornamental
130	*Ptychosperma macarthurii* (H.Wendl. ex H.J.Veitch) H.Wendl. ex Hook.f.	Macarthur Palm	Arecaceae		(+)	Ornamental
131	*Punica granatum* L.	Dalim; Pomegranate	Punicaceae		(+)	Edible
132	*Putranjiva roxburghii* Wall.	Putijia	Putranjivaceae	Ghosh, 2010	(+)	Medicinal
133	*Rhapis excelsa* (Thunb.) Henry	Lady palm	Arecaceae		(+)	Ornamental

134	*Roseodendron donnell-smithii* (Rose) Miranda	Primavera	Bignoniaceae		(+)	Ornamental
135	*Roystonea regia* (Kunth) O.F.Cook	Royal Palm	Arecaceae	Ghosh, 2010	(+)	Ornamental
136	*Saraca asoca* (Roxb.) Willd.	Asok; Asoca	Fabaceae		(+)	Ornamental & medicinal
137	*Schleichera oleosa* (Lour.) Oken	Kusum; Ceylon oak	Sapindaceae		(+)	Economic
138	*Senna siamea* (Lam.) H.S.Irwin & Barneby	Minjri, Kassod tree	Fabaceae		(+)	Ornamental
139	*Spathodea campanulata* P.Beauv.	Rudra Palash; African tuliptree	Bignoniaceae		(+)	Ornamental
140	*Sterculia foetida* L.	Baxo Badam; Poon tree	Sterculiaceae	Ghosh, 2010	(+)	Edible & economic
141	*Streblus asper* Lour.	Shaora; Sand Paper Tree	Moraceae		(+)	Medicinal
142	*Swietenia mahogani* L.	Chotopata Mahogani	Meliaceae	IWMED, 2001; Ghosh, 2010	(+)	Economic
143	*Swietenia macrophylla* King	Boropata Mahogani	Meliaceae		(+)	Economic
144	*Syzygium aqueum* (Burm.f.) Alston	Watery Rose Apple	Myrtaceae		(+)	Edible
145	*Syzygium cumini* (L.) Skeels	Guri Jaam; Jamun	Myrtaceae	Ghosh, 2010	(+)	Edible
146	*Syzygium jambolanum* (Lam.) DC.	Boro Jaam	Myrtaceae		(+)	Medicinal
147	*Syzygium samarangense* (Blume) Merr. & L.M.Perry	Jamrul; Wax Apple	Myrtaceae		(+)	Edible
148	*Tabebuia rosea* (Bertol.) Bertero ex A.DC.	Pink Trumpet Tree	Bignoniaceae	Ghosh, 2010	(+)	Ornamental
149	*Tabernaemontana divaricata* (L.) R.Br. ex Roem. & Schult.	Kath Tagar	Apocynaceae		(+)	Ornamental
150	*Tamarindus indica* L.	Tentul; Tamarind	Fabaceae	IWMED, 2001; Ghosh, 2010	(+)	Edible
151	*Tecoma stans* (L.) Juss. ex Kunth	Yellow trumpetbush	Bignoniaceae		(+)	Ornamental
152	*Tectona grandis* L.f.	Segun; Teak	Verbenaceae	IWMED, 2001; Ghosh, 2010	(+)	Economic
153	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.	Arjun	Combretaceae	IWMED, 2001; Ghosh, 2010	(+)	Medicinal
154	*Terminalia bellirica* (Gaertn.) Roxb.	Bahera; Beleric	Combretaceae		(+)	Medicinal
155	*Terminalia catappa* L.	Kath Badam; Malabar-almond	Combretaceae	IWMED, 2001; Ghosh, 2010	(+)	Economic
156	*Thespesia populnea* (L.) Sol. ex Corrêa	Parash Peepul; Portia tree	Malvaceae	IWMED, 2001; Ghosh,	(+)	Medicinal

				2010		
157	*Trachycarpus martianus* (Wall. ex Mart.) H.Wendl.	Fan Palm	Arecaceae		(+)	Ornamental
158	*Trema orientalis* (L.) Blume	Pigeon wood	Cannabaceae	IWMED, 2001; Ghosh, 2010	(+)	Medicinal
159	*Trewia nudiflora* Wight	Pituli; False white teak	Euphorbiaceae	Ghosh, 2010	(+)	Economic
160	*Vernonia amygdalina* Delile	Onugbu; Bitterleaf	Asteraceae		(+)	Medicinal
161	*Wodyetia bifurcata* A.K.Irvine	Foxtail Palm	Arecaceae		(+)	Ornamental
162	*Ziziphus mauritiana* Lam.	Topakul; Ber	Rhamnaceae	IWMED, 2001	(+)	Edible

E) Herbs, Shrubs, Climbers & Lianas

Table 3.6. List of herbs, shrubs, climber & lianas of Rabindra Sarobar; (+) indicates presence

Sl. No.	Name of the species	Common Name	Family	Habit	Earlier report	Present study	Note/Importance
1	*Abutilon indicum* (L.) Sweet	Indian Mallow	Malvaceae	Herb	Ghosh, 2010	(+)	Medicinal
2	*Acalypha hispida* Burm.f.	Chenille plant	Euphorbiaceae	Herb		(+)	Ornamental
3	*Acalypha indica* L.	Indian Acalypha	Euphorbiaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Weed
4	*Achyranthes aspera* L.	Apamarga	Amaranthaceae	Herb	Ghosh, 2010	(+)	Medicinal
5	*Acmella paniculata* (Wall. ex DC.) R.K.Jansen	Panicled Spot Flower	Asteraceae	Herb		(+)	Medicinal
6	*Ageratum conyzoides* (L.) L.	Billy-goat weed	Asteraceae	Herb	IWMED, 2001	(+)	Weed
7	*Allamanda cathartica* L.	Golden trumpet	Apocynaceae	Shrub		(+)	Ornamental
8	*Aloe vera* (L.) Burm.f.	Aloe	Xanthorrhoeaceae	Herb		(+)	Medicinal
9	*Alternanthera paronychioides* A.St.-Hil.	Smooth joyweed	Amaranthaceae	Herb		(+)	Weed
10	*Alternanthera philoxeroides* (Mart.) Griseb.	Alligator Weed	Amaranthaceae	Herb	Ghosh, 2010	(+)	Aquatic weed
11	*Alternanthera sessilis* (L.) R.Br. ex DC.	Sessile joyweed	Amaranthaceae	Herb		(+)	Edible

12	*Alternanthera tenella* Colla	True Yellow Calico Plant	Amaranthaceae	Herb		(+)	Weed
13	*Amaranthus spinosus* L.	Spiny Pigweed	Amaranthaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Medicinal and Edible
14	*Amaranthus viridis* L.	Green Amaranth	Amaranthaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Edible
15	*Anaphalis subdecurrens* (DC.) Gamble	Pearly everlastin g	Asteraceae	Herb		(+)	Weed
16	*Andrographis paniculata* (Burm.f.) Nees	Kalmegh	Acanthaceae	Herb		(+)	Medicinal
17	*Anisomeles indica* (L.) Kuntze	Indian Catmint	Lamiaceae	Herb	Ghosh, 2010	(+)	Weed
18	*Antirrhinum majus* L.	Snapdrago n	Scrophulariacea e	Herb		(+)	Ornament al
19	*Argemone mexicana* L.	Mexican Poppy	Papaveraceae	Herb	Ghosh, 2010	(+)	Medicinal
20	*Axonopus compressus* (Sw.) P.Beauv.	Broadleaf Carpet grass	Poaceae	Herb		(+)	Weed
21	*Bambusa tulda* Roxb.	Bans	Poaceae	Shrub		(+)	
22	*Bambusa ventricosa* McClure	Ghoti Bans	Poaceae	Shrub		(+)	
23	*Bambusa vulgaris* Schrad.	Sonali Bans	Poaceae	Shrub		(+)	
24	*Bixa orellana* L.	Lipstick Tree	Bixaceae	Shrub		(+)	Edible and Dye yielding
25	*Blumea lacera* (Burm.f.) DC.	Kakronda	Asteraceae	Herb		(+)	Weed
26	*Boerhavia diffusa* L.	Punarnava	Nyctaginaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Medicinal
27	*Bougainvillea spectabilis* Willd.	Bougainvi llea	Nyctaginaceae	Shrub		(+)	Ornament al
28	*Brachiaria mutica* (Forssk.) Stapf.	Para grass	Poaceae	Herb		(+)	Weed
29	*Cajanus cajan* (L.) Millsp.	Pigeon pea	Fabaceae	Shrub		(+)	Edible
30	*Calotropis gigantea* (L.) Dryand.	Crown flower	Asclepiadaceae	Shrub		(+)	Medicinal
31	*Calyptocarpus vialis* Less.	Straggler daisy	Asteraceae	Herb		(+)	Weed
32	*Canna indica* L.	Indian shot	Cannaceae	Herb		(+)	Ornament al
33	*Cardiospermum halicacabum* L.	Balloon Vine	Sapindaceae	Herb		(+)	Medicinal

34	*Catharanthus roseus* (L.) G.Don	Nayantara	Apocynaceae	Herb		(+)	Ornamental and Medicinal
35	*Cayratia pedata* (Lam.) Gagnep.	Birdfoot grape vine	Vitaceae	Climber		(+)	Weed
36	*Cayratia trifolia* (L.) Domin	Bush Grape	Vitaceae	Climber	IWMED, 2001; Ghosh, 2010	(+)	Weed
37	*Centella asiatica* (L.) Urb.	Thankuni	Apiaceae	Herb	IWMED, 2001	(+)	Medicinal
38	*Cestrum diurnum* L.	Day-blooming Jasmine	Solanaceae	Herb	IWMED, 2001	(+)	
39	*Chenopodium album* L.	Goosefoot	Chenopodiaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Edible
40	*Chloris barbata* Sw.	Swollen Finger Grass	Poaceae	Herb		(+)	Weed
41	*Christella dentata* (Forssk.) Brownsey & Jermy	Christella	Thelypteridaceae	Herb		(+)	Ornamental Fern
42	*Chromolaena odorata* (L.) R.M.King & H.Rob.	Siam Weed	Asteraceae	Shrub		(+)	Weed
43	*Chrozophora plicata* (Vahl) A.Juss. ex Spreng.	Plicate Chrozophora	Euphorbiaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	
44	*Chrozophora rottleri* (Geiseler) A.Juss. ex Spreng.	Rottler's Chrozophora	Euphorbiaceae	Herb		(+)	Weed
45	*Chrysanthemum indicum* L.	Chandramalika	Asteraceae	Herb		(+)	Ornamental
46	*Citrus medica* L.	Cedar Apple	Rutaceae	Shrub		(+)	Edible and Medicinal
47	*Cleome rutidosperma* DC.	Fringed Spider Flower	Cleomaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Weed
48	*Cleome viscosa* L.	Asian Spider Flower	Cleomaceae	Herb	IWMED, 2001	(+)	Medicinal
49	*Clerodendrum infortunatum* L. (Syn. *Clerodendrum viscosum* Vent.)	Hill Glory Bober	Verbenaceae	Herb	Ghosh, 2010	(+)	Medicinal
50	*Clerodendrum splendens* G.Don	Flaming glorybower	Verbenaceae	Liana		(+)	Ornamental
51	*Coccinia cordifolia* (L.) Cogn.	Scarlet gourd	Cucurbitaceae	Climber		(+)	Medicinal
52	*Coccinia grandis* (L.) Voigt	Ivy Gourd	Cucurbitaceae	Climber	IWMED, 2001; Ghosh, 2010	(+)	Edible

53	*Cocculus hirsutus* (L.) Diels	Broom creeper	Menispermaceae	Climber		(+)	Medicinal
54	*Codiaeum variegatum* (L.) Rumph. ex A.Juss.	Garden Croton	Euphorbiaceae	Shrub		(+)	Ornamental
55	*Colocasia esculenta* (L.) Schott	Kochu	Araceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Edible
56	*Combretum indicum* (L.) DeFilipps	Rangoon creeper	Combretaceae	Liana		(+)	Ornamental
57	*Commelina benghalensis* L.	Bengal dayflower	Commelinaceae	Herb	Roy et al. 2010	(+)	Weed
58	*Commelina diffusa* Burm.f.	Climbing dayflower	Commelinaceae	Herb	Roy et al. 2010	(+)	Weed
59	*Commelina zebrina* C.B.Clarke	Purple Wandering Jew	Commelinaceae	Herb		(+)	Ornamental
60	*Crescentia alata* Kunth	Mexican calabash	Bignoniaceae	Shrub		(+)	Ornamental
61	*Crinum asiaticum* L.	Spider lily	Amaryllidaceae	Herb		(+)	Ornamental
62	*Croton bonplandianus* Baill.	Kala Bhangra	Euphorbiaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Medicinal
63	*Cuscuta reflexa* Roxb.	Amar Bel	Convolvulaceae	Herb	Ghosh, 2010	(+)	Parasitic Weed
64	*Cyanthillium cinereum* (L.) H.Rob. (Syn. *Vernonia cinerea* (L.) Less)	Ironweed	Asteraceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Weed
65	*Cycas revoluta* Thunb.	Japanese Sago Palm	Cycadaceae	Shrub		(+)	Ornamental
66	*Cynodon dactylon* (L.) Pers.	Bermuda grass	Poaceae	Herb		(+)	Medicinal
67	*Cyperus alopecuroides* Rottb.	Purple nutsedge	Cyperaceae	Herb		(+)	Aquatic weed
68	*Cyperus alternifolius* L.	Umbrella sedge	Cyperaceae	Herb		(+)	Ornamental
69	*Cyperus rotundus* L.	Nut grass	Cyperaceae	Herb		(+)	Medicinal
70	*Dahlia pinnata* Cav.	Dahlia	Asteraceae	Herb		(+)	Ornamental
71	*Dentella repens* (L.) J.R.Forst. & G.Forst.	Creeping Dentella	Rubiaceae	Herb	IWMED, 2001	(+)	
72	*Desmodium gangeticum* (L.) DC.	Dhruva	Fabaceae	Herb	IWMED, 2001	(+)	Medicinal
73	*Desmodium triflorum* (L.) DC.	Tick Trefoil	Fabaceae	Herb	IWMED, 2001	(+)	Medicinal
74	*Digitaria sanguinalis* (L.) Scop.	Large crabgrass	Poaceae	Herb	IWMED, 2001	(+)	

75	*Dioscorea bulbifera* L.	Air Potato	Dioscoreaceae	Climber		(+)	Edible and Medicinal
76	*Dipteracanthus prostratus* (Poir.) Nees	Bell Weed	Acanthaceae	Herb		(+)	Weed
77	*Dracaena angustifolia* (Medik.) Roxb.	Dracaena	Asparagaceae	Shrub		(+)	Ornamental
78	*Dregea volubilis* (L.f.) Benth. ex Hook.f.	Sneezing Silk	Apocynaceae	Liana	IWMED, 2001	(+)	Medicinal
79	*Duranta erecta* L.	Golden Dew Drop	Verbenaceae	Shrub		(+)	Ornamental
80	*Eclipta prostrata* (L.) L.	False Daisy	Asteraceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Medicinal
81	*Elephantopus scaber* L.	Elephant Foot	Asteraceae	Herb		(+)	Medicinal
82	*Eleusine indica* (L.) Gaertn.	Indian Goosegrass	Poaceae	Herb	IWMED, 2001	(+)	Weed
83	*Epipremnum aureum* (Linden & André) G.S.Bunting	Money Plant	Araceae	Herb		(+)	Ornamental
84	*Eragrostis amabilis* (L.) Wight & Arn. (Syn. *Eragrostis tenella* (L.) P.Beauv. ex Roem. & Schult.)	Love Grass	Poaceae	Herb	Ghosh, 2010	(+)	Weed
85	*Eranthemum pulchellum* Andrews	Blue Sage	Acanthaceae	Shrub		(+)	Weed
86	*Euphorbia hirta* L.	Asthma Weed	Euphorbiaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Weed
87	*Euphorbia thymifolia* L.	Chhoti duddhi, Makikitot	Euphorbiaceae	Herb	IWMED, 2001	(+)	
88	*Euphorbia tithymaloides* L.	Jew Bush	Euphorbiaceae	Herb		(+)	Ornamental
89	*Evolvulus alsinoides* (L.) L.	Dwarf Morning Glory	Convolvulaceae	Herb		(+)	Weed
90	*Evolvulus nummularius* (L.) L.	Musakarni	Convolvulaceae	Herb	IWMED, 2001	(+)	Weed
91	*Excoecaria cochinchinensis* Lour.	Chinese croton	Euphorbiaceae	Shrub		(+)	Ornamental
92	*Ficus pumila* L.	Creeping Fig	Moraceae	Climber		(+)	Ornamental
93	*Gnaphalium luteoalbum* L.	Weedy Cudweed	Asteraceae	Herb		(+)	Weed
94	*Heliotropium indicum* L.	Herb	Boraginaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Medicinal

95	*Hemidesmus indicus* (L.) R.Br.	Indian sarsaparilla	Asclepiadaceae	Liana		(+)	Medicinal
96	*Hemigraphis hirta* (Vahl) T.Anderson	Hairy Hemigraphis	Acanthaceae	Herb		(+)	Weed
97	*Hibiscus rosa-sinensis* L.	China rose	Malvaceae	Shrub		(+)	Ornamental
98	*Hodgsonia macrocarpa* (Blume) Cogn.	Lard seed	Cucurbitaceae	Climber		(+)	Edible
99	*Hydrocotyle sibthorpioides* Lam.	Lawn marshpennywort	Araliaceae	Herb		(+)	
100	*Hymenocallis littoralis* (Jacq.) Salisb.	Beach Spider lily	Amaryllidaceae	Herb		(+)	Ornamental
101	*Ipomoea aquatica* Forssk.	Water Morning Glory	Convolvulaceae	Herb		(+)	Edible
102	*Ipomoea cairica* (L.) Sweet	Messina creeper	Convolvulaceae	Herb		(+)	Ornamental
103	*Ipomoea marginata (Desr.) Verdc. (Syn.Ipomoea sepiaria Koenig ex Roxb.)*	Purple Heart Glory	Convolvulaceae	Herb	Ghosh, 2010	(+)	Ornamental
104	*Ipomoea obscura* (L.) Ker Gawl.	Obscure Morning	Convolvulaceae	Herb	Ghosh, 2010	(+)	
105	*Ixora barbata* Roxb. ex Sm.	Ixora	Rubiaceae	Shrub		(+)	Ornamental
106	*Ixora chinensis* Lam.	Jungle Geranium	Rubiaceae	Shrub		(+)	Ornamental
107	*Ixora coccinea* L.	Jungle flame	Rubiaceae	Shrub		(+)	Ornamental
108	*Ixora grandifolia* Zoll. & Moritzi	Ixora	Rubiaceae	Shrub		(+)	Ornamental
109	*Jasminum multiflorum* (Burm.f.) Andrews	Star Jasmine	Oleaceae	Shrub		(+)	Ornamental
110	*Jasminum sambac* (L.) Aiton	Arabian jasmine	Oleaceae	Shrub		(+)	Ornamental
111	*Jatropha integerrima* Jacq.	Peregrina	Euphorbiaceae	Herb		(+)	Ornamental
112	*Jatropha podagrica* Hook.	Buddha belly plant	Euphorbiaceae	Herb		(+)	Ornamental
113	*Justicia gendarussa* Burm.f.	Willow-leaved justicia	Acanthaceae	Shrub		(+)	Medicinal
114	*Justicia prostrata* Schltdl. ex Nees	Bell Weed	Acanthaceae	Herb		(+)	Medicinal
115	*Kalanchoe pinnata* (Lam.) Pers.	Cathedral Bells	Crassulaceae	Herb		(+)	Ornamental
116	*Kopsia fruticosa* (Roxb.) A.DC.	Pink Kopsia	Apocynaceae	Shrub		(+)	Ornamental

117	*Kyllinga bulbosa* P.Beauv.	White Water Sedge	Cyperaceae	Herb		(+)	Medicinal
118	*Lantana camara* L. (*Lantana camara* L. var. *aculeata* (L.) Mold.)	Red Sage	Verbenaceae	Shrub	IWMED, 2001; Ghosh, 2010	(+)	Weed
119	*Laportea interrupta* (L.) Chew	Hen's Nettle	Urticaceae	Herb		(+)	Weed
120	*Leersia hexandra* Sw.	Southern cutgrass	Poaceae	Herb		(+)	Weed
121	*Leonurus sibiricus* L.	Siberian Motherwort	Lamiaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Medicinal
122	*Lindernia ciliata* (Colsm.) Pennell (Syn. *Lindernia brachiata* (Link & Otto) Biswas)	Fringed false pimpernel	Linderniaceae	Herb	IWMED, 2001	(+)	Medicinal
123	*Lygodium flexuosum* (L.) Sw.	Climbing fern	Lygodiaceae	Climber		(+)	
124	*Malpighia coccigera* L.	Singapore holly	Malpighiaceae	Shrub		(+)	Ornamental
125	*Malvastrum coromandelianum* (L.) Garcke (Syn. *Malvastrum tricuspidatum* A.Gray)	Threelobe false mallow	Malvaceae	Herb		(+)	
126	*Malvaviscus arboreus* Cav.	Sleeping hibiscus	Malvaceae	Shrub		(+)	Ornamental
127	*Manihot esculenta* Crantz	Cassava	Euphorbiaceae	Shrub		(+)	Ornamental and Edible
128	*Mecardonia procumbens* (Mill.) Small	Baby Jump Up	Plantaginaceae	Herb	IWMED, 2001	(+)	
129	*Mikania micrantha* Kunth	Bitter Vine	Asteraceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Weed
130	*Monstera dissecta* (Schott) Croat & Grayum	Monstera	Araceae	Herb		(+)	Ornamental
131	*Mucuna pruriens* (L.) DC.	Velvet bean	Fabaceae	Climber		(+)	Medicinal
132	*Mukia maderaspatana* (L.) M.Roem.	Madras pea pumpkin	Cucurbitaceae	Herb	IWMED, 2001	(+)	Medicinal
133	*Murdannia nudiflora* (L.) Brenan	Doveweed	Commelinaceae	Herb		(+)	Weed
134	*Murraya koenigii* (L.) Spreng.	Curry tree	Rutaceae	Shrub		(+)	Edible
135	*Murraya paniculata* (L.) Jack	Orange Jessamine	Rutaceae	Shrub		(+)	Ornamental
136	*Musa acuminata* Colla	Banana	Musaceae	Herb		(+)	Edible
137	*Nerium oleander* L.	Kaner;	Apocynaceae	Shrub		(+)	Ornament

		Oleander					al
138	*Nicotiana plumbaginifolia* Viv.	Tex-Mex Tobacco	Solanaceae	Herb	Ghosh, 2010	(+)	Weed
139	*Ocimum tenuiflorum* L.	Holy basil	Lamiaceae	Herb		(+)	Medicinal
140	*Oldenlandia biflora* L.	Two Flower Mille Graines	Rubiaceae	Herb	IWMED, 2001	(+)	
141	*Oldenlandia corymbosa* L.	Diamond Flower	Rubiaceae	Herb	IWMED, 2001	(+)	Medicinal
142	*Oplismenus burmannii* (Retz.) P.Beauv.	Wavy-Leaf Basketgrass	Poaceae	Herb		(+)	Weed
143	*Oplismenus compositus* (L.) P.Beauv.	Running Mountain Grass	Poaceae	Herb	IWMED, 2001	(+)	Weed
144	*Oxalis corniculata* L.	Wood Sorrel	Oxalidaceae	Herb	IWMED, 2001	(+)	Medicinal
145	*Pandanus dubius* Spreng.	Pandanus; Knob-fruited Screwpine	Pandanaceae	Shrub		(+)	Ornamental
146	*Panicum paludosum* Roxb.	Panicum grass	Poaceae	Herb		(+)	Weed
147	*Parthenium hysterophorus* L.	Congress Grass	Asteraceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Weed
148	*Passiflora suberosa* L.	Corky Passion Flower	Passifloraceae	Climber	IWMED, 2001	(+)	
149	*Pergularia daemia* (Forssk.) Chiov.	Trellis-vine	Asclepiadaceae	Liana		(+)	Medicinal
150	*Persicaria hydropiper* (L.) Delarbre	Water-pepper	Polygonaceae	Herb		(+)	Weed
151	*Persicaria orientalis* (L.) Spach	Prince's Feather	Polygonaceae	Herb		(+)	Weed
152	*Petrea volubiliis* L.	Sandpiper Vine	Verbenaceae	Liana		(+)	
153	*Phyla nodiflora* (L.) Greene (Syn. *Lippia nodiflora* (L.) Michx.)	Frog fruit,Turkey tangle	Verbenaceae	Herb	Ghosh, 2010	(+)	
154	*Phyllanthus fraternus* G.L.Webster	Bhui Awala	Phyllanthaceae	Herb		(+)	Medicinal
155	*Phyllanthus niruri* L.	Chanca Piedra	Phyllanthaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Medicinal
156	*Phyllanthus reticulatus* Poir. (Syn. *Kirganelia reticulata* (Poir.) Baill.)	Black Honey Shrub	Phyllanthaceae	Shrub	IWMED, 2001; Ghosh, 2010	(+)	Medicinal

157	*Physalis minima* L.	Wild Cape Gooseberry	Solanaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Medicinal
158	*Platycladus orientalis* (L.) Franco	Chinese thuja	Cupressaceae	Shrub		(+)	Ornamental
159	*Portulaca oleracea* L.	Pigweed	Portulacaceae	Herb	Ghosh, 2010	(+)	Edible
160	*Pouzolzia zeylanica* (L.) Benn.	Graceful Pouzolz's Bush	Urticaceae	Herb		(+)	Weed
161	*Pseudosasa japonica* (Steud.) Makino	Dwarf Bamboo	Poaceae	Shrub		(+)	Ornamental
162	*Pteris vittata* L.	Chinese brake	Pteridaceae	Herb		(+)	Ornamental
163	*Rauvolfia tetraphylla* L.	Wild Snake Root	Apocynaceae	Herb	Ghosh, 2010	(+)	Medicinal
164	*Ravenala madagascariensis* Sonn.	Traveler's palm	Strelitziaceae	Herb		(+)	Ornamental
165	*Ricinus communis* L.	Castor Bean	Euphorbiaceae	Shrub		(+)	Medicinal and Economic
166	*Rivina humilis* L.	Blood Berry	Phytolaccaceae	Herb		(+)	Weed
167	*Rorippa indica* (L.) Hiern	Indian Field-Cress	Brassicaceae	Herb	IWMED, 2001	(+)	Weed
168	*Rosa* sp.	Rose	Rosaceae	Shrub		(+)	Ornamental
169	*Ruellia prostrata* Poir.	Prostate wild petunia	Acanthaceae	Herb	Ghosh, 2010	(+)	
170	*Ruellia simplex* C.Wright	Britton's wild petunia	Acanthaceae	Herb		(+)	Ornamental
171	*Ruellia tuberosa* L.	Britton's Wild	Acanthaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	
172	*Rumex maritimus* L.	Golden dock	Polygonaceae	Herb		(+)	Weed
173	*Rungia pectinata* (L.) Nees	Comb Rungia	Acanthaceae	Herb		(+)	Weed
174	*Saccharum officinarum* L.	Sugar cane	Poaceae	Herb		(+)	Edible
175	*Salvia splendens* Sellow ex Schult.	Scarlet sage	Lamiaceae	Herb		(+)	Ornamental
176	*Scoparia dulcis* L.	Goat Weed	Plantaginaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Medicinal

177	*Senna occidentalis* (L.) Link	Coffee senna	Fabaceae	Shrub	IWMED, 2001	(+)	
178	*Senna sophera* (L.) Roxb.	Algarrobilla	Fabaceae	Shrub	IWMED, 2001; Ghosh, 2010	(+)	Medicinal
179	*Senna tora* (L.) Roxb.	Sickle Senna	Fabaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Medicinal
180	*Sesamum indicum* L.	Sesame	Pedaliaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Economic
181	*Setaria glauca* (L.) P. Beauv.	Wild Foxtail Millet	Poaceae	Herb		(+)	Weed
182	*Sida acuta* Burm.f.	Wire Weed	Malvaceae	Herb	IWMED, 2001	(+)	Medicinal
183	*Sida cordata* (Burm. F.) Borss.	Long-Stalk Sida	Malvaceae	Herb		(+)	Medicinal
184	*Sida rhombifolia* L.	Arrow leaf Sida	Malvaceae	Herb	Ghosh, 2010	(+)	Medicinal
185	*Solanum americanum* Mill. (Syn. *Solanum nigrum*)	American Black Nightshade	Solanaceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Medicinal
186	*Solanum sisymbriifolium* Lam.	Sticky Nightshade	Solanaceae	Shrub	IWMED, 2001; Ghosh, 2010	(+)	Medicinal
187	*Solanum verbascifolium* L.	Mullein nightshade	Solanaceae	Shrub	IWMED, 2001	(+)	
188	*Sonchus arvensis* L.	Field sowthistle	Asteraceae	Herb		(+)	
189	*Sphagneticola calendulacea* (L.) Pruski (Syn. *Wedelia chinensis* (Osbeck) Merr.)	Chinese Wedelia	Asteraceae	Herb	Ghosh, 2010	(+)	Medicinal
190	*Synedrella nodiflora* (L.) Gaertn.	Pig Grass	Asteraceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Weed
191	*Syngonium podophyllum* Schott	Nephthytis	Araceae	Herb		(+)	Ornamental
192	*Tiliacora racemosa* Colebr.	Vallikanjiram	Menispermaceae	Liana	IWMED, 2001	(+)	Medicinal
193	*Tinospora sinensis* (Lour.) Merr. (Syn. *Tinospora cordifolia* (Willd.) Miers)	Malabar Gulbel	Menispermaceae	Liana		(+)	Medicinal
194	*Typhonium trilobatum* (L.) Schott	Bengal Arum; Lobed Leaf Typhonium	Araceae	Herb	IWMED, 2001	(+)	

195	*Tradescantia spathacea* Sw.	Boat lily	Commelinaceae	Herb		(+)	Ornamental
196	*Trichosanthes cucumerina* L.	Snake gourd	Cucurbitaceae	Climber	IWMED, 2001	(+)	
197	*Trichosanthes dioica* Roxb.	Pointed gourd	Cucurbitaceae	Climber		(+)	Edible
198	*Trichosanthes palmata* L.	Mahakal; Chinese Cucumber	Cucurbitaceae	Climber		(+)	
199	*Tridax procumbens* (L.) L.	Coatbuttons	Asteraceae	Herb		(+)	Weed
200	*Urena lobata* L.	Caesarweed	Malvaceae	Shrub	IWMED, 2001	(+)	
201	*Vernonia elaeagnifolia* DC.	Curtain creeper	Asteraceae	Shrub		(+)	Ornamental
202	*Vigna trilobata* (L.) Verdc.	Wild gram; Three - lobe-leaf Cowpea	Fabaceae	Herb	IWMED, 2001	(+)	
203	*Woodfordia fruticosa* (L.) Kurz	Red Bell Bush	Lythraceae	Shrub		(+)	Medicinal
204	*Xanthium strumarium* L.	Common Cocklebur	Asteraceae	Herb	IWMED, 2001; Ghosh, 2010	(+)	Weed

The Schedule status of the above plants were verified and none were found to be included under IUCN tyhreat category and Wild nLife (Protection) Act (1972), though among trees, only mature tree of *Heritiera fomes* Buch.-Ham. locally known as “Sundari” in Bengali is under the category “Endangered A2cde ver.3.1” in “The IUCN Red Red List of Threatened Species (http://www.iucnredlist.org/details/178815/0 , accessed 06.04.2017; Kathiresan et al., 2010).

Census of Trees in Sarobar

Table 3.7. List of tree species observed during tree census of Rabindra Sarobar along with corresponding serial number used in preparation of census map.

Sl. No.	Name of the species	Common name	Family
1	*Acacia auriculiformis* Benth.	Akashmoni; Ear-leaf Acacia	Fabaceae
2	*Acacia nilotica* (L.) Delile	Babla	Fabaceae
3	*Adenanthera pavonina* L.	Barbados pride	Fabaceae
4	*Aegle marmelos* (L.) Corrêa	Atha Bel; Wood Apple	Rutaceae
5	*Acacia mangium* Willd.	Black Wattle	Fabaceae
6	*Ailanthus excelsa* Roxb.	Gokul; Indian tree of heaven	Simaroubaceae
7	*Albizia lebbeck* (L.) Benth.	Sirish	Fabaceae
8	*Alstonia macrophylla* Wall. ex G.Don	Hard Alstonia	Apocynaceae
9	*Alstonia scholaris* (L.) R. Br.	Chhatim	Apocynaceae
10	*Annona reticulata* L.	Nona	Annonaceae
11	*Araucaria luxurians* (Brongn. & Gris) de Laub.	Coast Araucaria	Araucariaceae
12	*Areca catechu* L.	Supari; Betel palm	Arecaceae
13	*Artocarpus integer* (Thunb.) Merr.	Kanthal	Moraceae
14	*Artocarpus lacucha* Buch.-Ham.	Monkey fruit; Deo	Moraceae
15	*Averrhoa carambola* L.	Kamranga	Oxalidaceae
16	*Azadirachta indica* A.Juss.	Neem	Meliaceae
17	Bambusa sp.1	Bans	Poaceae
18	Bambusa sp.2	Ghoti Bans	Poaceae
19	Bambusa sp.3	Sonali Bans	Poaceae
20	*Barringtonia acutangula* (L.) Gaertn.	Hijol; Indian Oak	Lecythidaceae
21	*Bauhinia purpurea* DC. ex Walp.	Rakta Kanchan	Fabaceae
22	*Bombax ceiba* L.	Lal Shimul; Cotton tree	Bombacaceae
23	*Borassus flabellifer* L.	Taal; Palmyra palm	Arecaceae
24	*Butea monosperma* (Lam.) Taub.	Palash; Flame of the forest	Fabaceae
25	*Calliandra haematocephala* Hassk.	Red powder puff	Fabaceae
26	*Callistemon brachyandrus* Lindl.	Bottle Brush	Myrtaceae
27	*Calophyllum inophyllum* L.	Alexandrian laurel balltree	Clusiaceae
28	*Caryota urens* L.	Fish tail palm	Arecaceae
29	*Cassia fistula* L.	Bandarlathi; Golden Rain Tree	Fabaceae
30	*Senna siamea* (Lam.) H.S.Irwin & Barneby	Minjri, Kassod tree	Fabaceae
31	*Castanospermum australe* A.Cunn. & C.Fraser	Black bean	Fabaceae
32	*Casuarina equisetifolia* L.	She-oak	Casuarinaceae
33	*Toona ciliata* M.Roem	Tun	Meliaceae
34	*Ceiba pentandra* (L.) Gaertn.	Sada Shimul	Bombacaceae

35	*Citrus maxima* (Burm.) Merr.	Batabi lebu; Pommelo	Rutaceae
36	*Citrus lemon* (L.) Osbeck	Lebu	Rutaceae
37	*Cocos nucifera* L.	Narkel; Coconut	Arecaceae
38	*Colvillea racemosa* Bojer	Pitchura; Colville's Glory	Fabaceae
39	*Cordia sebestena* (Willd.) ex Spreng.	Scarlet Cordia	Boraginaceae
40	*Couroupita guianensis* Aubl.	Nagalingam; Cannon Ball Tree	Lecythidaceae
41	*Crescentia cujete* L.	Belaiti Bel; Begger's Bowl	Bignoniaceae
42	*Dalbergia lanceolaria* L.f.	Takoli	Fabaceae
43	*Dalbergia sissoo* DC.	Sisoo	Fabaceae
44	*Delonix regia* (Hook.) Raf.	Gulmohor	Fabaceae
45	*Dillenia indica* Balanco	Chalta	Dilleniaceae
46	*Dimocarpus longan* Lour.	Aans Fal	Sapindaceae
47	*Diospyros ebenum* Koenig ex Retz.	Gaab	Ebenaceae
48	*Erythrina arborescens* Roxb.	Madar	Fabaceae
49	*Euphorbia neriifolia* L.	Mansa	Euphorbiaceae
50	*Eucalyptus globulus* Labill.	Potash	Myrtaceae
51	*Ficus benghalensis* L.	Bot; Banyan	Moraceae
52	*Ficus benjamina* L.	Weeping fig	Moraceae
53	*Ficus elastica* Roxb. ex Hornem.	Rubber fig	Moraceae
54	*Ficus geniculata* Kurz	Dotted fig	Moraceae
55	*Ficus hispida* L.f.	Dumur; Hairy Fig	Moraceae
56	*Ficus racemosa* L. (Syn. *Ficus glomerata* Roxb.)	Joggo Dumur; Cluster Fig tree	Moraceae
57	*Ficus religiosa* L.	Ashattha; Peepal	Moraceae
58	*Ficus rumphii* Bl.	Pakur; Mock Peepul tree	Moraceae
59	*Ficus virens* Aiton (Syn. *Ficus infectoria* (Miq.) Miq.)	White fig	Moraceae
60	*Gardenia jasminoides* J.Ellis	Gandhoraj; Cape jasmine	Rubiaceae
61	*Gelonium multiflorum* A.Juss.	False lime	Euphorbiaceae
62	*Gliricidia sepium* (Jacq.) Walp.	Quick stick	Fabaceae
63	*Gmelina arborea* Roxb.	Beech wood; Gamar	Lamiaceae
64	*Grevillea robusta* A. Cunn. Ex R.Br.	Silver Oak	Proteaceae
65	*Grewia asiatica* L.	Falsa	Tiliaceae
66	*Hamelia patens* Jacq.	Scarlet bush	Rubiaceae
67	*Heritiera fomes* Buch.-Ham.	Sundari	Sterculiaceae
68	*Holarrhena pubescens* Wall. & G. Don	Kurchi	Apocynaceae
69	*Trachycarpus martianus* (Wall. ex Mart.) H.Wendl.	Fan Palm	Arecaceae
70	*Jacaranda mimosifolia* D.Don	Jacaranda	Bignoniaceae
71	*Kigelia africana* (Lam.) Benth. (Syn. *Kigelia pinnata* (Jacq.) DC.)	Sausage Tree	Bignoniaceae
72	*Kleinhovia hospita* L.	Guest tree	Malvaceae

73	*Lannea coromandelica* (Houtt.) Merr.	Jiol	Anacardiaceae
74	*Lagerstroemia speciosa* (L.) Pers.	Jarul; Queen's crepe-myrtle	Lythraceae
75	*Lepisanthes tetraphylla* Radlk.	Kannada	Sapindaceae
76	*Leucaena leucocephala* (Lam.) de Wit	Subabul	Fabaceae
77	*Limonia acidissima* Houtt.	Koth bel	Rutaceae
78	*Litchi chinensis* Sonn.	Lichu	Sapindaceae
79	*Litsea glutinosa* (Lour.) C.B.Rob.	Ledachhal; Indian laurel	Lauraceae
80	*Madhuca longifolia* var. *latifolia* (Roxb.) A.Chev.	Indian Butter Tree; Mahua	Sapotaceae
81	*Michelia champaca* L.	Champa	Magnoliaceae
82	*Mangifera indica* L.	Aam; Mango	Anacardiaceae
83	*Manilkara hexandra* Dubard	Khir Kul	Sapotaceae
84	*Manilkara zapota* (L.) Royen	Sabeda	Sapotaceae
85	*Mimusops elengi* L.	Bakul; Spanish cherry	Sapotaceae
86	*Moringa oleifera* Lam.	Sajina; Drumstick tree	Moringaceae
87	*Morus alba* L.	Tunt; White mulberry	Moraceae
88	*Murraya exotica* L.	Kamini	Rutaceae
89	*Neolamarckia cadamba* (Roxb.) Bosser	Kadam; Cadamba	Rubiaceae
90	*Nyctanthes arbor-tristis* L.	Siuli	Oleaceae
91	*Millingtonia hortensis* L.f.	Parijat	Bignoniaceae
92	*Peltophorum pterocarpum* (DC.) K.Heyne	Radhachura	Fabaceae
93	*Phoenix roebelenii* O'Brien	Pygmy Date Palm	Arecaceae
94	*Phoenix sylvestris* (L.) Roxb.	Khejur; Date Palm	Arecaceae
95	*Pithecellobium dulce* (Roxb.) Benth./*Inga dulce*	Jilabi; Manilla Tamarind	Fabaceae
96	*Plumeria alba* L.	White fragipani	Apocynaceae
97	*Polyalthia longifolia* (Sonn.) Thwaites	Debdaru	Annonaceae
98	*Pongamia pinnata* (L.) Pierre	Karanja; Indian beech	Fabaceae
99	*Psidum guajava* L.	Peara; Guava	Myrtaceae
100	*Pterygota alata* (Roxb.) R. Br.	Buddha Coconut	Sterculiaceae
101	*Pterospermum acerifolium* (L.) Willd.	Muchkunda; Kanak Champa	Sterculiaceae
102	*Punica granatum* L.	Dalim; Pomegranate	Lythraceae
103	*Putranjiva roxburghii* Wall.	Putijia	Putranjivaceae
104	*Albizia saman* (Jacq.) Merr.	Khirish; Rain Tree	Fabaceae
105	*Saraca asoca* (Roxb.) Willd.	Asok; Asoca	Fabaceae
106	*Schleichera oleosa* (Lour.) Oken	Kusum; Ceylon oak	Sapindaceae
107	*Spathodea campanulata* P.Beauv.	Rudra Palash; African tuliptree	Bignoniaceae
108	*Sterculia foetida* L.	Baxo Badam; Poon tree	Sterculiaceae
109	*Streblus asper* Lour.	Shaora; Sand Paper Tree	Moraceae
110	*Swietenia mahogani* L.	Chotopata Mahogani	Meliaceae
111	*Swietenia macrophylla* King	Boropata Mahogani	Meliaceae
112	*Syzygium cumini* (L.) Skeels	Guri Jaam; Jamun	Myrtaceae

113	*Syzygium jambolanum* (Lam.) DC.	Boro Jaam	Myrtaceae
114	*Syzygium samarangense* (Blume) Merr. & L.M.Perry	Jamrul	Myrtaceae
115	*Handroanthus chrysanthus* (Jacq.) S.O.Grose	Yellow Ipe	Bignoniaceae
116	*Roseodendron donnell-smithii* (Rose) Miranda	Primavera	Bignoniaceae
117	*Tabebuia rosea* (Bertol.) Bertero ex A.DC.	Pink Trumpet Tree	Bignoniaceae
118	*Tabernaemontana divaricata* (L.) R.Br. ex Roem. & Schult.	Kath Tagar	Apocynaceae
119	*Tamarindus indica* L.	Tentul; Tamarind	Fabaceae
120	*Tecoma stans* (L.) Juss. ex Kunth	Yellow trumpetbush	Bignoniaceae
121	*Tectona grandis* L.f.	Segun	Verbenaceae
122	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.	Arjun	Combretaceae
123	*Terminalia bellirica* (Gaertn.) Roxb.	Bahera; Beleric	Combretaceae
124	*Terminalia catappa* L.	Kath Badam; Malabar-almond	Combretaceae
125	*Thespesia populnea* (L.) Sol. ex Corrêa	Parash Peepul; Portia tree	Malvaceae
126	*Cascabela thevetia* (L.) Lippold (Syn. *Thevetia peruviana* (Pers.) K. Schum.)	Kolke	Apocynaceae
127	*Trema orientalis* (L.) Blume	Pigeon wood	Cannabaceae
128	*Trewia nudiflora* Wight	Pituli; False white teak	Euphorbiaceae
129	*Roystonea regia* (Kunth) O.F.Cook	Royal palm	Arecaceae
130	*Ziziphus mauritiana* Lam.	Topakul; Ber	Rhamnaceae
131	*Wodyetia bifurcata* A.K.Irvine	Foxtail palm	Arecaceae

(F) Terrestrial Macrofungi

Table 3.8. List of macrofungi of Rabindra Sarobar belonging to Ascomycota

Sl. No.	Scientific Name	Common Name	Family	Habitat
1	*Daldinia concentrica* (Bolton) Ces.& De Not.	King Alfred's Cake; Cramp balls	Xylariaceae	Upon fallen hardwood log
2	*Hypoxylon haematostroma* Mont.		Xylariaceae	Upon fallen hardwood log
3	*Xylaria multiplex* (Kunze) Fr.		Xylariaceae	Upon fallen hardwood log
4	*Xylaria symploci* A. Pande, Waingankar, Punekar & Ranadive		Xylariaceae	Upon fallen hardwood log

Table 3.9. List of macrofungi of Rabindra Sarobar belonging to Basidiomycota

Sl. No.	Scientific Name	Common Name	Family	Habitat
1	*Amylosporus campbellii* (Berk.) Ryvarden.		Bondarzewiaceae	Upon cut stumps of Bamboo
2	*Auricularia mesenterica* (Dicks.) Pers.	Wood ear fungus	Auriculariaceae	Upon fallen hardwood log
3	*Cellulariella acuta* (Berk.) Zmitr. & V. Malysheva		Polyporaceae	Upon dead hardwood log
4	*Ceriporia xylostromatoides* (Berk.) Ryvarden		Phanerochaetaceae	Upon dead hardwood log
5	*Coprinopsis cinerea* (Schaeff.) Redhead, Vilgalys & Moncalvo	Khar Chhatu (Bangla)	Psathyrellaceae	Growing saprophytically upon decaying heap of straw
6	*Duportella tristicula* (Berk. & Broome) Reinking		Peniophoraceae	On the fallen branches of Albizia saman
7	*Earliella scabrosa* (Pers.) Gilb. & Ryvarden		Polyporaceae	Upon dead hardwood log
8	*Flavodon flavus* (Klotzsch) Ryvarden		Meruliaceae	Upon fallen hardwood log
9	*Fuscoporia senex* (Nees & Mont.) Ghob.-Nejh.		Hymenochaetaceae	Upon dead hardwood log
10	*Ganoderma applanatum* (Pers.) Pat.		Ganodermataceae	At the base of living hardwood
11	*Ganoderma lucidum* (Curtis) P. Karst.		Ganodermataceae	At the base of living hardwood
12	*Ganoderma philippii* (Bres. & Henn. Ex Sacc.) Bres		Ganodermataceae	At the base of living hardwood
13	*Ganoderma stipitatum* (Murrill) Murrill		Ganodermataceae	At the base of living hardwood
14	*Grammothele fuligo* (Berk. & Broome) Ryvarden		Polyporaceae	Upon dead stump of *Cocos* sp./ Palm
15	*Hjortstamias friesii* (Lév.) Boidin & Gilles		Phanerochaetaceae	On the fallen log of *Cassia* sp.
16	*Inonotus pachyphloeus* (Pat.) T. Wagner & M. Fisch.		Hymenochaetaceae	On dead branch of *Ficus* sp.

17	*Lentinus* sp.	Kath Chhatu (Bangla)	Polyporaceae	Growing saprophytically upon *Eucalyptus* logs used to guard bank of Lake
18	*Microporus xanthopus* (Fr.) Kuntze		Polyporaceae	Upon fallen hardwood
19	*Phanerochaete sordida* (P. Karst.) J. Erikss. & Ryvarden		Phanerochaetaceae	On fallen dead branch of *Mangifera indica*
20	*Phellinus allardii* (Bres.) S. Ahmad		Hymenochaetaceae	Upon living hardwood
21	*Phellinus badius* (Cooke) G. Cunn.		Hymenochaetaceae	Upon living hardwood
22	*Phellinus gilvus* (Schwein.) Pat.		Hymenochaetaceae	Upon living hardwood
23	*Phylloporia pectinata* (Klotzsch) Ryvarden		Hymenochaetaceae	Upon dead branch of *Ficus virens*
24	*Pluteus cervinus* (Schaeff.) P. Kumm.	Khar Chhatu (Bangla)	Pluteaceae	Growing saprophytically upon decaying heap of straw
25	*Polyporus grammocephalus* Berk.		Polyporaceae	Upon fallen hardwood
26	*Pycnoporus sanguineus* (L.) Murrill		Polyporaceae	Upon fallen hardwood
27	*Schizophyllum commune* Fr.		Schizophyllaceae	Upon fallen hardwood
28	*Scytinostroma duriusculum* (Berk. & Broome) Donk		Lachnocladiaceae	Upon dead branches of *Putranjiva roxburghii*
29	*Trametes apiaria* (Pers.) Zmitr.,Wasser & Ezhov		Polyporaceae	Upon fallen hardwood
30	*Trametes cingulata* Berk.		Polyporaceae	Upon fallen hardwood
31	*Trametes lactinea* (Berk.) Sacc.		Polyporaceae	On the dead branches of *Pithecellobium dulce*
32	*Trametes leonina* (Klotzsch) Imazeki		Polyporaceae	Upon fallen hardwood
33	*Ganoderma* sp.1	Kath Chhatu (Bangla)	Ganodermataceae	Growing parasitically upon base of *Delonix regia*
34	*Ganoderma* sp.2	Kath Chhatu (Bangla)	Ganodermataceae	Growing parasitically upon base of living *Leucaena leucocephala* tree

The cachment area of the lake ecosystem offers various sets of unique habitat for growth of macrofungi viz. living plants, litters, dead and decaying trunk, soil, moreover, fortified with the moisture emanating from the lake. Considering the availability of 34 species of macrofungi even in dry pre-monsoon condition, it may be proposed that the area should also be able to host manifold number of tropical mushrooms commonly called cups and saucers, puff-balls, crusts, jelly, earthstars, bird nests, bracket fungi etc. on arrival of favourable monsoon period.

Presence of saprophytic macrofungi in an ecosystem is beneficial as they help in natural recycling of nutrients. Many macrofungi like Polypores, Boletes, Russulas are important staple foods for many small organisms thus playing roles in the food chain as well as ecological succession. However, polypore fungi are responsible for majority of parasitic fungal incidence of trees. *Ganoderma* in particular is a common parasite of deciduous trees causing white rots and heart rot. Such fungal pathogenic incidence in trees of Rabindra Sarobar invites regular control, if not eradication and periodic followup for pest management.

Since the area has the ambience of anthropogenic interference (public transport, sports complex, amusements), exploration and study of macrofungi in the concerned area is of high significance. The present study gives a glimpse of macrofungal flora of pre-monsoon period for the area. Repeated survey for many seasonal variations in multiple years may bring forth valuable information regarding the macrofungal wealth of Rabindra Sarobar and its premises.

No species under "schedule" of Wild life Protection act, 1972 (http://www.moef.nic.in/legis/wildlife/wildlife2s6.pdf) was recorded during this study.

G) Classification of vascular plants/phytoplankton/fungi as per Schedule

Plants recorded in the study area were checked for Classification of existing plants according to "schedule" under Wild life Protection act, 1972, which was verified from website of Ministry of Environment, Forests and Climate Change (http://www.moef.nic.in/legis/wildlife/wildlife2s6.pdf). From the perusal of the same, only mature tree of *Heritiera fomes* Buch.-Ham. locally known as "Sundari" in Bengali came under the category "**Endangered A2cde ver.3.1**" in "The IUCN Red List of Threatened Species (http://www.iucnredlist.org/details/178815/0 , accessed 06.04.2017; Kathiresan et al., 2010).

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4.0. Faunal Diversity of Rabindra Sarobar and its premises

The State of West Bengal is adorned with remarkable richness of faunal species. So far, a lot of work on faunal diversity has already been done. The known faunal diversity of the State consists of 11,042 species, out of 91,771 species present in our country and 12, 39,166 in the world. It appears that the State is represented by 12.03% of the world's fauna (Sanyal *et al.* 2012).

Although not many studies have been done on the fauna of Rabindra Sarovar by earlier workers, records show some earlier studies on insects like Ants (Hymenoptera: Formicidae) by Ghosh *et al.* 2005; Chalcididae (Hymenoptera: Chalcidoidae) by Sheela and Tiwari 2004; Butterfly diversity by Ghosh and Siddiqui 2005 and Socoptera by Ray 1979. Besides insects group Protozoan by Bindu 2009, 2010; Earthworms by Halder *et. al.* 2007 and several study on physiochemical and biological parameters were done by Khan and Sinha (2002).

4.1. Materials and Methods

A) General Methodology

To study faunal diversity data was collected for a period of two months from February 2017 to March 2017. For schedule survey works sites were selected keeping in mind the anthropogenic factors like human interferences. Visits were made to all the selected locations preferably in the morning hours as most of the animals (insects, butterflies, birds, mammals, etc.) remain active during this hour. The listed species were thoroughly checked against the IUCN Red List of Threatened Species (*Ver. 3.1*) and Wildlife (Protection) Act, 1972 of India and their respective status is mentioned against individual species, when available. The detailed methodologies that were followed for various faunal groups are as follows –

a) Invertebrates

i) Zooplanktons

Plankton samples were collected by filtering 50 litres of surface water through 63 µm mesh size nylon plankton net and preserved in 4% formalin. During collection of surface water samples macrophytes were avoided. Investigations were carried out qualitatively and quantitatively. Taxonomic identification of zooplanktons was done following the standard literature, like - Battish (1992), Dhanapathi (2000), Edmondson (1959), Michael and Sharma (1988), and Sharma (1998). Quantitative enumeration of zooplankton and their constituent groups was done with a Sedgewick-Rafter counting cell. A comprehensive checklist of the Zooplanktons of Rabindra Sarovar was prepared by consulting existing literature and is represented in Table - 4.2.

ii) Insects

The insects specimens like Hymenoptera, Coleoptera, Hemioptera etc.were collected by the sweeping method and with the help of aspirator during the field visits of Rabindra Sarobar from mornings to late afternoons. Later these collected insects were identified in the laboratories of Zoological Survey of India, Kolkata by consulting relevant taxonomic literatures. Comprehensive checklists of Hemiptera (Bugs), Coleoptera (Beetles), Chalcids, and Psocopterans of Rabindra Sarovar were prepared by consulting existing literature and represented in Tables 4.3-4.9.

iii) Ants (Hymenoptera: Formicidae)

Ants were collected mostly by hand picking. Ants were identified by using standard literature (Bingham 1903, Bolton 1995). A comprehensive checklist of the ants of Rabindra Sarovar was prepared by consulting existing literature and represented in Table -4.7.

iv) Butterflies (Lepidoptera: Rhopalocera)

To study the butterfly diversity, paths around Rabindra Sarovar were used as fixed transects. Total four such transects were selected which almost covered the entire area. Each transect within the study area was visited once in every week during 8:00-11:00 Hrs. on bright sunny days with no rainfall. The butterflies were observed and recorded directly in the field. Enough precautions were taken, so that by no means the entire procedure can cause any damage to the target specimens. Photos of butterflies were taken using Canon EOS 7D DSLR Camera & Canon EF 100mm F/2.8 USM Macro Lens (Canon Inc., Japan) and preserved for future references. Identification of butterflies was done in the field using standard literature (Kunte 2000, Kehimkar 2008). A comprehensive checklist of the butterflies of Rabindra Sarovar was prepared and represented in Table -4.8.

v) Dragonflies & Damselflies (Odonata)

Adult dragonflies were surveyed between 8:00-11:00 Hrs. by direct search technique. Opportunistic observations have also been included in the present list (Table-9). The species were photographed using DSLR camera (Canon EOS 7D DSLR & EF 100mm F/2.8 USM Macro Lens; Canon Inc., Japan) and identified with the help of standard field guide (Subramanian 2009).

vi) Mollusca (Freshwater)

To collect data on the benthic fauna of the lake ecosystems, sampling was done from different sites of the lake, along the Littoral bottom zone extending from the lake margin to 3 m from the shore, usually surrounded by rooted aquatic vegetation. Survey/sampling was conducted over a period of one day.

Seven particular areas *viz.*, stations 1-7 (Table-4.10) were selected for sampling of benthic fauna in the lake. Sampling was done from each station by means of a box-type sampler (23 x 24.5 cm^2).

Species level identification was done by using 'Hand book: fresh water molluscs of India' (Subba Rao 1989). A comprehensive checklist of the molluscan species of Rabindra Sarovar was prepared by consulting existing literature and is represented in Table-4.11.

b) Vertebrates

i) Fishes (Chordata: Pisces)

Fish sampling was performed at different sites in Rabindra Sarovar. Hand nets (microfilament gill nets) of different mesh sizes were used for dragging. Sampling was conducted during early morning between 7:00-9:00 Hrs. All the species captured were released in the water without causing any harm. Species identification and confirmation were carried out using standard fish taxonomy textbooks (Jayaram 1981, Talwar and Jhingram 1991). Apart from that, to get the secondary information regarding fish diversity, people who live adjacent to Rabindra Sarovar were interviewed through semi-structured questionnaire. A comprehensive checklist of the fishes of Rabindra Sarovar was prepared by consulting existing literature and is represented in Table-4.12.

ii) Amphibians (Chordata: Amphibia)

Amphibian sampling was performed at different sites in Rabindra Sarovar using three different techniques. Visual surveys (through direct sighting method) were performed around the lake edges during day hours. The areas where the lake has submerged vegetation, searching was done by netting. The amphibians that were captured through netting were released in the same habitat after identification. At dusk the lake area was again searched from the bank using flashlight. Standard literature (Chanda 2002, Daniels 2004) was used for

field identification. A comprehensive checklist of the Amphibians of Rabindra Sarovar was prepared and is represented in Table-4.13.

iii) Reptiles (Chordata: Reptilia)

Reptiles are cold-blooded animals and they warm up by basking under direct sunlight or lying over warm objects. Direct search methods were applied for reptilian survey. During cool weather the animals need to bask for longer duration. The edges of vegetation and sheltered areas were also searched for recording their presence. When possible photographs were taken by using Canon EOS 7D DSLR Camera & Canon EF 100-400 mm F/4-5.6L IS II USM Lens (Canon Inc., Japan) and kept for further references. For identification standard literature was consulted (Whitaker and Captain 2004). A comprehensive checklist of the Reptiles of Rabindra Sarovar was prepared and is represented in Table-4.14.

iv) Birds (Chordata: Aves)

The fixed paths around the lake were used as permanent transects. Total four such transects were selected which almost covered the entire area. Each transect was walked in between 6:00-9:00 Hrs. atleast once a week during the study period. While walking at a constant pace along the transect birds that were encountered within 10m on both sides were noted. Birds flying overhead were also recorded. A Nikon 8×42 (Nikon Corporation, Japan) binocular was used for observation. In addition to the fixed transects, opportunistic sightings of birds also recorded. A large number of birds that perches on the trees in the islands were observed from the bank of the lake. Standard literature (Grimmett *et al.* 2011) was used for field identification; also, conspicuous birds were identified by hearing their calls. When possible photographs of birds were taken by using Canon EOS 7D DSLR Camera & Canon EF 100-400 mm F/4-5.6L IS II USM Lens (Canon Inc., Japan) and kept for further references. A comprehensive checklist of the birds of Rabindra Sarovar was prepared by consulting existing literature and is represented in Table -4.15.

v) Mammals (Chordata: Mammalia)

To study the diversity of mammalian species, transect method was adopted. Paths around Rabindra Sarovar were used as fixed transects. Total four such transects were selected which almost covered the entire area. Entire length of each transect was trekked early in the morning atleast once a week. However, rodents and chiropterans (bats) were observed during evening hours. For identification, the books by Prater (1971) and Menon (2003) were followed. The area was also searched for obtaining indirect evidences like pug marks, scats etc. A comprehensive checklist of the mammals of Rabindra Sarovar was prepared by consulting existing literature and is represented in Table -4.16.

B) Results and Discussion

a) Invertebrates

i) Zooplankton

A total of 51 zooplanktons belonging to 18 families (Table 4.2) were observed. Sub-family Chydoridae represents highest number of species (17) followed by sub-family Brachionidae (8 species). Conservation status of each species was evaluated against the IUCN Red List of Threatened Species (*Ver. 3.1*) and Wildlife (Protection) Act, 1972 respectively. However, not a single species is mentioned in those lists.

ii) Insects

A total of 4 Hemipteran species (Bugs) of belonging to 4 families, 1 Coleopteran species (Beetles) under 1 family, 12 Chalcids belonging to 2 families, 3 Psocopteran species under 2 families, and 14 Protozoan species distributed under 10 families were recorded (both from primary data and secondary sources) (Table 4.3-4.6). Conservation status of each species was evaluated against the IUCN Red List of Threatened Species (*Ver. 3.1*) and Wildlife (Protection) Act, 1972 respectively. However, not a single species is mentioned in those lists.

iii) Ants (Hymenoptera: Formicidae)

A total of 29 ant species belonging to 5 families (Table-4.7) were observed (both from primary data and secondary sources). Sub-family Myrmicinae represents highest number of species (17). Conservation status of each species was evaluated against the IUCN Red List of Threatened Species (*Ver. 3.1*) and Wildlife (Protection) Act, 1972 respectively. However, not a single species is mentioned in those lists.

iv) Butterflies (Lepidoptera: Rhopalocera)

In the present study, a total of 57 butterfly species belonging to 13 sub-families under 5 families (Table-4.8) were observed. Sub-family Polyommatinae represents highest number of species (14). Conservation status of each species was evaluated against the IUCN Red List of Threatened Species (*Ver. 3.1*) and Wildlife (Protection) Act, 1972 respectively. Not a single species is mentioned in the IUCN Red List. However, three butterflies (namely Pointed Ciliate Blue, Gram Blue and Pea Blue) and two butterflies (namely Striped Albatross and Paintbrush Swift) were listed under Schedule II Part II and Schedule IV of IWPA, 1972 respectively. It is to be noted that butterfly population is very much influenced by various seasons. Therefore, a year-long study may reveal many other species.

v) Dragonflies & Damselflies (Insecta: Odonata)

In the present study, a total of 13 species of dragonflies and damselflies (Odonates) belonging to 2 families under 2 sub-order (Table 4.9) were observed. Family Libellulidae

represents highest number of species (8). Conservation status of each species was evaluated against the IUCN Red List of Threatened Species (*Ver. 3.1*) and Wildlife (Protection) Act, 1972 respectively and has already been mentioned in the table. Saffron-faced Blue Dart and Ditch Jewel were the most common species.

vi) Mollusca (Freshwater)

A total of 20 molluscan species belonging to 9 families (Table-4.11) were observed (both from primary data and secondary sources). Family Thiaridae represents highest number of species (5). Conservation status of each species was evaluated against the IUCN Red List of Threatened Species (*Ver. 3.1*) and Wildlife (Protection) Act, 1972 respectively and already been mentioned in the table.

b) Vertebrates

i) Fishes (Chordata: Pisces)

In the present study, a total of 40 freshwater fish species belonging to 18 families under 7 orders (Table-4.12) were observed (both from primary data and secondary sources). Family Cyprinidae represents highest number of species (17). Conservation status of each species was evaluated against the IUCN Red List of Threatened Species (*Ver. 3.1*) and Wildlife (Protection) Act, 1972 respectively. Two fishes namely Feather Back (Folui) and Giant Gourami (Kholisa) are evaluated as Near Threatened in the IUCN Red List.

ii) Amphibians (Chordata: Amphibia)

In the present study, a total of 5 amphibian species belonging to 3 families (Table-4.13) were observed. Family Dicroglossidae represents highest number of species (3). Conservation status of each species was evaluated against the IUCN Red List of Threatened Species (*Ver. 3.1*) and Wildlife (Protection) Act, 1972 respectively. Indian Bull Frog is listed in the Schedule IV of the IWPA, 1972.

iii) Reptiles (Chordata: Reptilia)

In the present study, a total of 11 reptilian species belonging to 6 families (Table-4.14) were observed. Family Colubridae represents highest number of species (4). Among reptiles were two species of turtles (Indian Flap-shell Turtle and Indian Roofed Turtle) that were regularly seen basking on floating logs in winter. Both of these belong to the Schedule I Part II of IWPA, 1972 and need to be protected. Two other species (namely Monocellate Cobra and Chequered Keelback Snake) are listed under Schedule II Part II of IWPA, 1972.

iv) Birds (Chordata: Aves)

In the present study, a total of 107 bird species (both from primary data and secondary sources) belonging to 46 families (Table-4.15) were observed, of which 69 were non-migratory or resident species, 23 were long-distant migrant, 14 species were local

migrant, and one species was summer visitor. Family Muscicapidae represents highest number of species (13). Except few, most of the non-migratory birds were found to be nesting on the trees at the Rabindra Sarobar. Some of the resident birds like Cormorants, Egrets, Storks, Night Herons, and Pond Herons nest regularly on two islands inside the lake. These islands have few trees but due to pressure of nesting, all the trees have been denuded of their leaves and flowers as the dung, guano excreted daily by these birds have a lot of white uric acid crystals. Sooner or later all these trees will die and the birds will have no proper nesting place. None of the migratory species were found to be nesting at the lake area. White-rumped Vulture is listed in Schedule I Part III of IWPA, 1971 and the same is listed as Critically Endangered in IUCN Red List of Threatened Taxa. However, during the present study no White-rumped Vulture was observed either flying or perching. A total 70 bird species is listed under Schedule IV of IWPA, 1972.

v) Mammals (Chordata: Mammalia)

In the present study, a total of 10 mammalian species belonging to 8 families under 5 orders (Table-4.16) were observed (both from primary data and secondary sources). Families Muridae and Viverridae both represent highest number of species (2). Conservation status of each species was evaluated against the IUCN Red List of Threatened Species (*Ver. 3.1*) and Wildlife (Protection) Act, 1972 respectively. Indian Grey Mongoos, Common Palm Civet and Small Palm Civet are listed in the Schedule II Part I of the IWPA, 1972. Five-striped Palm Squirrel was the most common species as it was frequently encountered at the time of survey.

Nocturnal mammals, reptiles, amphibians etc. were less studied and when fully documented, the species list of each group is likely to increase further.

No comprehensive studies on the Insect/Arachnid fauna of Rabindra Sarobar have so far been made that really have any idea of the possible number of taxa inhabiting the area to give a comprehensive zoogeographic treatment. Hence, in absence of any adequate/ sufficient data on the Insect/Arachnid fauna of Rabindra Sarobar it is too early to establish the existence of dominant group of taxa.

C) Discussion

As a part of rapid EIA of Rabindra Sarovar evaluation of faunal resources of the area has been done based on previous reports and also present study. A concise list of species groups available in the area is depicted in Table-4.17. It is revealed on the table that no record was there in respect to Reptiles, Amphibians, Dragonflies & Damselflies, Butterflies etc. This study has enriched the list particularly of those mentioned groups which are mostly considered as the indicators of the environment. Butterflies have been studied extensively during this period and 57 species have been recorded. Besides 107 birds have been recorded, of which many are migratory species. It is clear from the study that the area in particular is an abode for diversified faunal resources. This indicates that the Rabindra sarovar is the only place which is inhabited by diversified faunal components in the concrete jungle of Kolkata.

A detailed year-long study may enhance the quality of the list. Therefore, it is imperative to say that this biodiversity-rich area should be conserved giving proper attention to it.

D) References

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Table 4.1. Diversity of Protozoans of Rabindra Sarovar

Sl. No.	Scientific Name	Common Name	Family	Order	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
1	*Chilodonella cucullus* (O. F. Müller) Ehrenberg, 1833	-	Chilodonellidae	Cryptophorida	+ (1)	-	-	-	Marine & Brackish Water
2	*Coleps hirtus* (Müller, 1786)	-	Colepidae	Prostomatida	+ (1)	-	-	-	
3	*Colpoda aspera* Kahl, 1926	-	Colpodidae	Colpodida	+ (1)	-	-	-	
4	*Holophrya annandalei* Ghosh, 1919	-	Holophryidae	Prostomatida	+ (1)	-	-	-	
5	*Holophrya bengalensis* Ghosh, 1919	-	Holophryidae	Prostomatida	+ (1)	-	-	-	
6	*Leptopharynx torpens* Kahl, 1931	-	Leptopharyngidae	Nassulida	+ (1)	-	-	-	
7	*Loxodes magnus* Stokes, 1887	-	Loxodidae	Karyorelictida	+ (1)	-	-	-	
8	*Loxodes striatus* (Englemann, 1862)	-	Loxodidae	Karyorelictida	+ (1)	-	-	-	
9	*Loxodes vorax* Stokes, 1884	-	Loxodidae	Karyorelictida	+ (1)	-	-	-	
10	*Loxophyllum levigatum* Sauerbrey, 1928	-	Amphileptidae	Pleurostomatida	+ (1)	-	-	-	Marine
11	*Loxophyllum undulatum* Sauerbrey, 1928	-	Amphileptidae	Pleurostomatida	+ (1)	-	-	-	Marine
12	*Nassula ornata* Ehrenberg, 1833	-	Nassulidae	Nassulida	+ (1)	-	-	-	
13	*Paramecium caudatum* Ehrenberg, 1834	-	Parameciidae	Hymenostomatida	+ (1)	-	-	-	Marine
14	*Prorodon discolor* Ehrenberg, 1831	-	Prorodontidae	Prostomatida	+ (1)	-	-	-	

1. Nair KN, Das AK, Mukherjee RN. 1979. On some freshwater Rhizopoda and Heliozoa (Protozoa) from Calcutta and its Environs, Part-I. Records Zoological Survey of India. 65(Part 1-4): 1-16.

Table 4.2. Diversity of Zooplanktons of Rabindra Sarovar

Sl. No.	Scientific Name	Common Name	Family	Order	Sub-Class	Class	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
1	*Acropus harpae* (Baird, 1834)	-	Chydoridae	Cladocera	Branchipoda	Crustacea	+ (1)	-	-	-	
2	*Alona davidi* Richard, 1895	-	Chydoridae	Cladocera	Branchipoda	Crustacea	+ (1)	-	-	-	
3	*Alona pulchella* King, 1853	-	Chydoridae	Cladocera	Branchipoda	Crustacea	+ (1)	-	-	-	
4	*Alona quadrangularis* (O. F. Müller, 1776)	-	Chydoridae	Cladocera	Branchipoda	Crustacea	-	+	-	-	
5	*Asplanchna brightwelli* Gosse, 1850	-	Asplanchnidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
6	*Bosmina longirostris* (O. F. Müller, 1776)	-	Bosminidae	Cladocera	Branchipoda	Crustacea	+ (1)	-	-	-	
7	*Brachionus angularis* Goose, 1851	-	Brachionidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
8	*Brachionus calciflorus* Pallas, 1761	-	Brachionidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
9	*Brachionus caudatus* Barrois & Daday, 1894	-	Brachionidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
10	*Brachionus fulcatus* Zacharias, 1898	-	Brachionidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
11	*Brachionus patulus* (O. F. Müller, 1786)	-	Brachionidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
12	*Brachionus quadridentatus* Hermann, 1783	-	Brachionidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
13	*Brachionus rubens* Ehrenberg, 1838	-	Brachionidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
14	*Cephalodella gibba* (Ehrenberg, 1830)	-	Notommatidae	Ploima	Eurotifera	Crustacea	-	+	-	-	
15	*Ceriodaphnia cornuta* Sars, 1885	-	Daphnidae	Cladocera	Branchipoda	Crustacea	+ (1)	+	-	-	
16	*Chydorus barroisi* Richard,	-	Chydoridae	Cladocera	Branchipoda	Crustacea	+ (1)	-	-	-	

Sl. No.	Scientific Name	Common Name	Family	Order	Sub-Class	Class	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
	1894										
17	*Chydorus sphaericus* (O. F. Müller, 1776)	-	Chydoridae	Cladocera	Branchipoda	Crustacea	+ (1)	+	-	-	
18	*Cypris subglobosa* Sowerby, 1840	-	Cyprididae	Podocopida	Ostracoda	Crustacea	+ (1)	-	-	-	
19	*Diaphanosoma excisum* Sars, 1885	-	Sididae	Cladocera	Branchipoda	Crustacea	+ (1)	-	-	-	
20	*Diaphanosoma sarsi* Richard, 1894	-	Sididae	Cladocera	Branchipoda	Crustacea	+ (1)	-	-	-	
21	*Dunhevedia crassa crassa* King, 1853	-	Chydoridae	Cladocera	Branchipoda	Crustacea	+ (1)	-	-	-	
22	*Filinia longesita* Ehrenberg, 1834	-	Filinidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
23	*Heliodiaptomus contortus* (Gurney, 1907)	-	Calanidae	Calanoida	Copepoda	Crustacea	+ (1)	-	-	-	
24	*Heliodiaptomus viduus* (Gurney, 1916)	-	Calanidae	Calanoida	Copepoda	Crustacea	+ (1)	-	-	-	
25	*Keretella tropica* (Apstein, 1907)	-	Brachionidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
26	*Lecane aculata* (Jakubski, 1912)	-	Lecanidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
27	*Lecane (Monostyla) bulla* (Goss, 1851)	-	Lecanidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
28	*Lecane curvicornis* (Murray 1913)	-	Lecanidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
29	*Lecane leotina* (Turner, 1892)	-	Lecanidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
30	*Lecane luna luna* (O. F. Müller, 1776)	-	Lecanidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
31	*Lecane (Monostyla) hamata* (Stokes, 1896)	-	Lecanidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
32	*Macrothrix triserials* (Brady, 1886)	-	Bosminidae	Cladocera	Branchipoda	Crustacea	+ (1)	-	-	-	

Sl. No.	Scientific Name	Common Name	Family	Order	Sub-Class	Class	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
33	*Mesocyclops hyalinus* (Rehberg, 1880)	-	Cyclopidae	Cyclopoida	Copepoda	Crustacea	+ (1)	-	-	-	
34	*Mesocyclops leuckarti* (Claus, 1857)	-	Cyclopidae	Cyclopoida	Copepoda	Crustacea	+ (1)	-	-	-	
35	*Mesocyclops leuckarti* (Claus, 1857)	-	Cyclopidae	Cyclopoida	Copepoda	Crustacea	-	+	-	-	
36	*Microcyclops varicans* (Sars, 1863)	-	Cyclopidae	Cyclopoida	Copepoda	Crustacea	+ (1)	-	-	-	
37	*Monia micrura* Kurz, 1874	-	Moinidae	Cladocera	Branchipoda	Crustacea	+ (1)	-	-	-	
38	*Mytilina ventratis* (Ehrenberg, 1832)	-	Mytilidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
39	*Oxyurella singalensis* (Daddy, 1898)	-	Chydoridae	Cladocera	Branchipoda	Crustacea	+ (1)	-	-	-	
40	*Pleuroxus similis* Vavra, 1900	-	Chydoridae	Cladocera	Branchipoda	Crustacea	+ (1)	-	-	-	
41	*Polyarthra vulgaris* (Carlin, 1943)	-	Synchaetidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
42	*Pseudochydorus globosus* (Baird, 1843)	-	Chydoridae	Cladocera	Branchipoda	Crustacea	+ (1)	-	-	-	
43	*Pseudosida bidentata* Herrick, 1884	-	Sididae	Cladocera	Phyllopoda	Crustacea	-	+	-	-	
44	*Rotatoria neptunia* Ehrenberg, 1832	-	Philodinidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	
45	*Scapholebris kingi* Sars, 1903	-	Daphnidae	Cladocera	Branchipoda	Crustacea	+ (1)	+	-	-	
46	*Sida crystallina* (O. F. Müller, 1776)	-	Sididae	Cladocera	Branchipoda	Crustacea	+ (1)	-	-	-	
47	*Simocephalus expinosus* (Koch, 1841)	-	Daphnidae	Cladocera	Branchipoda	Crustacea	+ (1)	-	-	-	
48	*Simocephalus vetulus* (O. F. Müller, 1776)	-	Daphnidae	Cladocera	Branchipoda	Crustacea	+ (1)	-	-	-	
49	*Testudinella patina* (Hermann, 1783)	-	Testudinellidae	Ploimida	Eurotaria	Rotifera	+ (1)	-	-	-	

Sl. No.	Scientific Name	Common Name	Family	Order	Sub-Class	Class	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
50	*Tropocyclops prasinus* (Fischer, 1860)	-	Cyclopidae	Cyclopoida	Copepoda	Crustacea	-	+	-	-	
51	*Vorticella* sp.	-	Vorticellidae	Sessilida	Oligohymenophorea	Ciliophora	-	+	-	-	

1. Khan RA, Sinha C. 2002. Studies on the physicochemical and biological properties of two man made lake of Culcutta. Records Zoological Survey of India. 100 (Part 3-4): 1-19.

Table 4.3. Diversity of Hemiptera (Bugs) of Rabindra Sarovar

Sl. No.	Scientific Name	Common Name	Family	Order	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
1	*Chrysocoris purpureus* (Westwood, 1781)	-	Scutelleridae	Hemiptera	-	+	-	-	
2	*Dysdercus cingulatus* (Fabricius, 1775)	Red Cotton Bug	Pyrrhocoridae	Hemiptera	-	+	-	-	
3	*Leptocorisa acuta* (Thunberg, 1783)	Rice Earhead Bug	Alydidae	Hemiptera	-	+	-	-	
4	*Spilostethus hospes* (Fabricius, 1794)	-	Lygaeidae	Hemiptera	-	+	-	-	

Table 4.4. Diversity of Coleoptera (Beetle) of Rabindra Sarovar

Sl. No.	Scientific Name	Common Name	Family	Order	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
1	*Coccinella transversalis* Fabricius, 1781	Transverse Ladybird Beetle	Coccinellidae	Coleoptera	-	+	-	-	

Table 4.5. Diversity of Chalcids of Rabindra Sarovar

Sl. No.	Scientific Name	Common Name	Family	Order	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
1	*Brachymeria atteviae* Joseph, Narendran & Joy, 1972	-	Chalcididae	Hymenoptera	+ (1)	-	-	-	
2	*Brachymeria bengalensis* (Cameron, 1897)	-	Chalcididae	Hymenoptera	+ (1)	-	-	-	
3	*Brachymeria burksi* Chhotani, 1966	-	Chalcididae	Hymenoptera	+ (1)	-	-	-	
4	*Brachymeria euploeae* (Westwood, 1837)	-	Chalcididae	Hymenoptera	+ (1)	-	-	-	
5	*Brachymeria hearseyi* (Kirby, 1883)	-	Chalcididae	Hymenoptera	+ (1)	-	-	-	
6	*Brachymeria lasus* (Walker, 1841)	-	Chalcididae	Hymenoptera	+ (1)	-	-	-	
7	*Dirhinus alticornis* (Masi, 1927)	-	Chalcididae	Hymenoptera	+ (1)	-	-	-	
8	*Dirhinus auratus* Ashmead, 1905	-	Chalcididae	Hymenoptera	+ (1)	-	-	-	
9	*Neochalcis breviceps* (Masi, 1929)	-	Chalcididae	Hymenoptera	+ (1)	-	-	-	
10	*Tropimeris monodon* Boucek, 1958	-	Chalcididae	Hymenoptera	+ (1)	-	-	-	
11	*Antrocephalus fascicornis* (Walker, 1871)	-	Chalcididae	Hymenoptera	+ (1)	-	-	-	
12	*Blepyrus insularis* (Cameron, 1886)	-	Encyrtidae	Hymenoptera	-	+	-	-	

1. Sheela S, Tiwari RN. 2004. Chalcid fauna of Rabindra Sarobar. Record Zoological Survey of India. 103: 3-4.

Table 4.6. Diversity of Psocopterans of Rabindra Sarovar

Sl. No.	Scientific Name	Common Name	Family	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
1	*Archipsocus recens* Enderlein, 1903	-	Archipsocidae	+ (1)	-	-	-	
2	*Ectopsocus bengalensis* Datta, 1965	-	Peripsocidae	+ (1)	-	-	-	
3	*Peripsocus sclerotus* Thornton & Wong, 1966	-	Peripsocidae	+ (1)	-	-	-	

1. Ray KK. 1979. Psocoptera of Calcutta and Environs (West Bengal: India). Records Zoological Survey of India. 75: 353-359.

Table 4.7. Diversity of Ants (Hymenoptera: Formicidae) of Rabindra Sarovar

Sl. No.	Scientific Name	Common Name	Sub family	Family	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
1	*Camponotus compressus* (Fabricius, 1787)	Deon Pipre	Formiciae	Formicidae	+ (1)	+	-	-	
2	*Camponotus dolendus* (Forel, 1892)	-	Formicinae	Formicidae	+ (1)	-	-	-	
3	*Cardiocondyla nuda* (Mayr, 1866)	-	Myrmicinae	Formicidae	+ (1)	-	-	-	
4	*Cardioeondyla tiwari* sp.nov.	-	Myrmicinae	Formicidae	+ (1)	-	-	-	
5	*Carebara lignata* (Westwood, 1840)	-	Myrmicinae	Formicidae	+ (1)	-	-	-	
6	*Crematogaster rothneyi* (Mayr, 1879)	-	Myrmicinae	Formicidae	+ (1)	-	-	-	
7	*Diacamma rugosum* (Le Guillou, 1842)	-	Ponerinae	Formicidae	+ (1)	-	-	-	
8	*Meranoplus bicolor* (Guérin-Méneville, 1844)	-	Myrmicinae	Formicidae	+ (1)	-	-	-	
9	*Monomorium destructor* (Jerdon, 1851)	-	Myrmicinae	Formicidae	+ (1)	-	-	-	
10	*Monomorium floricola* (Jerdon, 1851)	-	Myrmicinae	Formicidae	+ (1)	-	-	-	

Sl. No.	Scientific Name	Common Name	Sub family	Family	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
11	*Monomorium latinode* (Mayr, 1872)	-	Myrmicinae	Formicidae	+ (1)	-	-	-	
12	*Monomorium monomorium* (Bolton, 1987)	-	Myrmicinae	Formicidae	+ (1)	-	-	-	
13	*Monomorium pharaonis* (Linnaeus, 1758)	-	Myrmicinae	Formicidae	+ (1)	-	-	-	
14	*Oecophylla smaragdina* (Fabricius, 1775)	-	Formicinae	Formicidae	+ (1)	-	-	-	
15	*Pachycondyla rufipes* (Jerdon, 1851)	-	Ponerinae	Formicidae	+ (1)	-	-	-	
16	*Paratrechina longicornis* (Latreille, 1802)	-	Formicinae	Formicidae	+ (1)	-	-	-	
17	*Pheidole roberti* (Forel, 1902)	-	Myrmicinae	Formicidae	+ (1)	-	-	-	
18	*Pheidole* sp.	-	Myrmicinae	Formicidae	+ (1)	-	-	-	
19	*Pheidologeton diversus* (Jerdon, 1851)	-	Myrmicinae	Formicidae	+ (1)	-	-	-	
20	*Plagiolepis jerdonii* (Forel, 1894)	-	Formicinae	Formicidae	+ (1)	-	-	-	
21	*Platythyrea parallela* (Smith, 1859)	-	Ponerinae	Formicidae	+ (1)	-	-	-	
22	*Recurvidris recurvispinosa* (Forel, 1890)	-	Myrmicinae	Formicidae	+ (1)	-	-	-	
23	*Solenopsis geminata* (Fabricius, 1804)	-	Myrmicinae	Formicidae	+ (1)	-	-	-	
24	*Tapinoma melanocephalum* (Fabricius, 1793)	-	Dolichoderinae	Formicidae	+ (1)	-	-	-	
25	*Technomyrmex albipes* (Smith, 1861)	-	Dolichoderinae	Formicidae	+ (1)	-	-	-	
26	*Tetramorium* sp.	-	Myrmicinae	Formicidae	+ (1)	-	-	-	
27	*Tetramorium walshi* (Forel, 1890)	-	Myrmicinae	Formicidae	+ (1)	-	-	-	
28	*Tetraponera allaborans* (Walker, 1859)	-	Pseudomyrmecinae	Formicidae	+ (1)	-	-	-	
29	*Tetraponera rufonigra* (Jerdon,	Kath Pipre	Pseudomyrmecinae	Formicidae	+ (1)	+	-	-	

Sl. No.	Scientific Name	Common Name	Sub family	Family	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Rem arks
	1851)								

1. Ghosh SN, Sheela S, Kundu BG. 2005. Ants (Hymenoptera: Formicidae) of Rabindra Sarovar, Kolkata. Records Zoological Survey of India (Occasional Paper no. 234). p 1-40.

Table 4.8. Diversity of Butterflies (Lepidoptera: Rhopalocera) of Rabindra Sarovar

Sl. No.	Scientific Name	Common Name	Sub-family	Family	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (Ver. 3.1)	Remarks
1	*Acraea violae* (Fabricius, 1793)	Tawny Coster	Heliconiinae	Nymphalidae	-	+	-	-	
2	*Anthene emolus* (Godart, [1824])	Common Ciliate Blue	Polyommatinae	Lycaenidae	-	+	-	-	
3	*Anthene lycaenina* (R. Felder, 1868)	Pointed Ciliate Blue	Polyommatinae	Lycaenidae	-	+	Sch. II Part II	-	
4	*Appias libythea* (Fabricius, 1775)	Striped Albatross	Pierinae	Pieridae	-	+	Sch. IV	-	
5	*Ariadne ariadne* (Linnaeus, 1763)	Angled Castor	Biblidinae	Nymphalidae	-	+	-	-	
6	*Ariadne merione* (Cramer, [1777])	Common Castor	Biblidinae	Nymphalidae	-	+	-	-	
7	*Atrophaneura aristolochiae* (Fabricius, 1775)	Common Rose	Papilioninae	Papilionidae	-	+	-	-	
8	*Baoris farri* (Moore, 1878)	Paintbrush Swift	Hesperiinae	Hesperiidae	-	+	Sch. IV	-	
9	*Castalius rosimon* (Fabricius, 1775)	Common Pierrot	Polyommatinae	Lycaenidae	-	+	-	-	
10	*Catochrysops strabo*	Forget-me-not	Polyommatinae	Lycaenidae	-	+	-	-	

	(Fabricius, 1793)								
11	*Catopsilia pomona* (Fabricius, 1775)	Common Emigrant	Coliadinae	Pieridae	-	+	-	-	
12	*Catopsilia pyranthe* (Linnaeus, 1758)	Mottled Emigrant	Coliadinae	Pieridae	-	+	-	-	
13	*Cepora nerissa* (Fabricius, 1775)	Common Gull	Pierinae	Pieridae	-	+	-	-	
14	*Charaxes solon* (Fabricius, 1793)	Black Rajah	Charaxinae	Nymphalidae	-	+	-	-	
15	*Chilades lajus* (Stoll, [1780])	Lime Blue	Polyommatinae	Lycaenidae	-	+	-	-	
16	*Chilades pandava* (Horsfield, [1829])	Plains Cupid	Polyommatinae	Lycaenidae	-	+	-	-	
17	*Cigaritis vulcanus* (Fabricius, 1775)	Common Silverline	Theclinae	Lycaenidae	-	+	-	-	
18	*Danaus chrysippus* (Linnaeus, 1758)	Plain Tiger	Danainae	Nymphalidae	-	+	-	-	
19	*Danaus genutia* (Cramer, [1779])	Striped Tiger	Danainae	Nymphalidae	-	+	-	-	
20	*Delias eucharis* (Drury, 1773)	Common Jezebel	Pierinae	Pieridae	-	+	-	-	
21	*Elymnias hypermnestra undularis* (Drury, 1773)	Common Palmfly	Satyrinae	Nymphalidae	-	+	-	-	
22	*Euchrysops cnejus* (Fabricius, 1798)	Gram Blue	Polyommatinae	Lycaenidae	-	+	Sch. II Part II	-	
23	*Euploea core* (Cramer, [1780])	Common Crow	Danainae	Nymphalidae	-	+	-	-	
24	*Eurema hecabe* (Linnaeus, 1758)	Common Grass Yellow	Coliadinae	Pieridae	-	+	-	-	
25	*Euthalia aconthea* (Cramer, [1777])	Common Baron	Limenitidinae	Nymphalidae	-	+	-	-	
26	*Graphium agamemnon* (Linnaeus, 1758)	Tailed Jay	Papilioninae	Papilionidae	-	+	-	-	
27	*Hypolimnas bolina*	Great Eggfly	Nymphalinae	Nymphalidae	-	+	-	-	

	(Linnaeus, 1758)								
28	*Iraota timoleon* (Stoll, 1790)	Silverstreak Blue	Theclinae	Lycaenidae	-	+	-	-	
29	*Junonia almana* (Linnaeus, 1758)	Peacock Pansy	Nymphalinae	Nymphalidae	-	+	-	-	
30	*Junonia atlites* (Linnaeus, 1763)	Grey Pansy	Nymphalinae	Nymphalidae	-	+	-	-	
31	*Lampides boeticus* (Linnaeus, 1767)	Pea Blue	Polyommatinae	Lycaenidae	-	+	Sch. II Part II	-	
32	*Leptosia nina* (Fabricius, 1793)	Psyche	Pierinae	Pieridae	-	+	-	-	
33	*Leptotes plinius* (Fabricius, 1793)	Zebra Blue	Polyommatinae	Lycaenidae	-	+	-	-	
34	*Matapa aria* (Moore, [1866])	Common Redeye	Hesperiinae	Hesperiidae	-	+	-	-	
35	*Melanitis leda* (Linnaeus, 1758)	Common Evening Brown	Satyrinae	Nymphalidae	-	+	-	-	
36	*Moduza procris* (Cramer, [1777])	Commander	Limenitidinae	Nymphalidae	-	+	-	-	
37	*Mycalesis mineus* (Linnaeus, 1758)	Dark-brand Bushbrown	Satyrinae	Nymphalidae	-	+	-	-	
38	*Neopithecops zalmora* (Butler, [1870])	Quaker	Polyommatinae	Lycaenidae	-	+	-	-	
39	*Neptis jumbah* Moore, [1858]	Chestnut-streaked Sailer	Limenitidinae	Nymphalidae	-	+	-	-	
40	*Oriens goloides* (Moore, 1881)	Common Dartlet	Hesperiinae	Hesperiidae	-	+	-	-	
41	*Papilio clytia* Linnaeus, 1758	Common Mime	Papilioninae	Papilionidae	-	+	-	-	
42	*Papilio demoleus* Linnaeus, 1758	Lime Butterfly	Papilioninae	Papilionidae	-	+	-	-	
43	*Papilio polytes* Linnaeus, 1758	Common Mormon	Papilioninae	Papilionidae	-	+	-	-	
44	*Pareronia valeria* (Cramer, [1776])	Common Wanderer	Pierinae	Pieridae	-	+	-	-	
45	*Pelopidas mathias* (Fabricius, 1798)	Small Branded Swift	Hesperiinae	Hesperiidae	-	+	-	-	
46	*Phalanta phalantha* (Drury, [1773])	Common Leopard	Heliconiinae	Nymphalidae	-	+	-	-	
47	*Prosotas nora*	Common	Polyomm	Lycaenidae	-	+	-	-	

	(Felder, 1860)	Lineblue	atinae						
48	*Pseudozizeeria maha* (Kollar, [1844])	Pale Grass Blue	Polyommatinae	Lycaenidae	-	+	-	-	
49	*Rapala manea* (Hewitson, 1863)	Slate Flash	Theclinae	Lycaenidae	-	+	-	-	
50	*Rathinda amor* (Fabricius, 1775)	Monkey Puzzle	Theclinae	Lycaenidae	-	+	-	-	
51	*Suastus gremius* (Fabricius, 1798)	Indian Palm Bob	Hesperiinae	Hesperiidae	-	+	-	-	
52	*Telicota bambusae* (Moore, 1878)	Dark Palm Dart	Hesperiinae	Hesperiidae	-	+	-	-	
53	*Tirumala limniace* (Cramer, [1775])	Blue Tiger	Danainae	Nymphalidae	-	+	-	-	
54	*Ypthima baldus* (Fabricius, 1775)	Common Five-ring	Satyrinae	Nymphalidae	-	+	-	-	
55	*Ypthima huebneri* Kirby, 1871	Common Four-ring	Satyrinae	Nymphalidae	-	+	-	-	
56	*Zizula hylax* (Fabricius, 1775)	Tiny Grass Blue	Polyommatinae	Lycaenidae	-	+	-	-	
57	*Zizzeria karsandra* (Moore, 1865)	Dark Grass Blue	Polyommatinae	Lycaenidae	-	+	-	-	

Table 4.9. Diversity of Odonata (Dragonflies & Damselflies) of Rabindra Sarovar

Sl. No.	Scientific Name	Common Name	Family	Sub-order	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
1	*Agriocnemis pygmaea* (Rambur, 1842)	Pygmy Dartlet	Coenagrionidae	Zygoptera	-	+	-	Least Concern	
2	*Brachythemis contaminata* (Fabricius, 1793)	Ditch Jewel	Libellulidae	Anisoptera	-	+	-	Least Concern	
3	*Ceriagrion coromandelianum* (Fabricius, 1798)	Coromandel Marsh Dart	Coenagrionidae	Zygoptera	-	+	-	Least Concern	
4	*Crocothemis servilia* (Drury, 1773)	Ruddy Marsh Skimmer	Libellulidae	Anisoptera	-	+	-	Least Concern	
5	*Diplacodes trivialis* (Rambur, 1842)	Ground Skimmer	Libellulidae	Anisoptera	-	+	-	Least Concern	
6	*Ischnura senegalensis*	Senegal Golden	Coenagrionidae	Zygoptera	-	+	-	Least Concern	

	(Rambur, 1842)	Dartlet							
7	*Onychargia atrocyana* (Sélys, 1865)	Black Marsh Dart	Coenagrionidae	Zygoptera	-	+	-	Least Concern	
8	*Orthetrum sabina* (Drury, 1773)	Green Marsh Hawk	Libellulidae	Anisoptera	-	+	-	Least Concern	
9	*Pantala flavescens* (Fabricius, 1798)	Wandering Glider	Libellulidae	Anisoptera	-	+	-	Least Concern	
10	*Pseudagrion rubriceps* (Selys, 1876)	Saffron-faced Blue Dart	Coenagrionidae	Zygoptera	-	+	-	Least Concern	
11	*Rhodothemis rufa* (Rambur, 1842)	Rufous Marsh Glider	Libellulidae	Anisoptera	-	+	-	Least Concern	
12	*Rhyothemis variegata* (Linnaeus, 1763)	Common Picture Wing	Libellulidae	Anisoptera	-	+	-	Least Concern	
13	*Trithemis pallidinervis* (Kirby, 1889)	Long-legged Marsh Glider	Libellulidae	Anisoptera	-	+	-	Least Concern	

Table 4.10. Details of the survey stations

Site 1	Calcutta University Rowing Club
Site 2	Opposite of Calcutta University Rowing Club
Site 3	1st Island near Calcutta University Rowing Club
Site 4	Opposite of Bengal Rowing Club
Site 5	1st Island near Bengal Rowing Club
Site 6	2nd Island near Bengal Rowing Club
Site 7	Gol Park End

Table 4.11. Diversity of Mollusca (Freshwater) of Rabindra Sarovar

Sl. No.	Scientific Name	Common Name	Family	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
1	*Bellamya bengalensis* (Lamarck, 1822)	Geri Googly	Viviparidae	+ (1,2,3)	-	-	Least Concern	
2	*Brotia costula* (Rafinesque, 1833)	-	Thiaridae	+ (1,2,3)	+	-	Least Concern	
3	*Digoniostoma cerameopoma* (Benson, 1830)	-	Bithyniidae	+ (1,2,3)	-	-	Least Concern	

Sl. No.	Scientific Name	Common Name	Family	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
4	*Gabbia orcula* (Frauenfeld, 1862)	-	Bithyniidae	+ (1,2,3)	+	-	Least Concern	
5	*Gyraulus convexiusculus* (Hutton, 1849)	-	Planorbidae	+ (1,2,3)	+	-	Least Concern	
6	*Gyraulus labiatus* (Benson, 1850)	-	Planorbidae	+ (1,2,3)	-	-	Least Concern	
7	*Indoplanorbis exustus* (Deshayes,1834)	-	Planorbidae	+ (1,2,3)	+	-	Least Concern	
8	*Lamellidens marginalis* (Lamarck, 1819)	Jhinuk	Unionidae	+ (1,2,3)	+	-	Least Concern	
9	*Lamellidens corrianus* (Lea,1834)	Jhinuk	Unionidae	+ (1,2,3)	+	-	Least Concern	
10	*Lymnaea acuminata* (Lamarck, 1822)	-	Lymnaeidae	+ (1,2,3)	-	-	Least Concern	
11	*Lymnaea luteola* (Lamarck, 1822)	-	Lymnaeidae	+ (1,2,3)	-	-	Least Concern	
12	*Melanoides tuberculata* (Mueller, 1774)	-	Thiaridae	+ (1,2,3)	-	-	-	
13	*Mieniplotia scabra* (Müller, 1774)	-	Thiaridae	+ (1,2)	-	-	Least Concern	
14	*Parreysia pachyasoma* (Benson)	-	Amblenidae	+ (1,2,3)	-	-	-	
15	*Parreysia (Parreysia) corrugata* (Mueller, 1774)	-	Amblenidae	+ (1,2,3)	-	-	-	
16	*Parreysia caerulea* (Lea,1831)	-	Amblenidae	+ (1,2,3)	-	-	Least Concern	
17	*Pila globosa* (Swainson, 1822)	-	Pilidae	+ (1,2,3)	+	-	Least Concern	
18	*Pisidium clarkeanum* (G and H Nevill, 1871)	-	Pisidiidae	+ (1,2,3)	-	-	Least Concern	
19	*Tarebia granifera* (Lamarck, 1822)	-	Thiaridae	+ (1,2,3)	-	-	Least Concern	
20	*Tarebia lineata* (Gray, 1828)	-	Thiaridae	+ (1,2,3)	+	-	Least Concern	

1. Roy M, Nandi NC. 2008. Macrozoobenthos of some Lacustrine Wetland of West Bengal, India. In: Sengupta M, Dalwani R. (Eds.). Proceedings of Taal 2007: The 12th World Lake Conference. p. 506-512.
2. Mukherji M, Nandi NC. 2004. Studies on Macrozoobenthos of Rabindra Sarovar and Subhas Sarovar in Kolkata in relation to water and sediment characteristics. Records Zoological Survey of India (Occasional Paper No. 225). p. 1-119.
3. Khan RA. 2002. Diversity of freshwater macro-invertebrate communities associated with macrophytes. Record Zoological Survey of India. 100(part 1-2): 211-228.

Table 4.12. Diversity of Fishes (Chordata: Pisces) of Rabindra Sarovar

Sl. No.	Scientific Name	Common Name	Family	Order	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
1	*Amblypharyngodon mola* (Hamilton, 1822)	Mola Carplet/ Mourola	Cyprinidae	Cypriniformes	+ (1)	+	-	Least Concern	
2	*Anabas testudineus* (Bloch, 1792)	Climbing Perch/ Koi	Anabantidae	Perciformes	+ (1)	+	-	Least Concern	
3	*Aplocheilus panchax* (Hamilton, 1822)	Blue Panchax/ Techokha	Aplocheilidae	Cyprinodontiformes	+ (1)	+	-	Least Concern	
4	*Badis badis* (Hamilton, 1822)	Dwarf Chameleon Fish/ Pod Koi	Badidae	Perciformes	+ (1)	-	-	-	
5	*Catla catla* (Hamilton, 1822)	Catla	Cyprinidae	Cypriniformes	+ (1)	+	-	Least Concern	
6	*Chanda nama* Hamilton, 1822	Elongate Glass Perchlet	Ambassidae	Perciformes	+ (1)	-	-	-	An Introduced species
7	*Channa gachua* (Hamilton, 1822)	Dwarf Snakehead/ Cheng	Channidae	Perciformes	+ (1)	+	-	-	An introduced species
8	*Channa marulius* (Hamilton, 1822)	Giant Snakehead/ Shal	Channidae	Perciformes	-	+	-	Least Concern	
9	*Channa punctata* (Bloch, 1793)	Spotted Snakehead/ Latha	Channidae	Perciformes	+ (1)	+	-	Least Concern	
10	*Channa striata* (Bloch, 1793)	Banded Snakehead/ Shol	Channidae	Perciformes	+ (1)	+	-	Least Concern	
11	*Cirrhinus mrigala* (Hamilton, 1822)	Mrigal Carp/ Mrigal	Cyprinidae	Cypriniformes	+ (1)	+	-	-	An introduced species
12	*Clarias batrachus* (Linnaeus, 1758)	Magur	Clariidae	Siluriformes	+ (1)	+	-	Data Deficient	An introduced species
13	*Clarias gariepinus* (Burchell, 1822)	African Catfish/ Hybrid Magur	Clariidae	Siluriformes	-	+	-	Least Concern	
14	*Ctenopharyngodon idella* (Valenciennes, 1844)	Grass Carp/ Gheso Rui	Cyprinidae	Cypriniformes	-	+	-	Least Concern	
15	*Cyprinus carpio* Linnaeus, 1758	Wild Common Carp	Cyprinidae	Cypriniformes	+ (1)	-	-	Least Concern	
16	*Danio rerio* (Hamilton, 1822)	Zebrafish	Cyprinidae	Cypriniformes	-	+	-	Least Concern	
17	*Devario devario* (Hamilton, 1822)	Bengal Danio/ Nipati	Cyprinidae	Cypriniformes	-	+	-	Least Concern	

Sl. No.	Scientific Name	Common Name	Family	Order	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
18	*Esomus danrica* (Hamilton, 1822)	Flying Barb/ Danrika	Cyprinidae	Cypriniformes	+ (1)	-	-	-	
19	*Glossogobius giuris* (Hamilton, 1822)	Bareye Goby/ Bele	Gobiidae	Perciformes	+ (1)	+	-	Least Concern	
20	*Heteropneustes fossilis* (Bloch, 1794)	Stinging Catfish/ Shingi	Heteropneustidae	Siluriformes	+ (1)	+	-	Least Concern	
21	*Hypophthalmichthys molitrix* (Valenciennes, 1844)	Silver Carp	Cyprinidae	Cypriniformes	+ (1)	+	-	Least Concern	
22	*Hypophthalmichthys nobilis* (Richardson, 1845)	Bighead Carp	Cyprinidae	Cypriniformes	-	+	-	Least Concern	
23	*Labeo bata* (Hamilton, 1822)	Minor Carp/ Bata	Cyprinidae	Cypriniformes	+ (1)	+	-	Least Concern	
24	*Labeo calbasu* (Hamilton, 1822)	Orange-fin Labeo/ Kalbos	Cyprinidae	Cypriniformes	+ (1)	+	-	Data Deficient	
25	*Labeo rohita* (Hamilton, 1822)	Rohu	Cyprinidae	Cypriniformes	+ (1)	+	-	Least Concern	
26	*Lepidocephalus guntea* (Hamilton, 1822)	Guntea Loach/ Gunte	Cobitidae	Cypriniformes	-	+	-	Least Concern	
27	*Macrognathus aculeatus* (Bloch, 1786)	Lesser Spiny Eel/ Pankal	Mastacembelidae	Synbranchiformes	+ (1)	+	-	Least Concern	
28	*Monopterus cuchia* (Hamilton, 1822)	Mud Eel/ Cunche	Synbranchidae	Synbranchiformes	-	+	-	Least Concern	
29	*Mystus vittatus* (Bloch, 1794)	Striped Dwarf Catfish/ Tangra	Bagridae	Siluriformes	-	+	-	Least Concern	
30	*Notopterus notopterus* (Pallas, 1769)	Feather Back/ Folui	Notopteridae	Osteoglossiformes	-	+	-	Near Threatened	
31	*Oreochromis mossambicus* (Peters, 1852)	Mozambique Tilapia/ Tilapia	Cichlidae	Perciformes	+ (1)	+	-	-	An introduced species
32	*Oreochromis niloticus* (Linnaeus, 1758)	Nile Tilapia/ Nilontika	Cichlidae	Perciformes	+ (1)	+	-	Least Concern	
33	*Parambassis ranga* (Hamilton, 1822)	Indian Glassy Fish/ Chanda	Ambassidae	Perciformes	+ (1)	+	-	Least Concern	
34	*Pethia ticto* (Hamilton, 1822)	Ticto Barb/ Tit Punti	Cyprinidae	Cypriniformes	+ (1)	+	-	Least Concern	
35	*Puntius sophore* (Hamilton, 1822)	Spotfin Swamp	Cyprinidae	Cypriniformes	-	+	-	Least Concern	

Sl. No.	Scientific Name	Common Name	Family	Order	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
		Barb/ Bhadi Puti							
36	*Rasbor daniconius* (Hamilton, 1822)	Common Rasbora/ Daria/ Darkina	Cyprinidae	Cypriniformes	-	+	-	Least Concern	An introduced species
37	*Systomus sarana* (Hamilton, 1822)	Olive Barb/ Sar Punti	Cyprinidae	Cypriniformes	+ (1)	-	-	Least Concern	
38	*Trichogaster fasciata* (Bloch & Schneider, 1801)	Giant Gourami/ Kholisha	Osphronemidae	Perciformes	+ (1)	+	-	Near Threatened	
39	*Wallago attu* (Bloch & Schneider, 1801)	Boal	Siluridae	Siluriformes	-	+	-	-	
40	*Xenentodon cancila* (Hamilton, 1822)	Freshwater Garfish /Bogo/ Kakila	Belonidae	Beloniformes	-	+	-	Least Concern	

1. IWMED. 2001. Monitoring of Environmental Status of Rabindra Sarovar & Preparation of Management Action Plan. Dept. of Environment, Govt. of West Bengal. 73 p. +XXXII.

Table 4.13. Diversity of Amphibians (Chordata: Amphibia) of Rabindra Sarovar

Sl. No.	Scientific Name	Common Name	Family	Order	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
1	*Duttaphrynus melanostictus* (Schneider, 1799)	Common Indian Toad	Bufonidae	Anura	-	+	-	Least Concern	
2	*Euphlyctis cyanophlyctis* (Schneider, 1799)	Skittering Frog	Dicroglossidae	Anura	-	+	-	Least Concern	
3	*Fejervarya* sp.	Cricket Frog	Dicroglossidae	Anura	-	+	-	Least Concern	
4	*Hoplobatrachus tigerinus* (Daudin, 1802)	Indian Bull Frog	Dicroglossidae	Anura	-	+	Sch. IV	Least Concern	
5	*Polypedates maculatus* (Gray, 1830)	Common Indian Tree Frog	Rhacophoridae	Anura	-	+	-	Least Concern	

Table 4.14. Diversity of Reptiles (Chordata: Reptilia) of Rabindra Sarovar

Sl. No.	Scientific Name	Common Name	Family	Order	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
1	*Amphiesma stolatum* (Linnaeus, 1758)	Buff-striped Keelback	Colubridae	Squamata	-	+	Sch. IV	-	
2	*Calotes versicolor* (Daudin, 1802)	Garden Lizard	Agamidae	Squamata	-	+	-	-	
3	*Dendrelaphis tristis* (Daudin, 1803)	Bronzed-back Tree Snake	Colubridae	Squamata	-	+	Sch. IV	-	
4	*Eutropis carinata* (Schneider, 1801)	Common Grass Skink	Scincidae	Squamata	-	+	-	Least Concern	
5	*Eutropis macularia* (Blyth, 1853)	Bronzed Grass Skink	Scincidae	Squamata	-	+	-	-	
6	*Lissemys punctata* (Lacépède, 1788)	Indian Flap-shell Turtle	Trionychidae	Testudines	-	+	Sch. I Part II	Least Concern	
7	*Lygosoma albopunctata* (Gray, 1846)	White-spotted Supple Skink	Scincidae	Squamata	-	+	-	-	
8	*Naja kaouthia* Lesson, 1831	Monocellate Cobra	Elapidae	Squamata	-	+	Sch. II Part II	-	
9	*Pangshura tecta* (Gray, 1830)	Indian Roofed Turtle	Geoemydidae	Testudines	-	+	Sch. I Part II	Least Concern	
10	*Ptyas mucosa* (Linnaeus, 1758)	Indian Rat Snake	Colubridae	Squamata	-	+	Sch. II Part II	-	
11	*Xenochrophis piscator* (Schneider, 1799)	Chequered Keelback Snake	Colubridae	Squamata	-	+	Sch. II Part II	-	

Table 4.15. Diversity of Birds (Chordata: Aves) of Rabindra Sarovar

Sl. No.	Scientific Name	Common Name	Family	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks	Nest in Rabindra Sarovar
1	*Accipiter badius* (Gmelin, 1788)	Shikra/ Turki Baj	Accipitridae	+ (2)	-	-	Least Concern	Resident	Yes
2	*Acridotheres fuscus* (Wagler, 1827)	Jungle Myna/ Jhunt Shalik	Sturnidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes

Sl. No.	Scientific Name	Common Name	Family	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks	Nest in Rabindra Sarovar
3	*Acridotheres tristis* (Linnaeus, 1766)	Common Myna/ Shalik	Sturnidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
4	*Acrocephalus aedon* (Pallas, 1776)	Thick-billed Warbler/ Mota-chonchu Tikra	Acrocephalidae	+ (2)	-	-	Least Concern	Long-distant Migrant	No
5	*Acrocephalus dumetorum* Blyth, 1849	Blyth's Reed Warbler/ Jhonp Tikra	Acrocephalidae	+ (1, 2)	-	-	Least Concern	Long-distant Migrant	No
6	*Alcedo atthis* (Linnaeus, 1758)	Common Kingfisher/ Chhoto Machhranga	Alcedinidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
7	*Amaurornis phoenicurus* (Pennant, 1769)	White-breasted Waterhen/ Dahuk	Rallidae	+ (1, 2)	+	-	Least Concern	Resident	Yes
8	*Anastomus oscitans* (Boddaert, 1783)	Asian Openbill/ Shamuk-khol	Ciconiidae	+ (2)	+	Sch. IV	Least Concern	Resident	Yes
9	*Anhinga melanogaster* Pennant, 1769	Darter/ Goyar	Anhingidae	+ (2)	-	Sch. IV	Near Threatened	Resident	No
10	*Anthus hodgsoni* Richmond, 1907	Olive-backed Pipit/ Muchashi	Motacillidae	+ (2)	-	Sch. IV	Least Concern	Resident	No
11	*Apus nipalensis* (Hodgson, 1836)	House Swift/ Batashi	Apodidae	+ (1)	-	-	Least Concern	Resident	Yes
12	*Ardea purpurea* Linnaeus, 1766	Purple Heron/ Lal Kank	Ardeidae	+ (1)	-	Sch. IV	Least Concern	Resident	No
13	*Ardeola grayii* (Sykes, 1832)	Indian Pond Heron/ Konch Bok	Ardeidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
14	*Athene brama* (Temminck, 1821)	Spotted Owlet/ Kuture Pancha	Strigidae	+ (2)	-	Sch. IV	Least Concern	Resident	Yes
15	*Bubulcus ibis* (Linnaeus, 1758)	Cattle Egret/ Go-bok	Ardeidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
16	*Cacomantis merulinus* (Scopoli, 1786)	Plaintive Cuckoo/ Lalpet Bilapi Pik	Cuculidae	+ (2)	-	Sch. IV	Least Concern	Resident	No (Brood Parasite of other bird's nest)

Sl. No.	Scientific Name	Common Name	Family	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks	Nest in Rabindra Sarovar
17	*Caprimulgus macrurus* Horsfield, 1821	Large-tailed Nightjar/ Bodo Thukthukiya	Caprimulgidae	+ (2)	-	Sch. IV	Least Concern	Resident	No
18	*Centropus sinensis* (Stephens, 1815)	Greater Coucal/ Kubo	Cuculidae	+ (1, 2)	-	Sch. IV	Least Concern	Resident	No
19	*Chlidonias hybrid* (Pallas, 1811)	Whiskered Tern/ Dhenkchil	Laridae	+ (2)	-	-	Least Concern	Local Migrant	No
20	*Cinnyris asiaticus* (Latham, 1790)	Purple Sunbird/ Durga-Tuntuni/ Mouchushi	Nectariniidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
21	*Columba livia* Gmelin, 1789	Common Pigeon/ Gola Payra	Columbidae	+ (1)	+	-	Least Concern	Resident	Yes
22	*Copsychus saularis* (Linnaeus, 1758)	Oriental Magpie Robin/ Doyel	Muscicapidae	+ (1, 2)	+	-	Least Concern	Resident	Yes
23	*Coracina macei* (Lesson, 1831)	Large Cuckooshrike/ Kabashi	Campephagidae	+ (2)	-	-	Least Concern	Resident	No
24	*Corvus macrorhynchos* Wagler, 1827	Large-billed Crow/ Dandkak	Corvidae	+ (1)	+	-	Least Concern	Resident	Yes
25	*Corvus splendens* Vieillot, 1817	House Crow/ Patikak	Corvidae	+ (1)	+	-	Least Concern	Resident	Yes
26	*Cuculus canorus* Linnaeus, 1758	Eurasian Cuckoo/ Kukku	Cuculidae	+ (2)	-	Sch. IV	Least Concern	Summer Visitor	No
27	*Cyornis rubeculoides* (Vigors, 1831)	Blue-throated Blue Flycatcher/ Ghotki/ Chatki	Muscicapidae	+ (2)	-	Sch. IV	Least Concern	Long-distant Migrant	No
28	*Cypsiurus balasiensis* (Gray, 1829)	Asian Palm Swift/ Talchodai/ Talchonch	Apodidae	+ (1)	+	-	Least Concern	Resident	Yes
29	*Dendrocitta vagabunda* (Latham, 1790)	Rufous Treepie/ Handichacha/ Takachor	Corvidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
30	*Dendrocopos macei* (Vieillot, 1818)	Fulvous-breasted Woodpecker/ Jorod Kath-thokra	Picidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes

Sl. No.	Scientific Name	Common Name	Family	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks	Nest in Rabindra Sarovar
31	*Dendrocygna javanica* (Horsfield, 1821)	Lesser Whistling Duck/ Chhoto Saral	Anatidae	+ (2)	-	Sch. IV	Least Concern	Local Migrant	No
32	*Dendronanthus indicus* (Gmelin, 1789)	Forest Wagtail/ Jongli Khonjon	Motacillidae	+ (2)	-	-	Least Concern	Local Migrant	No
33	*Dicrurus aeneus* Vieillot, 1817	Bronzed Drongo/ Chhoto Bhujongo	Dicruridae	+ (2)	-	Sch. IV	Least Concern	Resident	No
34	*Dicrurus annectans* (Hodgson, 1836)	Crow-billed Drongo/ Kak-chonchu Phinge	Dicruridae	+ (2)	-	Sch. IV	-	Local Migrant	No
35	*Dicrurus hottentottus* (Linnaeus, 1766)	Hair-crested Drongo/ Spangled Drongo/ Keshraj	Dicruridae	+ (2)	-	Sch. IV	Least Concern	Resident	No
36	*Dicrurus leucophaeus* Vieillot, 1817	Ashy Drongo/ Nil Phinge	Dicruridae	+ (2)	-	Sch. IV	Least Concern	Local Migrant	No
37	*Dicrurus macrocercus* Vieillot, 1817	Black Drongo/ Phinge	Dicruridae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
38	*Dicrurus remifer* (Temminck, 1823)	Lesser Racket-tailed Drongo	Dicruridae	+ (2)	-	Sch. IV	Least Concern	Local Migrant	No
39	*Dinopium benghalense* (Linnaeus, 1758)	Lesser Goldenback/ Chhoto Sonali Kath-thokra	Picidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
40	*Eudynamys scolopaceus* (Linnaeus, 1758)	Asian Koel/ Kokil	Cuculidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	No (Brood Parasite of Crow's nest)
41	*Eumyias thalassinus* Swainson, 1838	Verditer Flycatcher/ Nil Kotkotiya	Muscicapidae	+ (2)	+	Sch. IV	Least Concern	Long-distant Migrant	No
42	*Ficedula albicilla* (Pallas, 1811)	Taiga Flycatcher	Muscicapidae	+ (2)	-	Sch. IV	Least Concern	Long-distant Migrant	No
43	*Ficedula parva* (Bechstein, 1792)	Red-throated or Red-breasted Flycatcher/ Chutki	Muscicapidae	+ (1, 2)	-	Sch. IV	Least Concern	Long-distant Migrant	No
44	*Ficedula superciliaris* (Jerdon,	Ultramarine Flycatcher/ Shada-bhuru	Muscicapidae	+ (2)	-	Sch. IV	Least Concern	Long-distant Migrant	No

Sl. No.	Scientific Name	Common Name	Family	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks	Nest in Rabindra Sarovar
	1840)	Nil Chutki							
45	*Gallinago stenura* (Bonaparte, 1830)	Pintail Snipe/ Sunchpuchchho Kadakhoncha	Scolopacidae	+ (2)	-	Sch. IV	Least Concern	Long-distant Migrant	No
46	*Gallinula chloropus* (Linnaeus, 1758)	Common Moorhen/ Jolmurgi	Rallidae	+ (2)	-	-	Least Concern	Local Migrant	No
47	*Gracupica contra* (Linnaeus, 1758)	Asian Pied Starling/ Go-shalik	Sturnidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
48	*Gyps bengalensis* (Gmelin, 1788)	White-rumped Vulture/ Shokun	Accipitridae	+ (1)	-	Sch. I Part III	Critically Endangered	Resident	No
49	*Halcyon smyrnensis* (Linnaeus, 1758)	White-throated Kingfisher/ Sadabuk Machhranga	Alcedinidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
50	*Hierococcyx varius* (Vahl, 1797)	Common Hawk Cuckoo/ Papia/ Chokh-galo	Cuculidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
51	*Hypothymis azurea* (Boddaert, 1783)	Black-naped Monarch/ Kalo-matha Kotkotiya	Monarchidae	+ (2)	-	-	Least Concern	Resident	Yes
52	*Lanius cristatus* Linnaeus, 1758	Brown Shrike/ Kajolpakhi/ Karkata	Laniidae	+ (1, 2)	-	-	Least Concern	Long-distant Migrant	No
53	*Leptocoma zeylonica* (Linnaeus, 1766)	Purple-rumped Sunbird/ Durga-Tuntuni/ Moutushi	Nectariniidae	+ (1)	+	Sch. IV	Least Concern	Resident	Yes
54	*Lonchura punctulata* (Linnaeus, 1758)	Scaly-breasted Munia/ Tile Muniya	Estrildidae	+ (1, 2)	-	Sch. IV	Least Concern	Resident	No
55	*Luscinia brunnea* Hodgson, 1837	Indian Blue Robin/ Nil Shama	Muscicapidae	+ (2)	-	-	Least Concern	Long-distant Migrant	No
56	*Luscinia calliope* (Pallas, 1776)	Siberian Rubythroat/ Gupigora	Muscicapidae	+ (2)	-	-	Least Concern	Long-distant Migrant	No
57	*Luscinia cyane* (Pallas, 1776)	Siberian Blue Robin	Muscicapidae	+ (2)	-	-	Least Concern	Long-distant Migrant	No
58	*Megalaima asiatica*	Blue-throated Barbet/	Megalaimidae	+ (1, 2)	+	Sch. IV	-	Resident	Yes

Sl. No.	Scientific Name	Common Name	Family	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks	Nest in Rabindra Sarovar
	(Latham, 1790)	Nilgola Boshonto Bouri							
59	*Megalaima haemacephala* (Müller, 1776)	Coppersmith Barbet/ Chhoto Boshonto Bouri	Megalaimidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
60	*Megalaima lineate* (Vieillot, 1816)	Lineated Barbet/ Rekha Boshonto	Megalaimidae	+ (2)	+	Sch. IV	Least Concern	Resident	Yes
61	*Merops orientalis* Latham, 1802	Green Bee-eater/ Banshpati	Meropidae	+ (1, 2)	-	-	Least Concern	Resident	No
62	*Metopidius indicus* (Latham, 1790)	Bronze-winged Jacana/ Jolpipi	Jacanidae	+ (1)	-	Sch. IV	Least Concern	Resident	Yes
63	*Micropternus brachyurus* (Vieillot, 1818)	Rufous Woodpecker/ Badami Kath-thokra	Picidae	+ (2)	-	Sch. IV	Least Concern	Resident	Yes
64	*Milvus migrans* (Boddaert, 1783)	Black Kite/ Chil	Accipitridae	+ (1, 2)	+	-	Least Concern	Resident	Yes
65	*Motacilla alba* Linnaeus, 1758	White Wagtail/ Khonjona	Motacillidae	+ (1, 2)	+	-	Least Concern	Long-distant Migrant	No
66	*Motacilla cinerea* Tunstall, 1771	Grey Wagtail/ Dhushor Khonjon	Motacillidae	+ (1)	+	-	Least Concern	Long-distant Migrant	No
67	*Motacilla citreola* Pallas, 1776	Citrine Wagtail/ Holde-matha Khonjon	Motacillidae	+ (2)	-	-	Least Concern	Long-distant Migrant	No
68	*Muscicapa dauurica* Pallas, 1811	Asian Brown Flycatcher/ Patkile Chutki	Muscicapidae	+ (2)	-	Sch. IV	Least Concern	Long-distant Migrant	No
69	*Muscicapa muttui* (Layard, 1854)	Brown-breasted Flycatcher	Muscicapidae	+ (2)	-	Sch. IV	Least Concern	Long-distant Migrant	No
70	*Muscicapa sibirica* Gmelin, 1789	Dark-sided Flycatcher/ Gadho-pash Chutki	Muscicapidae	+ (2)	-	Sch. IV	Least Concern	Long-distant Migrant	No
71	*Mycteria leucocephala* (Pennant, 1769)	Painted Stork/ Shona-jongha	Ciconiidae	+ (2)	+	Sch. IV	Near Threatened	Resident	Yes
72	*Nycticorax*	Black-crowned	Ardeidae	+ (1, 2)	+	Sch. IV	Least	Resident	Yes

Sl. No.	Scientific Name	Common Name	Family	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks	Nest in Rabindra Sarovar
	nycticorax (Linnaeus, 1758)	Night Heron/ Bachka					Concern		
73	*Oriolus chinensis* Linnaeus, 1766	Black-naped Oriole/ Kaloghad Bene-bou	Oriolidae	+ (1, 2)	+	Sch. IV	Least Concern	Local Migrant	No
74	*Oriolus kundoo* Sykes, 1832	Indian Golden Oriole/ Shona-bou	Oriolidae	+ (1, 2)	-	Sch. IV	Least Concern	Resident	No
75	*Oriolus xanthornus* (Linnaeus, 1758)	Black-hooded Oriole/ Bene-bou	Oriolidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
76	*Orthotomus sutorius* (Pennant, 1769)	Common Tailorbird/ Tuntuni	Cisticolidae	+ (1, 2)	-	-	Least Concern	Resident	Yes
77	*Otus scops* (Linnaeus, 1758)	Eurasian Scops Owl	Strigidae	+ (1)	-	Sch. IV	Least Concern	Local Migrant	No
78	*Parus major* Linnaeus, 1758	Great Tit/ Ramgangra	Paridae	+ (1)	-	Sch. IV	Least Concern	Resident	No
79	*Passer domesticus* (Linnaeus, 1758)	House Sparrow/ Chodai	Passeridae	+ (1)	+	-	Least Concern	Resident	Yes
80	*Pelargopsis capensis* (Linnaeus, 1766)	Stork-billed Kingfisher/ Gudiyal	Alcedinidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
81	*Phalacrocorax carbo* (Linnaeus, 1758)	Great Cormorant/ Bodo Pankoudi	Phalacrocoracidae	+ (1, 2)	-	Sch. IV	Least Concern	Resident	Yes
82	*Phalacrocorax fuscicollis* Stephens, 1826	Indian Cormorant/ Majhari Pankoudi	Phalacrocoracidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
83	*Phalacrocorax niger* (Vieillot, 1817)	Little Cormorant/ Chhoto Pankoudi	Phalacrocoracidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
84	*Phylloscopus collybita* (Vieillot, 1817)	Common Chiffchaff/ Badami Shakha Phutki	Phylloscopidae	+ (1)	-	-	Least Concern	Long-distant Migrant	No
85	*Phylloscopus fuscatus* (Blyth, 1842)	Dusky Warbler/ Godhuli Shakha Phutki	Phylloscopidae	+ (2)	-	-	Least Concern	Long-distant Migrant	No
86	*Phylloscopus humei* (Brooks, 1878)	Hume's Leaf Warbler	Phylloscopidae	+ (1)	-	-	Least Concern	Local Migrant	No

Sl. No.	Scientific Name	Common Name	Family	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks	Nest in Rabindra Sarovar
87	*Phylloscopus inornatus* (Blyth, 1842)	Yellow-browed Leaf Warbler/ Holde-bhuru Shakha Phutki	Phylloscopidae	+ (1, 2)	-	-	Least Concern	Long-distant Migrant	No
88	*Phylloscopus trochiloides* (Sundevall, 1837)	Greenish Warbler/ Shobje Shakha Phutki	Phylloscopidae	+ (2)	-	-	Least Concern	Long-distant Migrant	No
89	*Pitta brachyura* (Linnaeus, 1766)	Indian Pitta/ Nilpakhi	Pittidae	+ (2)	-	Sch. IV	Least Concern	Local Migrant	No
90	*Prinia inornata* Sykes, 1832	Plain Prinia	Cisticolidae	+ (2)	-	-	Least Concern	Resident	Yes
91	*Psittacula eupatria* (Linnaeus, 1766)	Alexandrine Parakeet/ Chondona	Psittacidae	+ (1)	-	Sch. IV	Near Threatened	Resident	Yes
92	*Psittacula krameri* (Scopoli, 1769)	Rose-ringed Parakeet/ Tiya	Psittacidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
93	*Pycnonotus cafer* (Linnaeus, 1766)	Red-vented Bulbul/ Bulbuli	Pycnonotidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
94	*Pycnonotus jocosus* (Linnaeus, 1758)	Red-whiskered Bulbul/ Shipai Bulbul	Pycnonotidae	+ (1)	+	Sch. IV	Least Concern	Resident	Yes
95	*Saxicoloides fulicatus* (Linnaeus, 1766)	Indian Robin/ Kalishama	Muscicapidae	+ (2)	-	-	Least Concern	Resident	No
96	*Stigmatopelia chinensis* (Scopoli, 1786)	Spotted Dove/ Tile Ghughu	Columbidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
97	*Streptopelia decaocto* Frivaldszky, 1838	Eurasian Collared Dove/ Konthi Ghughu	Columbidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
98	*Sturnia malabarica* (Gmelin, 1789)	Chestnut-tailed Starling/ Pat Shalik/ Pawai	Sturnidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
99	*Sturnia pagodarum* (Gmelin, 1789)	Brahminy Starling/ Bamun Shalik	Sturnidae	+ (2)	-	Sch. IV	Least Concern	Resident	No
100	*Terpsiphone paradisi* (Linnaeus, 1758)	Asian Paradise-flycatcher/ Phite-bulbul/ Dudhraj	Monarchidae	+ (2)	-	-	Least Concern	Resident	No

Sl. No.	Scientific Name	Common Name	Family	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks	Nest in Rabindra Sarovar
101	*Treron phoenicopterus* (Latham, 1790)	Yellow-footed Green Pigeon/ Horiyal	Columbidae	+ (1, 2)	-	Sch. IV	Least Concern	Resident	Yes
102	*Turdoides striata* (Dumont, 1823)	Jungle Babbler/ Chhatare	Timaliidae	+ (1, 2)	+	Sch. IV	Least Concern	Resident	Yes
103	*Turdus unicolor* Tickell, 1833	Tickell's Thrush/ Machashah	Turdidae	+ (2)	-	Sch. IV	Least Concern	Long-distant Migrant	No
104	*Upupa epops* Linnaeus, 1758	Common Hoopoe/ Mohonchuda	Upupidae	+ (1, 2)	-	-	Least Concern	Local Migrant	No
105	*Vanellus cinereus* (Blyth, 1842)	Grey-headed Lapwing/ Shalang	Charadriidae	+ (1)	-	-	Least Concern	Local Migrant	No
106	*Zoothera citrina* (Latham, 1790)	Orange-headed Thrush/ Dama	Turdidae	+ (2)	-	Sch. IV	Least Concern	Resident	No
107	*Zoothera dauma* (Latham, 1790)	Scaly Thrush/ Sonali Giridama	Turdidae	+ (2)	-	Sch. IV	Least Concern	Local Migrant	No

1. Ghosh, S. 2010. Urban Biodiversity of Kolkata: Flowering Plants, Butterflies, Birds and Mammals. Zoological Survey of India (Occasional Paper no. 327).
2. Anonymous, 2016. Birds of Rabindra Sarovar. Kolkata Improvement Trust.

Table 4.16. Diversity of Mammals (Chordata; mammalia) of Rabindra Sarovar

Sl. No.	Scientific Name	Common Name	Family	Order	Earlier Reports	Present Study	IWPA, 1972	IUCN Red List (*Ver. 3.1*)	Remarks
1	*Bandicota bengalensis* (Gray, 1835)	Lesser Bandicoot Rat	Muridae	Rodentia	+ (1)	+	-	Least Concern	
2	*Cynopterus sphinx* (Vahl, 1797)	Short-nosed Fruit Bat	Pteropodidae	Chiroptera	-	+	-	Least Concern	
3	*Funambulus pennantii* Wroughton, 1905	Five-striped Palm Squirrel	Sciuridae	Rodentia	+ (1)	+	-	Least Concern	
4	*Herpestes auropunctatus* (Hodgson,1836)	Small Indian Mongoose	Herpestidae	Rodentia	-	+	Sch. II Part I	Least Concern	

5	*Herpestes edwardsii* (É. Geoffroy Saint-Hilaire, 1818)	Indian Grey Mongoose	Herpestidae	Carnivora	+ (1)	+	Sch. II Part I	Least Concern	
6	*Paradoxurus hermaphroditus* (Pallas, 1777)	Common Palm Civet	Viverridae	Carnivora	+ (1)	+	Sch. II Part I	Least Concern	
7	*Pipistrellus coromandra* (Gray, 1838)	Indian Pipistrelle	Vespertilionidae	Chiroptera	+ (1)	-	-	Least Concern	
8	*Pteropus giganteus* (Brünnich, 1782)	Indian Flying Fox	Pteropodidae	Chiroptera	+ (1)	+	-	Least Concern	
9	*Rattus norvegicus* (Berkenhout, 1769)	Brown Rat	Muridae	Rodentia	+ (1)	-	-	Least Concern	
10	*Semnopithecus entellus* (Dufresne, 1797)	Bengal Hanuman Langur	Cercopithecidae	Primates	+ (1)	-	-	Least Concern	
11	*Suncus murinus* Linnaeus, 1766	House Shrew	Soricidae	Eulipotyphla	+ (1)	+	-	Least Concern	
12	*Viverricula indica* (É. Geoffroy Saint-Hilaire, 1803)	Small Indian Civet	Viverridae	Carnivora	+ (1)	-	Sch. II Part I	Least Concern	

1. Ghosh, S. 2010. Urban Biodiversity of Kolkata: Flowering Plants, Butterflies, Birds and Mammals. Zoological Survey of India (Occasional Paper no. 327).

Table 4.17. A Concise List of the Faunal Groups and their Species number

Sl. No.	Species Group	Earlier Surveys (no. of species)	Present Surveys (no. of species)	Consolidated (total no. of species)
1	Protozoans	14	0	14
2	Zooplanktons	45	9	51
3	Hemipterans or Bugs (Insecta: Hemiptera)	0	4	4
4	Coleopterans or Beetles (Insecta: Coleoptera)	0	1	1
5	Chalcids (Hymenoptera: Chalcididae)	11	1	12
6	Psocopterans (Insecta: Psocodea)	3	0	3
7	Ants (Hymenoptera: Formicidae)	29	2	29
8	Butterflies (Lepidoptera: Rhopalocera)	0	57	57
9	Dragonflies & Damselflies (Insecta: Odonata)	0	13	13
10	Mollusca (Freshwater)	20	8	20
11	Fishes (Chordata: Pisces)	26	35	40
12	Amphibians (Chordata: Amphibia)	0	5	5
13	Reptiles (Chordata: Reptilia)	0	11	11
14	Birds (Chordata: Aves)	107	44	107
15	Mammals (Chordata: Mammalia)	10	8	12

5.0. Air Quality of Rabindra Sarobar and its premises

5.1. Introduction

Air quality of the Sarobar area was monitored with a view to understand the impact of the events that involves huge mass mobilisation in the park. Two such spots could be identified, one at Nazrul Mancha (cultural programmes, indoor activity) and the other at the Stadium (sports event, outdoor activity). During February, the Nazrul Mancha had programmes almost every day at different times, but the Stadium hosted major Football events on 02nd, 04th, 18th and 28th of February 2017. Non-event days were 12th, 16th, 21st and 26th of the same month. Such events happened during late evening and continued till late evening, movement of vehicles and people starting during 1500 to 1600 hours. The term "event day" therefore means the days when the Stadium hosted Football matches and "non-event day" means no Football match at the Stadium. Air quality data are presented below along with standards.

5.2. Methodology

Air quality monitoring was performed employing manual samplers following the standard methodologies recommended by the Ministry of Environment of Forest, Government of India (Gazette Notification of National Ambient Air Quality Standard, NOVEMBER-2009) and elaborated by the Central Pollution Control Board (CPCB) in published document "National Ambient Air Quality Series:NAAQMS/36/2012-13".

5.3. Results

5.3.1. Previous Observations

Air quality of the Rabindra Sarobar in particular has never been monitored before. However, during the Chhat Puja in month of November 2016, Air Quality was monitored in the Rabindra Sarobar area as described below.

The monitoring was done during 5th November, 2016 to 8th November, 2016 at the following locations

Sl.	Station Name	Location
1	Near Fountain (KIT Control Room)	Near Fountain (Tollygunge Lake side), Kolkata
2	Near Art Gallery	Near Art Gallery (Dhakuria Lake side), Kolkata

Parameters monitored were:

- Particulate Matter 10 (PM_{10})
- Sulphur Dioxide (SO_2)
- Nitrogen Dioxide (NO_2)

Monitoring was conducted for both the locations as per the following schedule:

Sl. No.	Date & Time
Day-1	06 AM of 05 November 2016 to 06 AM of 06 November 2016
Day-2	06 AM of 06 November 2016 to 06 AM of 07 November 2016
Day-3	06 AM of 08 November 2016 to 06 AM of 09 November 2016

- with each day of 24 hours, divided into three shifts of 8 hourly sampling for $PM_{10,}$ with the monitoring for each day, commencing from Shift – I (06:00 – 14:00) hours, thus completing the 24-hourly schedule on the subsequent days with the Shift-III (22:00 – 06:00) hours.

- with each day of 24 hours, divided into six shifts of 4 hourly sampling for Sulphur Dioxide (SO_2) & Nitrogen Dioxide (NO_2) with the monitoring for each day, commencing from Shift – I (06:00 – 10:00) hours, thus completing the 24-hourly schedule on the subsequent days with the Shift-VI (02:00 – 06:00) hours.

The results are provided below:

Location	PM10 Average (mg/m^3)	PM10 Standard (mg/m^3)	NO2 Average (mg/m^3)	NO2 Standard (mg/m^3)	SO2 (mg/m^3)	SO2 Standard (mg/m^3)
Near Fountain (Tollygunge Lake side)	81.6	100	28.1	80	2.4	80
Near Art Gallery (Dhakuria Lake side)	93.3	100	31.0	80	2.8	80

From the results it is observed that the Air Quality complies with the National Ambient Air Quality Standard and is not impacted with the event “Chhat Puja”.

5.3.2. Present Observations

The Table below summarizes the Standard for Ambient Air Quality.

Air Quality Standard	
PM10	100 micro-g/cubic meter
PM2.5	60 micro-g/cubic meter
SO2	80 micro-g/cubic meter
NO2	80 micro-g/cubic meter

From the data presented above it can be clearly observed that for both the places, the Stadium and the Nazrul Mancha, the event days recorded higher counts. It can be concluded that such higher counts, being the average of four such days, clearly carry an imprint of the event, i.e., movement of a large number of people for Football match in the Stadium and concomitant activities.

The results obtained during the monitoring in February 2017 in the Rabindra Sarobar Area may now be compared with the ambient air quality situation in the Kolkata city. The Table below summarizes the results and puts the same for comparison with the February 2017 scenario of the Kolkata City.

Location	PM10 (mg/m^3)	PM2.5 (mg/m^3)	SO2 (mg/m^3)	NO2 (mg/m^3)
Rabindra Sarobar Stadium(Event Day Average)	228	100	7	60
Nazrul Mancha(Event Day Average)	179	87	5	49
Rabindra Sarobar Stadium(Non-Event Day Average)	196	100	5	55
Nazrul Mancha(Non Event Day Average)	168	87	4	46
Kolkata City Average	208	121	6.8	56
National Standard	100	60	80	80

It is observed that the maximum non-compliance in February 2017 is for parameters PM10 and PM 2.5 and if one compares the results with those obtained in the Sarobar points one observes that the Nazrul Mancha reflects comparatively better air quality than the Kolkata average, and although the Stadium scores marginally higher value in PM10 (228 against 208 in mg/m^3), PM2.5 is higher in Kolkata city average, and the gaseous air pollutants are comparable.

5.4. Conclusion

Although the monitoring results suggest that the Sarobar air quality is impacted by events like football matches in the Stadium, the air situation of the Sarobar as a whole is

partially better in comparison with the whole of Kolkata. Therefore, the ambient air quality in the Sarobar area may not be considered in the present respect as a causal agent putting significant ecological pressure on the habitats of the Lake premise.

6.0. Water Quality of Rabindra Sarobar and its premises

6.1. Introduction

Water samples were collected from four positions of the entire stretch of the lake as described below. Pictorially the locations are presented in Fig. 1.

1. AMRI Gate (2 Nos) South Eastern Corner (Lake-1)
2. Beside Bengal Rowing Club South- West Corner (Lake-1)
3. Beside Bengal Navy NCC (Lake -2)
4. Beside Lake Gardens Railway Station (South Side) (Lake-2)

Sampling for this water quality determination exercise of the Sarobar water was performed on 07 February, 2017. The water temperature of the lake that day was rather low, at 18˚C. Considering the lower temperature the profiling (diurnal variation of dissolved oxygen) was not performed on the same day. Later, this diurnal variation of dissolved oxygen was performed during mid-day (1200 hrs) of 06th to morning (1000 hrs) of 07th of April at the site number 2, i.e., by the side of Bengal Rowing Club. Such DO profiling provides a deep insight of the behavior of dissolved oxygen, its uptake by the aquatic life and rate and extent of replenishment of the dissolved oxygen in water through two mechanisms, (i) Respiration, i.e., solubility equilibrium of dissolved oxygen in water and the partial pressure of atmospheric oxygen and (ii) Photo Synthesis, in which oxygen is provided by the greeneries inside the water pool in presence of sun light.

6.2. Methodology

Methodology adopted for sampling, preservation and analysis were developed in-house with the methods published in the manual of American Public Health Association for analysis of water and wastewater. The collected samples were analyzed and the results are presented below. The analyses were done in presence of the direction of the Hon'ble National Green Tribunal, and to understand the health of the lake water. For DO profiling, Dissolved Oxygen was measured at the site every 2 hours and sample was collected from 1 foot depth. Water quality analysis was performed on the collected fresh water within 2 hours of the collection and therefore the question of preservative did not arise.

6.3. Results

6.3.1. Observations from previous studies

The most impressive observation on the water quality relevant to the present report was obtained from the report of Modi and Saraogi (1989). According to them, at that time,

the larger lake water was used for bathing, drinking, cooking and small lake for Public Swimming Pool. Their observations on water quality parameters are provided below.

- **pH:** This value gives an idea of the acidity-alkalinity condition of water. The pH scale ranges between 0 and 14, indicating 7 as neutral i.e., neither acidic nor alkaline. Most aquatic species of biological matters, organic microorganisms and botanical entities can grow in the pH range 6.5 and 8.5. If the pH falls to 5.0 or goes above 9.0, lachrymation of the eye (water secretion) starts. The water acquires a bitter taste. Moreover, any inadvertent gulping of the bitter water, upsets the acid-alkali balance of the digestive system resulting in stomach disorder. The irritation of the skin becomes progressively intensive beyond the pH ranges 5.0-9.0. Irrigation and gardening are not possible with water of the pH ranges below 5.0 and 9.0. Corrosion of metals, cement, brick, and other building materials becomes pronounced at the lower and higher pH values. The study recorded a pH value between 7.3 to 7.7 and therefore the water condition was found to be fairly alkaline.

- **Bacterial Organisms:** These are two types – (i) pathogenic i.e. disease producing like the 'coliform' bacteria is an indication of sewage contamination of water. It is expressed in a bacterial count, called MPN (mean probable number) per 100 milliliter of water. If the count is 500 and above, it is unsafe for drinking. Even an inadvertent gulping by a bather or a swimmer may cause disease. Such pathogen contaminated water may cause dermatitis like eczema of the skin. If such water is used for irrigation and gardening, the vegetation may be affected. In some soils, bacteria further proliferates. The study identified bacterial presence like *Bacillus subtilis, Pseudomonas aeruginosa,* and other Coliform organisms including *Micrococcus* and determined innumerable bacteriological colonies on experimental culture plate and opined that the water quality did not conform to the Bacteriological Standards (1984) of the Union Ministry of Works and Housing, New Delhi.

- **Dissolved Oxygen (DO):** Oxygen dissolved in water ensures the supply of oxygen to all living botanical and biological matters in water. When the oxygen content falls below 3 mg per litre of water, the survival of fish becomes difficult. Moreover, other aquatic species begin to suffer. The higher the oxygen content the better is the water. It also indicates that the oxygen has not been consumed by degradable matter put into water as a pollutant. When its value is zero, water begins to smell.

- **Biochemical Oxygen Demand (BOD):** The BOD value indicates the amount of degradable pollutants that are present in water. Pure water has a BOD value of one milligram per litre of water. A BOD value of 2 mg/litre or less ensures that the water is almost pure. According to the British valuation system, a BOD value of 2 to 4 mg/liter is fairly clean but beyond 4, water is of poor and doubtful quality, as it contains degradable matter. Above the value of 8, it is bad water containing pollutants, which should be avoided. BOD was determined during the study in a range of 2.5 to 5.2 mg/l which is rather high. The corresponding COD values were 32 and 79 mg/l indicating more than usual presence of oxygen consuming entities which are not bio-degradable, but of chemical nature.

- **Toxic Materials:** These may be organic, like benzene, mineral oil, grease, such things that may be harmful to living bodies. Arsenic and cyanides are poisons. Heavy metals like cadmium, chromium, lead, mercury and selenium cause permanent damage to the living bodies. The study tested the water samples for Arsenic and Cadmium but could not detect any such toxic metal species in the samples.

Other previous studies include the water quality determination by the WBPCB during the Fish Death Case in June 2016. The reports are provided below.

Table 6.1. Sampling was performed on 11th June 2016 and analysis were done immediately

Sl.	Pesticides	Near RC Side	Near Padma Pukur	Near Buddha Mandir
1	pH (value)	8.97	9.0	9.15
2	DO	11.7	12.4	14.5
3	BOD	4.7	5.7	5.95
4	Ammonical N	< 0.1	< 0.1	< 0.1
5	a-BHC	NT	NT	NT
6	g-BHC	NT	NT	NT
7	MP	NT	NT	NT
8	MALATHION	NT	NT	NT
9	CPS	BDL	BDL	NT
10	Aldrin	BDL	NT	NT
11	ENDO I	NT	NT	NT
12	DIALDRIN	NT	NT	NT
13	Endo II	BDL	NT	NT
14	2,4 DDT	NT	NT	NT
15	p,p-DDT	NT	NT	NT
16	ANILOPHOS	NT	NT	NT
Results are expressed in mg/L for parameters at 2 to 4 and □g/L for parameters at 5 to 16.				
BDL: Below Detectable Limit (DL - 0.05 ppb)				
NT: Not Traceable				

The results could not indicate, other than very high pH, any causal agent for the Fish death that happened 2 days age. However, a rather in-depth study was performed by the ICAR-Central Inland Fisheries Research Institute, (Indian Council of Agricultural Research), Barrackpore, Kolkata, India- 700 120 with following details. Water sampling for this study was done at two sites, (Site 1) Near Mosque and (Site 2) Near Buddha Temple.

CIFRI observed that there was excess growth of filamentous green algae (*Spirogyra*) on bottom sediment towards the bank of the lake (lentic zone) and the growth was very high at the sampling site-II Near to Buddha *mandir*. Interestingly, the lake bottom (at least up to about 10-15 feet from banks where this study was limited) was devoid of typical soil/sediment, and instead was full of rocks and bricks. With much difficulty only few grams of sediment could be collected by the Lake personnel which was insufficient for detailed study. The hard lake bottom, especially towards the Buddha Temple, was covered with decomposed filamentous algae.

The water quality analysis showed high BOD and COD levels, more oxygen consumption for decomposition of organic matter in the lake, as well as, presence of ammonia. Biological Oxygen Demand (BOD) level of the lake is more than 6 PPM, indicating the lake is not good health condition. High BOD may create low dissolved oxygen level for the aquatic animal in early hours and this when combined with rainfall might be the reason for recurrent seasonal fish mortality. It was remarkable that DO at site-II (measured at 5:30 pm) (with much decomposed algae at bottom) was only half of that in site-I (measured at 4:45 pm), suggesting very rapid oxygen depletion from the system.

CIFRI, however, could not indicate any single of bunch of reason for the fish death event but indicated the deteriorating environmental status of the water body and strongly recommended (1) Periodic physical removal of the filamentous green algae from lentic and lotic zones of the lake, at least before and during summer, (2) Removal of semi-decomposed filamentous green algae from the lake bottom, (3) Prohibiting feeding the fish by visitors and dumping of waste food matter, discharge of waste water etc. in the lake, (4) Removal of numerous plastic materials along the bank and (5) An assessment of density and distribution of fish in the lake may be assessed.

West Bengal University of Animal and Fishery Sciences (WBUAFS) performed a scholarly study on the fish death case in June 2016. Major observations of the WBUAFS study is narrated below.

- Most of the water quality parameters were well within the optimal levels recommended for fish.
- The pH was always above 8.0 and the range of pH observed was 8.20 – 9.15.
- The water was almost clear and the Secchi disc reading was in the range of 86-90 cm, indicating poor productivity.
- The levels of ammonia and nitrate were below detectable level, thus ruling out the toxic effects of ammonia, nitrite and nitrate for fish kills.
- Analysis of pesticides by WBPCB, Kolkata revealed no traces of pesticide residues in water, thus ruling out their involvement in fish kills.
- No conclusion could be drawn from the above water quality parameters, as they were determined from the surface water samples.
- Water quality parameters especially temperature and dissolved oxygen from the bottom water samples would have thrown some light on the observed fish kills.
- Fish kill in tropical regions are frequently attributed to low dissolved oxygen concentrations; however the circumstances causing these events vary considerably.
- The fish kills in ponds and small lakes usually occur during summer and winter stratification and are specially related to critically low oxygen levels; however, pollution, fish diseases and a phenomenon known as turnover can also kill fish.

WBUAFS further performed analysis of old reports and concluded the following in relation to the environmental condition of the lake. Two publications were duly considered during this study, those of Samal et. al. of year 2009 and 2014. Detailed observations are the following.

- The lake Rabindra Sarobar exhibits anoxic (DO < 1ppm or 1 mg/l) conditions only during the peak summer and generally to a height of 0.5-0.75 m from the bottom

sediment-water interface. The oxic conditions (DO: >5 mg/l) usually occur up to a depth of 2-2.5 m from the water surface with hypoxia (DO: 1-5 mg/l) in between. The hypoxic conditions in general exist within the oxycline layer of the water column.

- Over the years, the lake Rabindra Sarobar shows hypoxic conditions of dissolved oxygen except during the summer season. The Rabindra Sarobar remains completely mixed (about 8 months) from mid-June to February until the onset of thermal stratification (from March to mid-June: summer period).
- The available scientific data revealed the development of thermal stratification and dissolved oxygen stratification in Rabindra Sarovar (Samal et al., 2009, 2014). The thermal stratification is the result of energy exchanges between water and the surrounding environment, particularly the atmosphere. Low value of dissolved oxygen near the sediment-water interface develops the hypoxic condition (DO < 5 mg/l) and it gradually extended upward throughout the summer. As a result of thermal stratification the bottom layer is cut-off from atmospheric oxygen and oxygen producing plants.
- The rate of oxygen consumption is rapid in the thermocline zone due to high temperature gradient and contribute to the development of minimum DO and is continued throughout the summer and fall and persisted until thickening of the mixed layer destroyed it in early winter.
- Low value of DO cannot enhance other chemical oxidation processes in the band of hypolimnion, resulting in increasing the toxicity of the water and the water quality becomes unfit for the sustenance of the aquatic life in the water body.
- The tolerable limit of DO has been prescribed as 40% saturation level or 3.0 mg/l for fish. In a study by Samal et al. (2009), the DO value was found to drop below 1.0 mg/l at Rabindra Sarobar from the depth of 3.5 m to the bottom, which may account for a sudden fish die off.
- Lake stratification creates a thermal/density barrier to oxygen transfer between the epilimnion and hypolimnion of a lake, thus inhibiting reoxygenation of hypolimnetic waters. The decreasing DO level with depth is indicative of hypolimnetic DO depletion.
- The depletion of dissolved oxygen in the hypolimnion and the variability in water column temperature may be highly dependent and the variability over time series is an indicator of climate change both in tropical and temperate weather conditions. Formation of a hypolimnion oxygen minimum is of great importance for fishery management.

6.3.2. Observations of the present study

The Rabindra Sarobar lake is one of the stations of the National Water Monitoring Programme and the WBPCB performs analysis of water quality of this Sarobar every month. Comparing the reports of such continuous monitoring with the data of the present job (Table-2), all were found to be within usual range found round the year. The coliform counts has always been found high in respect of use of the water for outdoor bathing predominantly because of the continuous supply of such bacterial inoculum from the bird droppings and faeces of warm blooded animals. What is rather disturbing is the BOD of the water samples, which is a measure of biodegradable component in water that can be used up as food by the bacterial inoculum discussed above and as a result the water pool gets higher counts of such bacteria. Regarding water quality therefore it can be concluded that all possible sources

contributing such components to the Sarobar (e.g., wastewater drains or sewages, kitchen waste, solid food waste etc.) are required to be identified and blocked by the Authority managing the environmental health of the Sarobar. Comparing the reports with the national water quality criteria for use of natural water resource (Attachment-1) it can be opined that the Sarobar water may be used for "Propagation of Wild life and Fisheries" if the pH of the water can be brought down below 8.5.

Table 6.2. Water Quality of Rabindra Sarobar. Date of sampling = 07 FEB 2017

parameters	**Station 1**	**Station 2**	**Station 3**	**Station 4**
Ammonia-N (mg/l)	0.101	BDL	0.112	0.105
BOD (mg/l)	13.15	4.2	2.75	4.6
Boron (mg/l)	BDL	BDL	BDL	BDL
Calcium (mg/l)	22.4	20.8	20.8	22.4
Chloride (mg/l)	31.99	31.99	29.99	33.99
COD (mg/l)	38.51	32.9	20.47	24.12
Conductivity (µs/cm)	324.1	303.5	324.9	329
Dissolved O_2 (DO)(mg/l)	14.7	11.4	12.1	15.5
Fecal Coliform (MPN/100ml)	1700	2200	1300	3000
Fluoride (mg/l)	0.234	0.23	0.25	0.274
Magnesium (mg/l)	4.86	4.86	5.83	5.83
Nitrate-N (mg/l)	0.58	0.61	0.63	0.64
pH (Unit)	9.28	9	8.89	9.24
Phenolpthalein Alkanity (mg/l)	0	0	0	0
Phosphate-P (mg/l)	0.04	0.04	0.02	0.02
Phosphate-Total (mg/l)	0.2	0.22	0.22	0.08
Potassium (mg/l)	20	20	20	19
Sodium (mg/l)	63.77	63.77	63.77	63.77
Sulphate (mg/l)	20.66	18.29	21.05	20.03
Temperature (˚C)	25	25	25	27
Total Alkalinity (mg/l)	132	132	134	136
Total Coliform (MPN/100ml)	3000	5000	2300	8000
Total Dissolved Solids (TDS)(mg/l)	226	194	206	218
Total Fixed Solids (TFS)(mg/l)	130	138	88	126
Total Hardness as $CaCO_3$ (mg/l)	76	72	76	80
Total Suspended Solids (TSS)(mg/l)	12	12	6	10
Turbidity (NTU)	7.36	4.25	3.26	6.12
Copper (mg/l)	BDL	BDL	BDL	BDL
Zinc (mg/l)	BDL	BDL	BDL	BDL
Lead (mg/l)	BDL	0.2	BDL	BDL
Chromium (mg/l)	BDL	BDL	BDL	BDL
Arsenic (mg/l)	BDL	BDL	BDL	BDL
Iron (mg/l)	0.21	BDL	0.36	BDL
Cadmium (mg/l)	BDL	BDL	BDL	BDL
Nickel (mg/l)	BDL	BDL	BDL	BDL
Manganese (mg/l)	BDL	BDL	BDL	BDL
Mercury (mg/l)	BDL	BDL	BDL	BDL

The diurnal behavior of the lake water is a very important parameter at this juncture. To evaluate that, the Dissolved Oxygen of the lake water at a single point (Near Bengal Rowing Club) was determined at the spot for 24 hours round the clock. The date selected was from 1200 hrs. of 07 April to 1000 hrs of 08 April, 2017. As the ambient

temperature on this date the air temperature was 32˚C and the water temperature was 30˚C, sufficient solubility was expected for aerobic oxygen and expectedly, during the late noon (16:10 hours), the high DO value of 11.1 mg/L was recorded (Figure-2) when the Photo-Synthesis reached its maximum, along with the respiration. But with immediate disappearance of the sun, the DO value was found to drop to around 5.2.

Table 6.3. Dissolved Oxygen at different time of the day

Time	DO (mg/L)
12:10	7.7
14:10	10.8
16:10	11.1
18:10	5.2
20:10	3.6
22:10	3.3
0:10	3.2
2:10	3.1
4:10	2.8
6:10	2.5
8:10	2.9
10:10	4.6

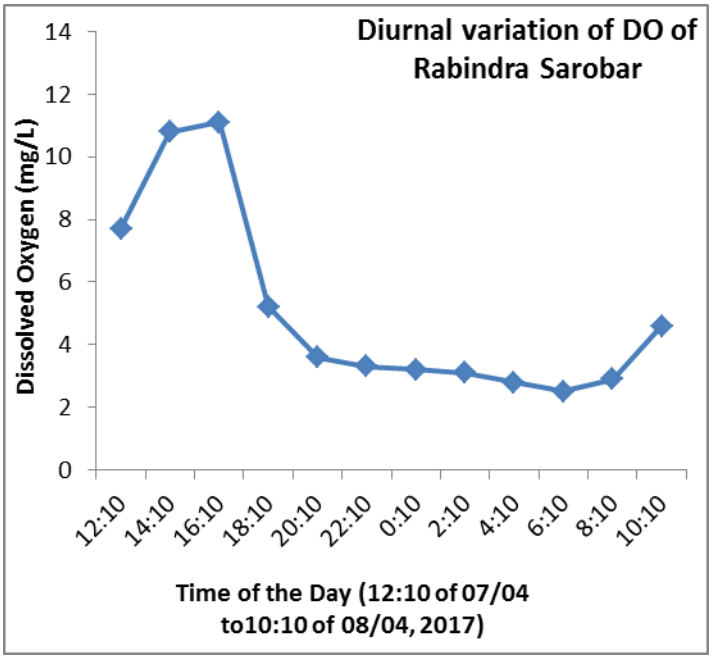
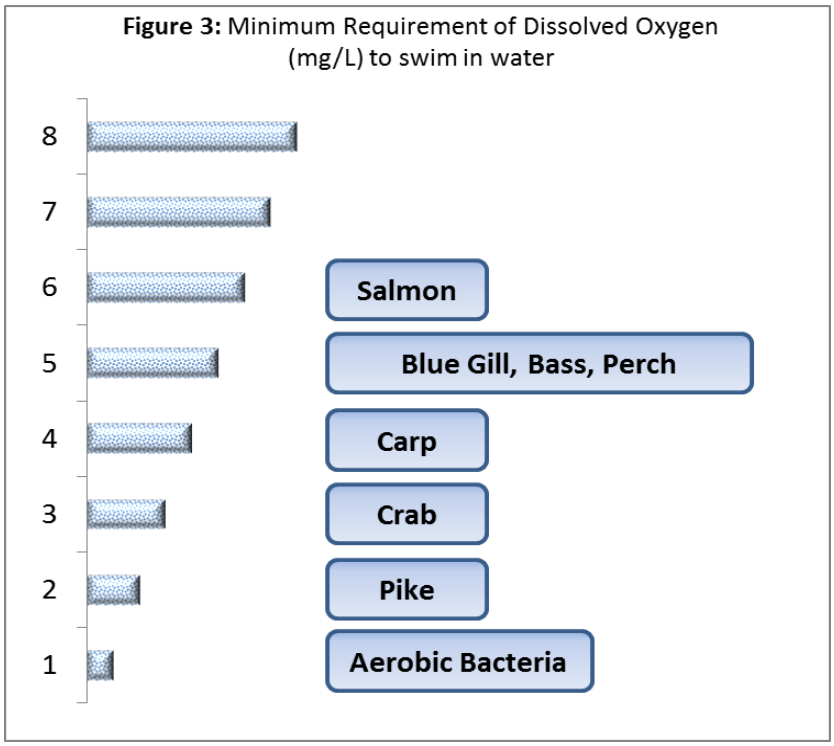


Figure 2: Diurnal behavior of Dissolved Oxygen in Rabindra Sarobar



18:10 hours. Later, during the night

and early morning before the sun rise on the following day, the DO value remained below 4.0 mg/l, reaching below 3.0 mg/l for more than 6 hours between morning 02:00 and 08:00 hours. Figure-3 provides the data on required Dissolved Oxygen for normal proliferation of different fish species. In a recent publication 'Water quality guidelines for the management of pond fish culture', Bhatnagar and Devi (2013) have categorically mentioned that the Dissolved Oxygen of 5.0 mg/l or more is a compulsory requirement for healthy fish growth. The Dissolved Oxygen Profile, compared with the values of BOD and bacteriological parameters of Sarobar equivocally indicates the environmental status of the water body towards Eutrophication.

The principal water quality parameters which were found to critical, are tabulated below with comments.

Table6. 4. Comparison of water quality parameters of concern.

parameters	Sample 1	Sample 2	Sample 3	Sample 4	Comments
BOD(mg/l)	13.15	4.2	2.75	4.6	Very high BOD leads to high bacterial count and ensures high growth of micro-organisms depleting the dissolved oxygen fast.
pH(Unit)	9.28	9	8.89	9.24	When the pH of freshwater becomes highly alkaline (> 9.0), the effects on fish are lethal. as it becomes unable to dispose of metabolic wastes. High pH may also increase the toxicity of other substances. For example, the toxicity of ammonia is ten times more severe at a pH of 8 than it is at pH 7. It is directly toxic to aquatic life when it appears in alkaline conditions. Low concentrations of ammonia are generally permitted for discharge.
Potassium (mg/l)	20	20	20	19	Potassium is more toxic to fish and shellfish than calcium, magnesium or sodium. Potassium stimulates plankton growth in lakes. Potassium in lakes from 0.4 to 1.5 mg/L in oligotrophic and mesotrophic lakes As high as 5 to 6 mg/L indicates beginning of eutrophication.
Phosphate-P (mg/L)	0.034	0.04	0.02	0.02	Phosphate Phosphorus is at standard value.
Total Phosphate (mg/L)	0.2	0.22	0.11	0.08	Average total phosphorus is 0.15 mg/l, almost 5 times over average Phosphate Phosphorus. This clearly establishes that a huge proportion of phosphorus is available in form of organically bound which indicates movement of the water resource from Oligotrophic to Mesotrophic.

The very high pH therefore may be identified as the focal issue in relation to the environmental health of the pond. A tentative reason for this is placed below.

6.3.3. Possible reasons for very high pH of Rabindra Sarobar

High pH in natural lakes is generally attributed to ill management of the underwater biological activity that controls carbon dioxide concentrations in surface water systems. Living organisms continuously produce carbon dioxide as a product of respiration and during daylight, algae and underwater plants remove carbon dioxide from the water as part of the sunlight-driven process of photosynthesis. The relative rates of respiration and photosynthesis within the pond determine whether there is a net addition or removal of carbon dioxide. In case the removal dominates, the pH of the water body increases.

pH rises during the day as underwater photosynthesis exceeds respiration, and carbon dioxide is extracted from the water followed by higher rates of photosynthesis controlled primarily by sunlight intensity, plant biomass and water temperature. With setting sun in late afternoon, rate of photosynthesis decreases and eventually stops and pH falls throughout the night as respiring organisms keep on adding carbon dioxide to the water as their metabolic outcome. The next day when the sun rises, plants resume photosynthesis and removal of carbon dioxide from water begins in the same cycle.

In cases where daily photosynthesis equals respiration, pH remains within a range tolerated by most of the aquatic species. However, with high algal growth and count of bacterial species, more carbon dioxide is removed each day by photosynthesis than is added each night by respiration. As a result, pH rises to abnormally high levels. This condition may last for many days, until photosynthesis decreases or respiration increases. Extended episodes of high pH are particularly common in ponds where filamentous algae dominate the plant community. Ponds with filamentous algae usually have clear water, allowing sunlight to penetrate deep into the water column and promote intense photosynthesis by underwater or floating mats of algae.

6.4. Conclusion

The following concluding points are provided on the basis of the previous studies and determinations performed for the present study during February to April 2017.

- The lake Rabindra Sarobar exhibits a DO profile during the sunniest days of the year with clear indication of mechanism existing in the pool that eats up the dissolved oxygen faster than should happen for healthy aquatic habitat. Hypoxic condition is expected any time with 3 / 4 consecutive overcast days.
- The high rate of oxygen consumption by the microbes tend to destroy the healthy dissolved oxygen balance and as low value of DO cannot enhance other chemical oxidation processes in the water, COD becomes very high in proportion with the biodegradable components. This makes the water to be toxic for the sustenance of the aquatic life in the water body.
- The pH was always above 9.0 and the range of pH observed was 8.89 to 9.28. Such high pH for natural water body is simply unacceptable.

- The Sarobar water is neither toxic in respect of Ammonia or any other sewage-related contamination, nor is there any threat of contamination from industrial waste or agricultural run offs, as no trace of toxic metals or pesticides could be identified ever.
- On the final count, the lake water is not fit for any of the purposes mentioned in the "Designated national use criteria of natural water and their classes" (Attachment – 1) prescribed by the Ministry of Environment and Forests, Government of India.

Attachment - 1

Designated national use criteria of natural water and their classes		
Drinking Water Source without conventional treatment but after disinfection	**A**	• Total Coliforms Organism MPN/100ml shall be 50 or less • pH between 6.5 and 8.5 • Dissolved Oxygen 6mg/l or more • Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
Outdoor bathing (Organised)	**B**	• Total Coliforms Organism MPN/100ml shall be 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5mg/l or more • Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Drinking water source after conventional treatment and disinfection	**C**	• Total Coliforms Organism MPN/100ml shall be 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more • Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Propagation of Wild life and Fisheries	**D**	• pH between 6.5 to 8.5 Dissolved Oxygen 4mg/l or more • Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	**E**	• pH between 6.0 to 8.5 • Electrical Conductivity at 25°C micro mhos/cm Max.2250 • Sodium absorption Ratio Max. 26 • Boron Max. 2 mg/l

6.6. References

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7.0. Lake Sediment and Subsurface Soil of Rabindra Sarobar and its premises

7.1. Introduction

Soil and sediment supply the essential nutrients, water, oxygen and root support for the plants and microbial world. They also serve as buffer to protect the delicate variations in the system. Also sediments are an important source of nutrients to fresh water ecosystem.

In the present study, the team of expert has worked in the Rabindra Sarobar Lake, popularly known as Dhakuria Lake, situated on the southern fringe of Kolkata, which is under extreme threat. Over exploitation of its resources due to urbanization, unprecedented developmental and anthropogenic activities have resulted in silting up of the Lake, choking with weeds, encroachment from all sides and subsequent shrinkage of the size of the lake, pollution and deterioration of water quality, loss of biodiversity and other biological resources. Contaminated sediment release under hydrodynamic condition is the focus area in this study. The study focused on the distribution of nutrients in the sediment(N &P) and also its toxic compounds like Cd, Pb, As & Hg.

7.2. Material and Method

For the quantification of available Nitrogen, available Phosphorus and presence of toxic chemicals like Cadmium (Cd), Lead (Pb), Arsenic (As) and Mercury (Hg) samples were collected from eight locations. The sites and mode of sampling are described in Table-I.

Table 7.1. Location Detail of Sampling of Lake Sediment

Site	Locational Detail	Sampling method
1	AMRI Gate No-2 (South- East corner)	By Boat (with Sediment Sampler)
2	Public Swimming Pool (North- East corner)	By Boat (with Sediment Sampler)
3	Besides Bengal Rowing Club (South-West corner)	By Boat (with Sediment Sampler)
4	Behind Kolkata Rowing Club (North- west corner)	By Boat (with Sediment Sampler)
5	Beside Rabindra Sarobar stadium	By Boat (with Sediment Sampler)
6	Opposite to Mother dairy Depot (North side)	By Boat (with Sediment Sampler)
7	Beside Tollygunge Railway station (south side)	By Boat (with Sediment Sampler)
8	Beside Bengal navy NCC	By Boat (with Sediment Sampler)

Apart from this sub-surface soil from in and around Rabindra Sarobar Lake was collected and the locational details are described in the Table-II.

Table 7.2. Locational detail of Sampling of Sub surface soil

Sl No.	Detail of the location of sub surface soil
1	Opposite to Tollygangue railway station

2	Near Navy NCC
3	Besides water works & Civil Defence
4	Opposite to civil Defence
5	Near Kolkata cricket Coaching Club
6	In front of Menoka

Collected samples were coded and transferred to the Laboratory for processing and analysis. Air dried samples were grinded, sieved and analysed.

7.3. Methodology

i) Available Nitrogen

Available Nitrogen of soil and lake sediments was estimated using alkaline $KMnO_4$, which oxidizes the organic matter present in the soil and hydrolysis the liberated ammonia which is condensed and absorbed in boric acid. The absorbed ammonia in boric acid was titrated against standard acid following the standard procedure (Subbiah and Asija, 1956). This method has been widely adopted to get a reliable index of nitrogen availability in soil due to its rapidity and reproducibility.

ii) Available Phosphorus

Available Phosphorus from soil and lake sediments was determined following the standard method based on the pH of the soil and sediment which is the pre requisite criteria for selection of extraction method. As the soils are neutral to slightly alkaline range, the Olsen method was adopted for extraction and determination of available phosphorous form ant. For determination of Available Phosphorus 0.5 M $NaHCO_3$ solution at pH 8.5 was used for extraction followed by color development for extraction followed by color development by Ammonium molybdate solution and Stannous Chloride solution. The intensity of the color was measured spectrophotometrically with reference to the standard solution for determination of Available Phosphorus (Jackson, 1973 and Black, 1965)

iii) Heavy Metal

Nitric acid digestion undertaken for heavy metal analysis of the Sediment/Sub surface Soil.

7.4. Results

Table 7.3. Quantification of available nitrogen, available phosphorus and Heavy metals from the sediments of the Lake

S.No	Detail of the Location	Date of Collection	Nutrients(mg/Kg)		Heavy Metals(mg/Kg)			
			Available Nitrogen	Available Phosphorus	Cd	Pb	As	Hg
1	AMRI gate (2 No) /(KIT) – South – East Corner	25.01.2017	143.62	69.2	<0.03	48	3.34	0.012
2	Public Swimming Pool North –East Corner	25.01.2017	151.61	62.0	<0.03	55	1.50	0.013
3	Beside Bengal Rowing Club South –West Corner	25.01.2017	292.57	60.0	<0.03	115	3.10	0.009
4	Behind Kolkata Rowing Club North-West Corner	25.01.2017	186.20	55.0	<0.03	65	1.73	0.006
5	Beside Rabindra Sarabor Stadium	25.01.2017	417.45	51.0	<0.03	146	2.64	0.057
6	Opposite of Mother Dairy Depot (North side)	25.01.2017	77.13	65.0	<0.03	93	1.67	0.017
7	Beside Tollygunge Railway Station (South side)	25.01.2017	212.76	70.0	<0.03	66	3.12	0.003
8	Beside Bengal Navy NCC	25.01.2017	93.1	59.0	<0.03	77	3.11	0.012

Table 7.4. Quantification of Available Nitrogen, Available Phosphorus and Heavy metals from the sub-surface soil in and around the Lake

S. No	Detail of the Location	Date of Collection	Nutrients(mg/Kg)		Heavy Metals (mg/Kg)				
			Available Nitrogen	Available Phosphorus	Cd	Pb	Fe	As	Hg
1	Opposite to Tollygunge Railway Station	21.02.2017	104	150	BDL	32	13750	1.68	0.019
2	Near Navy NCC	21.02.2017	101	78		86	15210	2.13	0.030
3	Besides Water Works & Civil Defense	21.02.2017	84	98		32	21207	2.38	0.090
4	Opposite to Civil Defense	21.02.2017	174	246.6		53	17580	2.27	0.069

5	Near Calcutta Cricket Coaching Centre	21.02.2017	204	166		79	18483	1.92	0.080
6	In front of Menoka	21.02.2017	84	163		38	33647	2.08	0.192

Sediment samples were collected from eight sites at Rabindra Sarobar Lake as elaborated in the Table-III, Results are reported from data collected during post winter season in the month of February just before the onset of summer Results in Table -III reveals wide variation in available Nitrogen ranging from 77.13 mg/kg to 417.45 mg/kg is observed in the lake sediment with the variation of sampling site. Sample site 3 & 5 shows the high content of available Nitrogen when compared with the critical limit 280 mg/kg. However, sampling site 6 & 8 shows low content i.e. less than 140 mg/kg and sampling site 1,2,4&7 shows moderate level. All the sites show high content of available Phosphorus. Among the heavy metal Lead & Arsenic are quite in the higher range whereas Cadmium and Mercury are quite low. The data reveals that the lake is under threat due to anthropogenic activity in all the sites. The Sites 3 & 5 are mostly affected sites.

Sub surface soil sample collected from six important locations in an around the lake. Results in the Table-IV reflects that available Nitrogen and phosphorus are higher in the site 4 & 5 available Nitrogen ranges 84 mg/kg to 204 mg/kg and available Phosphorus ranges from 78 mg/kg to 247 mg/kg. Heavy metals Lead and Iron were quite high but others like Cadmium, Arsenic and Mercury were found within critical limit.

7.5. Discussion

Quantification of available Nitrogen, available Phosphorus and Heavy metals like Cadmium, lead, arsenic and Mercury shows that there is a strong site wise variation in data both in the sediments of lake and sub surface soil. The sites near the banks are definitely more accessible and are ideal for anthropogenic activities like bathing, washing clothes and immersion of idols particularly after the festive season. Due to the high popularity of the Rabindra Sarobar Lake it is regularly visited by joggers, children and visitors for recreational purpose. The banks are thus often burned by pollutants which are dumped into the water by these visitors.

Phosphorus level enhancement is often related to washing and laundering activities as detergents are the main source of phosphates. In this report available phosphorus

in the sediment of lake and in the sub surface soil were found to be quite high at most sites. This could be related to extensive bathing and washing activities which is carried out on the banks of the lakes. Such high phosphorus levels are alarming as phosphorus is often regarded as the main culprit in cases of eutrophication in lakes. The concentration of algae and the tropic state of lakes correspond well to phosphorus level in water. High levels of algae reduce clarity and can lead to decrease in available dissolved oxygen as the algae decays.

Concentration of the different metal ions in the sediment of lake and in the sub surface soil Pb, Fe are found to be above the permissible levels but other metal ions like Cd in sediment as well as in sub surface soil it is below the permissible limit.

Since absorption of Lead poses a risk, where possibilities of uptake of Lead by the fishes and other aquatic organisms breeding in this area could easily lead to the death in the long run. This could mean a total disruption of the ecological balance in the aquatic ecosystem.

7.7. References

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8.0. Noise Scenario of Rabindra Sarobar and its premises

8.1. Introduction

The Rabindra Sarovar lake is a very important and notable landmark in Kolkata city. It covers about 192 acres of marshy land. Kolkata Improvement Trust (KIT) is responsible for development and maintenance of the lake. Presently, about 73 acres of this lake is covered by water. It is the natural habitat of different types of flora, fauna and birds. Many shrubs and trees are present at the banks of

the lake and some of them are more than 100 years old. According to 2012 census, about 50 different species of trees are found in the area. To the north of the lake, Rabindra Sarovar Stadium is present, having a seating capacity of approximately 26000 people. It was established in 1950s'. It is the first stadium in the city to be fully equipped with audio-visual training facilities.

It is presumed that holding football matches in Rabindra Sarovar stadium could cause ecological and environmental damages to the lake and its flora and fauna. During the match, floodlights are used along with loudspeakers, which could affect the nesting and movement of birds and animals and also detrimentally affect natural habitats of flora and fauna in and around the lake. Also, high decibel sound of the crowd, uses of drums, loudspeaker could hamper fauna and birds around the lake. A petitioner has moved the National Green Tribunal pleading that the games should not be organized at night without proper environmental monitoring and clearance. A committee was formed by NGT EZB to undertake a rapid EIA study on the baseline scenario of the lake biodiversity and the effects of football matches on the lake flora and fauna

Continuous ambient sound level monitoring study was undertaken to understand the influence of football matches on ambient sound levels in the vicinity of Rabindra Sarovar Stadium. The specific goal of sound monitoring was to understand the changes in ambient sound levels during football matches over background levels and likely positive or negative influence of sound generated during football matches on the local fauna/birds that is found to reside or nest temporarily or permanently in and around Rabindra Sarovar Lake. Also, sound level on normal non-event (no football match) days were also planned to be measured to understand business as usual scenario. The sound waves are expected to propagate even to the main lake area that is about 300 m away from the stadium towards Lake Club or definitely through the tree lines to the lake area that is just adjacent to the stadium, about 100 m away. Also, the site at Nazrul Mancha may be influenced by stadium sound, even if about 1000 m away.

Two different noise level monitoring survey were undertaken and presented at para 8.2.1 and 8.2.2 separately.

8.2. Methodology

8.2.1. Study Area for Noise Survey No. 1

The study area chosen for ambient sound level monitoring was centered around Rabindra Sarovar Stadium that held a few football matches of Mohan Bagan club during 4-28th February, 2017. Rabindra Sarovar stadium is located near Rabindra Sarovar Lake in Kolkata city. Five sampling points in and around the Rabindra Sarovar stadium were chosen for sound monitoring where the birds, animals and humans, residing or visiting the lake or surroundings may be disturbed due to sound

generated during football matches held at Rabindra Sarovar Stadium. **Table 8.1** represents a summary of the sites .

CSIR-NEERI initiated the first monitoring exercise on 4th February, 2017 near Lake Club Entrance. A mosque is situated on one of the lake's islands about 30 m away from this point, which is connected to the southern shore by a wooden suspension bridge. As this point is the interphase between stadium and the largest part of the lake, this area is of prime importance as far sound wave propagation to the largest part of lake is concerned. This site has an approximate distance of about 300 meters from the centre of stadium. Sound level monitoring was conducted at 3:00 PM to 10:00 PM. The match started at about 7:05 PM and ended at about 8:50 PM. The second sound monitoring exercise was undertaken on 7th February just beside the Press Box in the stadium to examine the sound level at a close-by point during a football match. On this day, monitoring was undertaken from 3:00 PM up to 10:00 PM and the match started at about 7:00 PM and ended at about 9:00 PM. The third and last of the monitoring exercises was undertaken on 18th February when another football match was held at 4:35 PM at the same stadium. This point is situated just adjacent to the building of Calcutta University, which is about 80 m away from the centre of stadium. This point is also a part of Rabindra Sarovar lake area. It was the nearest point outside stadium periphery where the lake biodiversity is present including birds that nest and rest on the trees. To minimize the effect of floodlight and sound on the trees that line this area and also a part of the lake that extends here, black plastic curtain has been used around the stadium periphery on this side to minimize light and sound transmission from the stadium to this area. The details of sites and monitoring are presented in Table - 1.

Another sound level monitoring exercise was initiated by WBPCB at two other positions (Behind press box in the stadium and at Nazrul Macha) during 4-18th February with the objective of capturing grab hourly average sound levels on even days (football match) and non-event (no football match) days. Monitoring on 4, 7, 12, 16, 18, 21, 26 and 28th February that included event (football matches on 4, 7, 18 and 28th February) and non-event days (12, 16, 21 and 26th February) (Table-1).

Table 8.1. Summary of sampling sites and sound monitoring exercise

Site No.	Site Location	Approx. distance from centre of stadium	Site selection justification and remarks	Sources of sound	Date, time and type of sound level monitoring
1.	Near Lake	300 m	This site represents the	Occasional loudspeakers	4th February, 2017 (Continuous sound level

	Club entrance (Code: LC)		interphase between sound propagation from stadium and the largest part of Rabindra Sarovar Lake	from Lake club, Bengal Rowing Club, Calcutta Rowing Club, vehicular traffic of Debaki Kumar Bose Sarani, Parking lot of Lake Club, prayers from the Masjid etc.	data at 1-second intervals during 3:47 PM to 9:21 PM. The match on this date was held during 7:05 PM to 8:50 PM)
2.	Left side of Press Box on terrace in the stadium (Code: PB)	50 m	This site represents a very close-by point of sound propagation in the stadium	Vehicular traffic of Sarat Chatterjee Avenue behind press box, loudspeakers of stadium	7th February (Continuous sound level data at 1 second intervals during 3:00 PM to 9:30 PM. The match on this date was held during 7:05 PM to 8:50 PM)
3.	Behind the tree line on the Southern side of stadium. Behind black curtain of stadium (Code: TL)	100 m	This site represents a tree covered fringe of the stadium where birds reportedly nest and rest at night	Vehicular traffic of Sarat Chatterjee Avenue and Debaki Kumar Bose Sarani. Also, occasional passing of trains of circular railway	18th February (Continuous sound level data at 1 second intervals during 3:00 PM to 8:15 PM. The match on this date was held during 3:45 PM to 5:30 PM)
4.	Behind Press Box in the stadium	55 m	This site represents another very close-by point of sound propagation within the stadium periphery	Vehicular traffic of Sarat Chatterjee Avenue behind press box, loudspeakers of stadium	Monitoring on 4, 7, 12, 16, 18, 21, 26 and 28th February that included event (football matches on 4, 7, 18 and 28th February) and non-event days (12, 16, 21 and 26th February). Monitoring results are reported hourly from 7 AM to 12 PM (night)
5.	Nazrul Mancha	1000 m	This site represents a far-off point from	Sound from Anderson Club activities, Nazrul	Monitoring on 4, 7, 12, 16, 18, 21, 26 and 28th February that included

			stadium beside the Eastern fringe of Rabindra Sarovar	Mancha and Southern Avenue traffic	event (football matches on 4, 7, 18 and 28th February) and non-event days (12, 16, 21 and 26th February). Monitoring results are reported hourly from 7 AM to 12 PM (night)

8.2.2. Monitoring Methodology for Noise Survey No.1

Continuous sound level monitoring was undertaken by continuously datalogging sound level meter (Cirrus Research Plc., UK). Sound level parameters like LA_{eq} (Equivalent continuous sound level with A-weighted frequency response) and LAS_{max} (The maximum level with A-weighted frequency response and slow time constant) were recorded before, during and after the football matches to understand the trend of ambient sound level affected by the football matches. Hourly grab sound level (LA_{eq}) monitoring was undertaken by another sound level meter (Lutron Electronic Enterprise Co., Ltd.).

8.2.3. Study Area for Noise Survey No. 2

The survey was for eight days (24 hours each day) for ambient noise level monitoring at two locations given in the table below:

Sl.	Station Name	Location at Rabindra Sarobar
1	Football Stadium	Roof Top of Pavilion Hall of the Football Stadium
2	Nazrul Mancha	Balcony of VIP Gate at Nazrul Mancha

The ambient noise level in dBA at the both locations was monitord from 6:00 am to 6:00 am (next day) with an interval of 1 (one) minute. At each location, monitoring was conducted for both the locations as per the following schedule:

Sl. No.	Date & Time
Day-1	06 AM of 04 February 2017 to 06 AM of 05 February 2017
Day-2	06 AM of 07 February 2017 to 06 AM of 08 February 2017
Day-3	06 AM of 12 February 2017 to 06 AM of 13 February 2017
Day-4	06 AM of 16 February 2017 to 06 AM of 17 February 2017
Day-5	06 AM of 18 February 2017 to 06 AM of 19 February 2017

Day-6	06 AM of 21 February 2017 to 06 AM of 22 February 2017
Day-7	06 AM of 26 February 2017 to 06 AM of 27 February 2017
Day-8	06 AM of 28 February 2017 to 06 AM of 01 March 2017

8.2.4. Monitoring Methodology for Noise Survey No. 2

The ambient noise level in dBA was monitored by using Sound Level Meter, HTC Instruments make SL-1352 Professional. The ambient noise level in dBA was monitored for 24 hrs with one minute interval and sound level range Automatic: (30dB~130dB) as per methodology prescribed by Central Pollution Control Board (CPCB). Also, Ambient noise level monitoring was conducted with an interval of 15 minutes using make Lutron SL-4001.

Specification of Sound Level Meter (HTC Instruments make SL-1352)

Basic Function	Range
Accuracy	1.4dB
Resolution	0.1dB
Frequency Range	31.5Hz ~8kHz
Dynamic Range	50dB
Level Range	Low:30dB~80dB Medium:50dB~100dB
	High:80dB~130dB Auto: 30dB~130dB
Time Wieghting	FAST (125mS),SLOW (1s)
Microphone	½ inch electric condenser microphone
Display Update	2 times/sec
Analog Output	AC/DC outputs,AC=1Vrms,DC=10mV/dB

8.3. Results

8.3.1. Previous Observations

A very important previous observation on the noise level of the Rabindra Sarobar area was obtained in a report published by Mr. Rusy Modi and Mr. Atmaram Saraogi in 1989. They performed noise level measurements at a lateral distance of 500 meters due north from the Lake Gardens Crossing and just outside the Sarobar Complex area deploying the methodology prescribed by the

Indian Standard document IS-3028:1980 prevailing at that material time. The noise level measurement was performed using a National Physical Laboratory certified machine with "A" rating average.

The back ground noise level, i.e., during "no traffic" condition, the noise level was measured to be 64 dB(A) in the morning and night hours. In contrast, with an average traffic flow of 750 to 800 per hour during high traffic period (0900 to 1100 hours in the morning and 0600 to 0800 hours in the evening), the average noise level was recorded to be 75 dB(A). The background and the high traffic noise level both were high compared to the speech interference level (SIL), i.e 50 – 55 dB(A) at which the conversations are usually made.

Noise monitoring was performed at the Rabindrasarobar during Chaat Puja by the West Bengal Pollution Control Board. Although Grab sampling was performed in such cases, levels as high as 78 to 80 db(A) were recorded inside the Sarobar premise, although very near (within 2 meter) the Chatt activity. Since a huge gathering happens during Chatt, such noise level may have been predominantly influenced by the combined speeches of the gathering and therefore may not be relevant for comparison for the present case.

8.3.2. Present Survey

Sound level monitoring was undertaken on continuous basis, starting from a few hours before the start of the football match, during the match and a little after the match and therefore the trend of sound level indicated fairly the temporal variation in sound with the effect of the football match. The LA_{eq} (Equivalent continuous sound level with A-weighted frequency response) and LAS_{max} (The maximum level with A-weighted frequency response and slow time constant) were plotted against time to understand temporal variation in sound level as affected by the football matches. The time-series sound level graph is full of spikes as expected due to various sources of sound around the sites apart from sounds from the football ground. To understand the effects of sound generated within football stadium during matches, trendline fitting was undertaken. The sound level trends (polynomial fitting) in time-series graphs of all the matches indicated a slightly elevated sound level trend during matches as presented by a blue block, representing match duration. During the match on 4th February, elevation in sound levels were not so remarkable probably as this site was about 300 m away from the stadium and was partially blocked by trees in between. The elevation in sound level was most conspicuous for the match on 7th February as the site was just adjacent to the ground on the stadium without any effective blockage .During the match on 18th, several sound peaks were observed during the match, indicating periodical sound bursts and roars and as this site was behind the tree lines outside the stadium, there could be partial sound blockages.

Descriptive statistical analysis (mean, median, mode, 50th, 75th, and 90th percentile, standard deviation and coefficient of variation) of the sound level data generated before, during and after the football matches held on 4th, 7th and 18th February were performed (**Table 8.2-8.4**) to evaluate summary levels of LA_{eq}, LC_{peak} (The Peak, referred to as the L_{peak} or sometimes L_{pk}, is the maximum value reached by the sound pressure. There is no time-constant applied and the signal has not passed through an RMS circuit or calculator. This is the true peak of the sound pressure wave. So, LC_{peak} is C-weighed peak of sound pressure) and LAS_{max} before, during and after the football matches by which it could be understood if the football matched indeed had some effects on ambient sound level or not. It is evident that during the football matches, there was indeed some quantifiable increase in mean, median, mode, 50th, 75th and 90th percentile in sound levels in terms of LA_{eq}, LC_{peak} and LAS_{max}, that are important sound level evaluating parameters. The values indicating standard deviation and coefficient of variation only indicated the extent of variation in respective sound level parameters (i.e. LA_{eq}, LC_{peak} and LAS_{max}) before, during and after the matches. These two statistical parameters showed random trends amongst before, during and after match scenarios and hold little significance under present context.

Further, the continuous sound level data (LA_{eq}) was mined and hourly (when the match was started at 7:00 PM and ended at about 9:00 PM) or hourly and half-hourly (when the match was started at 4:30 PM and ended at about 6:30 PM) average LA_{eq} (dB) was extracted to evaluate time-bound periodical sound level behaviour before, during and after football matches held on 4th, 7th and 18th February. As evident from the presented graphs, sound level (LA_{eq}) had distinct elevation during football matches over the average background sound levels (an elevation roughly in a range of about 2-5 dB) and after matches the sound levels came down to background or even lower levels in some cases especially when it was past 10 PM, when sources of sound like traffic and other anthropogenic sources came down to much lower levels.

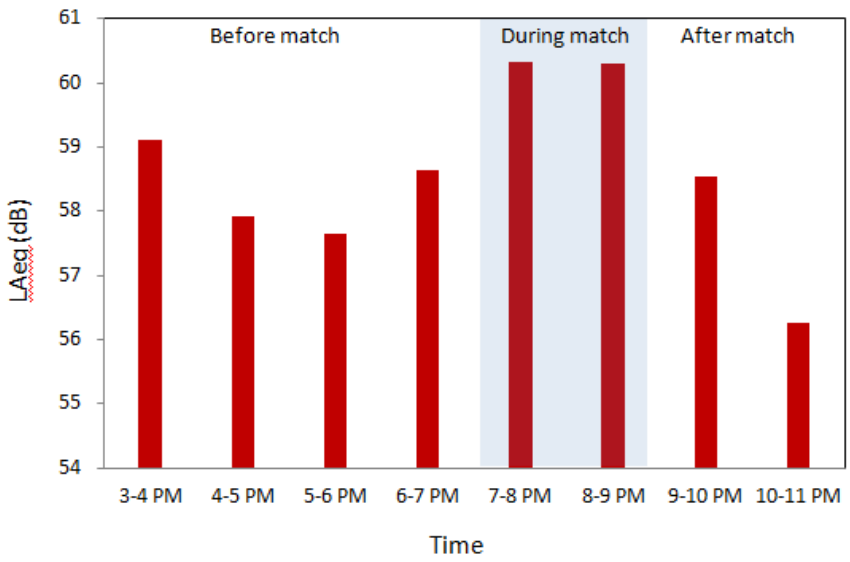

Fig. 8.1. Hourly variation of LA_{eq} before, during and after the football match held at Rabindra Sarovar Stadium on 4th February (site: Lake Club entrance)

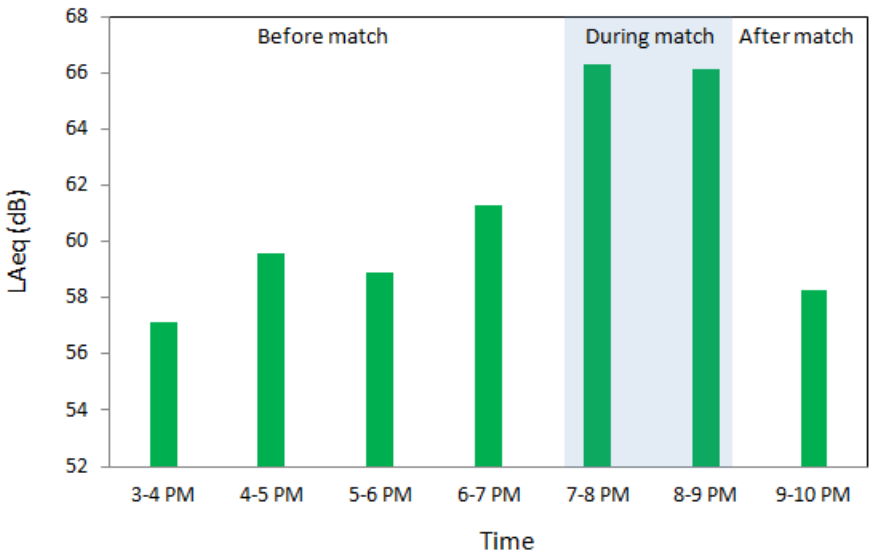

Fig. 8.2. Hourly variation of LA_{eq} before, during and after the football match held at Rabindra Sarovar Stadium on 7th February (site: Beside Press Box)

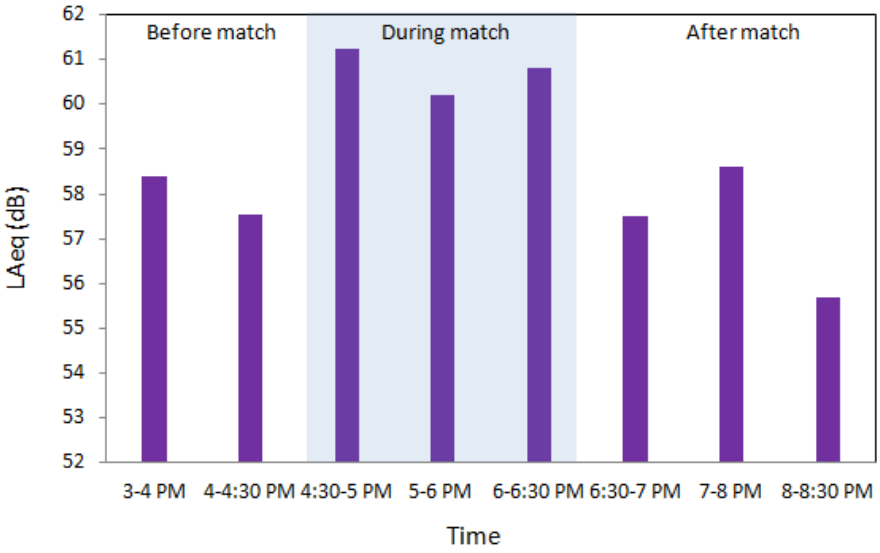

Fig. 8.3. Hourly/Half-hourly variation of LA_{eq} before, during and after the football match held at Rabindra Sarovar Stadium on 18th February (site: Behind tree line)

Table 8.2. Summary statistics of ambient sound level (dB, LA_{eq}) before, during and after the match held on 4th, 7th and 18th February

Parameter	Lake Club Entrance			Beside Press box			Behind tree line		
	4th			7th			18th		
	Before	During	After	Before	During	After	Before	During	After
50 percentile	57.89	59.67	57.87	58.6	65.14	57.56	57.76	60.87	58.27
90 percentile	62.4	64.62	63.40	63.64	72.17	63.206	60.89	64.65	60.55
75 percentile	59.95	61.81	60.31	60.98	67.79	59.97	59.3	62.66	58.99
Mode	56.58	58.28	57.18	57.51	64.33	55.43	56.54	61.29	58.7
Median	57.89	59.67	57.87	58.6	65.14	57.56	57.76	60.58	58.27
Mean	58.40	60.30	58.27	59.16	66.19	58.28	58.03	60.40	58.04
Standard Deviation	3.42	3.50	4.06	3.58	4.31	3.3247	2.45	3.75	2.85
Coefficient of variation (CV in %)	5.86	5.81	6.98	6.06	6.51	5.70	4.22	6.21	4.91

Table 8.3. Summary statistics of ambient sound level (dB, LC_{peak}) before, during and after the match held on 4th, 7th and 18th February

Parameter	Lake Club Entrance			Beside Press box			Behind tree line		
	4th			7th			18th		
	Before	During	After	Before	During	After	Before	During	After
50 percentile	80.48	82.08	80.59	80.23	83.55	79.17	78.12	83.79	78.46
90 percentile	83.59	86.04	83.8	83.13	88.83	82.99	80.58	88.36	81
75 percentile	81.97	83.53	82.05	81.73	85.22	81.41	79.21	86.41	79.62
Mode	79.87	81.83	80.62	81.19	81.87	77.87	78.44	78.76	77.76
Median	80.48	82.08	80.59	80.23	83.55	79.17	78.12	83.34	78.46
Mean	80.67	82.92	80.73	80.03	84.42	79.60	78.42	83.08	78.80
Standard Deviation	2.62	3.44	2.94	3.12	3.22	2.61	2.07	4.04	1.90
Coefficient of variation (CV in %)	3.25	4.15	3.64	3.90	3.82	3.28	2.64	4.86	2.41

Table 8.4. Summary statistics of ambient sound level (dB, LAS_{max}) before, during and after the match held on 4th, 7th and 18th February

Parameter	Lake Club Entrance			Beside Press box			Behind tree line		
	4th			7th			18th		
	Before	During	After	Before	During	After	Before	During	After
50 percentile	58.97	60.68	59.10	59.71	66.04	58.31	58.6	61.62	58.76
90 percentile	63.5	66.01	64.785	64.68	73.12	63.83	61.58	65.36	61.54
75 percentile	60.91	62.82	61.69	62.16	68.58	60.81	60.05	63.28	59.54
Mode	57.61	60.5	60.11	58.52	66.87	55.73	58.69	62.02	58.79
Median	58.97	60.68	59.10	59.71	66.04	58.31	58.6	61.41	58.76
Mean	59.51	61.39	59.59	60.22	67.07	58.94	58.89	61.24	58.76
Standard Deviation	3.43	3.64	4.17	3.64	4.30	3.36	2.46	3.64	2.92
Coefficient of variation (CV in %)	5.77	5.93	6.99	6.05	6.41	5.71	4.17	5.94	4.98

A rather conclusive involvement of the event, The football match in Rabindra Sarobar Stadium, and associated activities like deployment of huge sound boxes etc.. could be identified by the sound level monitoring performed under survey #2. From the presented graphs, it clearly transpired that the event day (Football Match at the Stadium) has much augmented noise level at both the locations and such higher noise levels on event days happen during the afternoon-to-midnight period at Nazrul Mancha and mid-day to mid-night at the Stadium. The Stadium obviously recorded noise levels on event days over the non-event days much higher than the Nazrul Mancha.

An average augmentation of the noise level during the time period of 1600 hours till midnight by an amount of 5.3 dB(A) at the Nazrul Mancha and 5.7 dB(A) at the Stadium were recorded which clearly establishes that the contribution in noise level in the entire Sarobar area due to the event of Foot Ball match in the stadium and associated activities is considerable. Measurements were also performed during Football Match period at locations on the Southern Side (opposite to the Lotus Pond) of the main lake and no significant difference in Noise level could be recorded between the event and non-event days.

One major previous noise measurement record needs mention at this point. Modi and Saraogi in 1989 recorded, at the Stadium, 64 dB(A) in no-traffic condition and 75 dB(A) during high traffic condition. As motorcar horns contribute enormously to the ambient noise level, and the Sarobar is located in a place heavily populated roads on three of it's sides, the nesting place of the birds, the southern side of the main lake predominantly gets noise from the automobile source.

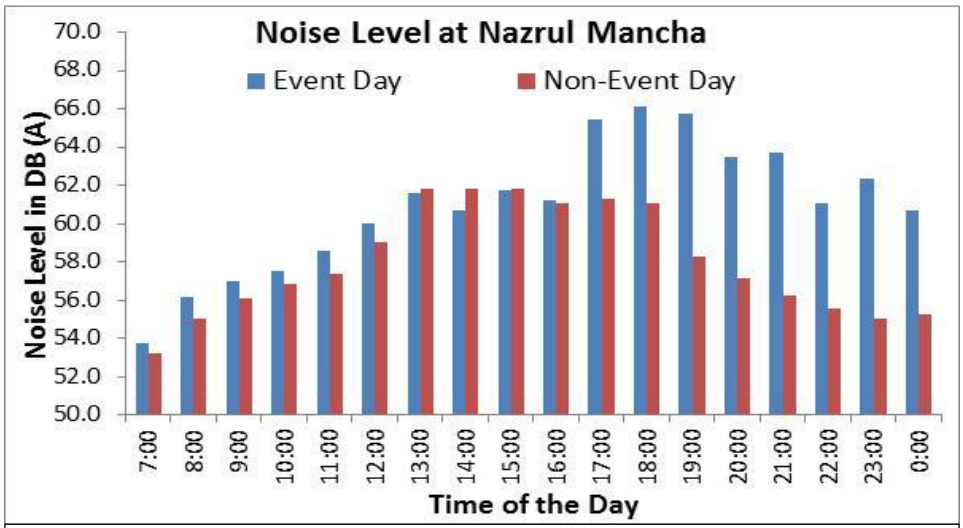

Fig. 8.4. Temporal variation of LA_{eq} at various time of day and night based on sound level monitoring undertaken during event days (football match) and non-event days (site: Nazrul Mancha)

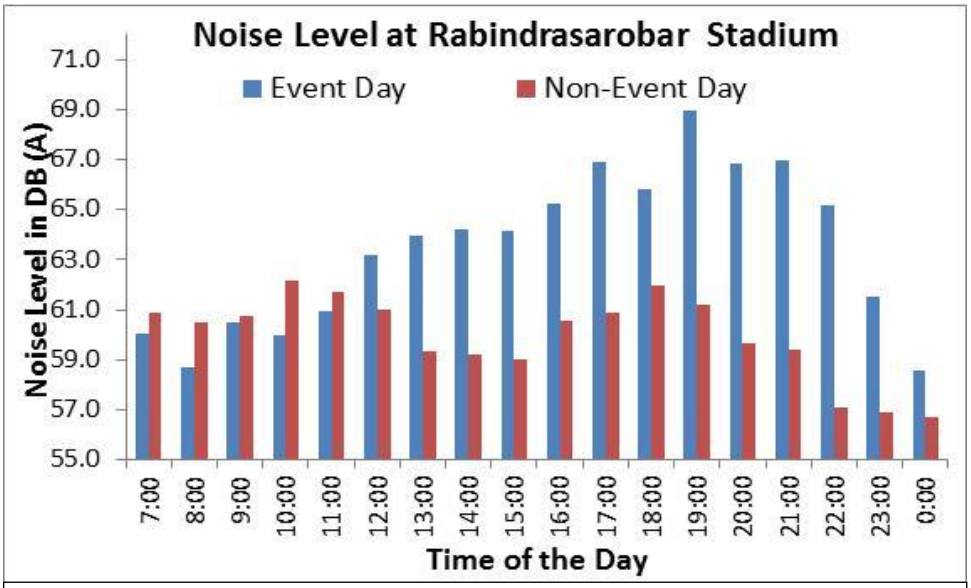

Fig. 8.5. Temporal variation of LA_{eq} at various time of day and night based on sound level monitoring undertaken during event days (football match) and non-event days (site: Behind Press Box)

8.4. Likely effects of sound on birds

As per Ortega (2012), although avian species have long been exposed to loud natural sounds such as streams, waterfalls, and wind, anthropogenic noise pollution is a relatively recent experience for birds. Early investigations on bird responses to noise tended to focus on physical damage to ears, stress responses, flight or flushing responses, changes in foraging, and other behavioral reactions. These studies were often conducted under laboratory conditions because determining effects of noise on freeranging birds is particularly difficult, in that it is impossible to isolate noise as a single testable variable. By coupling introduced noise on the landscape (e.g., from gas well compressors) with ecologically similar controls, it has been found that birds make additional responses like avoidance of noisy areas, changes in reproductive success, and changes in vocal communication. Numerous investigators have compared urban birds with their rural counterparts in quieter surroundings and found that at least some birds can compensate for the masking effect of noise through shifts in vocal amplitude, song and call frequency, and song component redundancies, as well as temporal shifts to avoid noisy rush-hour traffic (Ortega, 2012). Dooling and Popper (2007) have presented effects of highway noise in relation to distance on birds and recommended various guidelines (**Table 8.5**) on sound levels on birds, based on research data available from all over the world (http://www.dot.ca.gov/hq/env/bio/files/caltrans_birds_10-7-2007b.pdf).

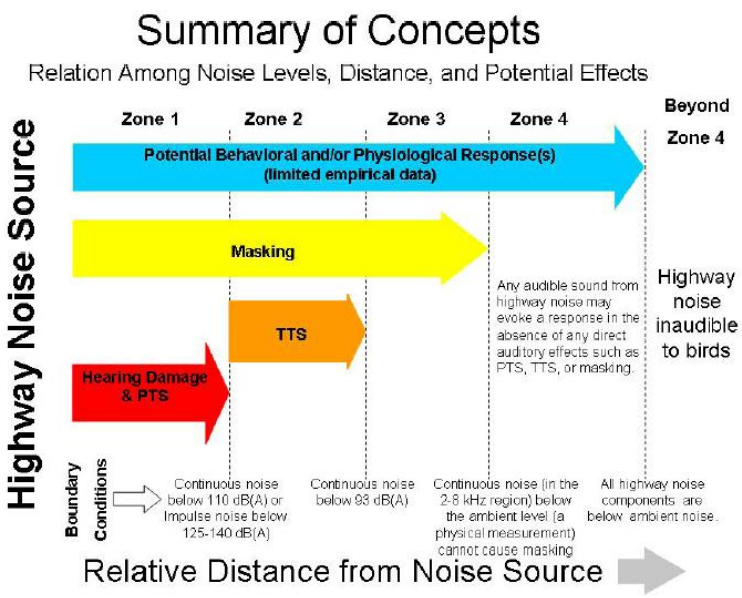

Fig. 8.6. Categories of highway noise effects on birds with distance from the source. Zone 1 is closest to the source while Zone 4 is furthest away. Sound level decreases further from the source
Source: Dooling and Popper (2007) [http://www.dot.ca.gov/hq/env/bio/files/caltrans_birds_10-7-2007b.pdf]

Table 8.5. Recommended Interim Guidelines for Potential Effects from Different Noise Sources

Noise Source Type	Hearing Damage	TTS	Masking	Potential Behavioral/ Physiological Effects
Single Impulse (e.g., blast)	140 dB(A)[1]	NA[3]	NA[7]	Any audible component of highway noise has the potential of causing behavioral and/or physiological effects independent of any direct effects on the auditory system of PTS, TTS, or masking
Multiple Impulse (e.g., jackhammer, pile driver)	125 dB(A)[1]	NA[3]	ambient dB(A)[5]	
Non-Strike Continuous (e.g., construction noise)	None[2]	93 dB(A)[4]	ambient dB(A)[5]	
Highway Noise	None[2]	93 dB(A)[4]	ambient dB(A)[5]	
Alarms (97 dB/100 ft)	None[2]	NA[2]	NA[6]	

[1] Estimates based on bird data from Hashino et al.1988 and other impulse noise exposure studies in small mammals.
[2] Noise levels from these sources do not reach levels capable of causing auditory damage and/or permanent threshold shift based on empirical data on hearing loss in birds from the laboratory.
[3] No data available on TTS in birds caused by impulse noises.
[4] Estimates based on study of TTS by continuous noise in the budgerigar and similar studies in small mammals.
[5] Conservative estimate based on addition of two uncorrelated noises. Above ambient noise levels, critical ratio data from 14 bird species, well documented short term behavioral adaptation strategies, and a background of ambient noise typical of a quiet suburban area would suggest noise guidelines in the range of 50—60 dB(A).
[6] Alarms are non-continuous and therefore unlikely to cause masking effects.
[7] Cannot have masking to a single impulse.

Source: Dooling and Popper (2007) [http://www.dot.ca.gov/hq/env/bio/files/caltrans_birds_10-7-2007b.pdf]

N.B.: Temporary Threshold Shift (TTS) lasts from seconds to days depending on the intensity and duration of the noise to which the animal was exposed. At continuous noise levels below 110 dB(A) down to about 93 dB(A), birds can experience a temporary threshold shift

As per the details given in Table-5, it may be stated that at the levels of sound that the birds are exposed to near the Rabindra Sarovar Stadium before, during and after footballs matches, chances of hearing loss to birds are rare. Data on chances of TTS based on sound levels is limited to serve any conclusion for some sound types, but where data is available, chances of TTS near Rabindra Sarovar seems to be limited. But, there could be enough chances of physiological and behavioral effects on birds at these sound levels near the stadium during matches or even without matches as there are other sources of sound within the prescribed sound level to cause this impact, but cannot be confirmed without a dedicated and specialized study on effect of sound on birds' behaviour in the area. There are also chances of masking (impairment in detection and discrimination of vocal signals by birds) at the observed sound levels, as per the data given in Table-5.

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9.0. Illumination at Rabindra Sarovar in general & before & during football match in the stadium

9.1. Introduction

General idea: Amount of light spilling out of the stadium, before and during football match has to be measured. This spill light may cause changes in ambiance and affect biodiversity in the surrounding plants of the stadium.

9.2. Present Study Details

9.2.1. Material & Methods

Lux meter is used to measure Vertical Illuminance (Light level when the instrument is kept vertical) at six feet height from top position of the gallery. Measurements were taken on surface of the black light guard, at different positions on the gallery surrounding the stadium as well as from the top of the green room of the playground.

The schematic diagram is shown in figure 1. The points A, AB, C, CD are the different positions where the measurements were taken at gallery and the top of the green room.

9.3. Results

a) Average Vertical Illuminance Level on the front of the Black Light guard at a height of six feet from the top position of the gallery is about 169.4 lux during the football match, measurement taken at different points around the whole stadium gallery as mentioned in Appendix 1 between 5:50 p.m. and 6:28 p.m. on 18th February, 2017.
b) Average Vertical Illumination at a specific portion (C5 - A in the Fig. 1) of the stadium at same height is about 131 lux during the football match, measurement taken between 5:45 p.m. and 6:00 p.m. on 28th February, 2017.
c) Black-light guard absorbs sufficient light almost 98% falling it. (Illumination value measured was 213 lux on it, 5 lux behind it at a specific measurement point C34 in fig: 1 as mentioned in Appendix 1).
d) During the match average horizontal Illuminance level on the general play ground outside the stadium is found 10.7 lux, and average vertical Illuminance level is found 41.4 lux. After the match, when Flood lights were made OFF; it is found zero.

   The vertical illuminance around the stadium road is 12 lux in the front side of the street light pole at a height of 6 feet and 8 lux in the back side of the pole at the same height.

   On 15th March, 2017, horizontal illuminance was measured in two zones of the road surrounding the stadium. No flood lights were ON at that time. In one zone average horizontal illuminance was found 13.85 lux and in other zone it was found 29.5 lux.

9.4. General Discussion

On 18th February, whole gallery of the stadium was full with audience; measurement could not been possible in heavily crowded audience zones with team supporters singing the team songs with drums, flutes, sound blowers etc. and waving team flags.

On 28th February, only a specific part of the stadium had audience, just opposite to the Green room (in between D5 – E2 in the figure) of the stadium.

It was not understood whether all lights were made ON during daylight in the no-audience zone on 28th February.

On 15th March, 2017 a team measured the horizontal light level on the stadium surrounding street way at two different portions of the street, illuminated by street lighting luminaires in staggered (zig-zag placement of lighting poles) orientation with different types of light sources; High pressure Sodium vapor, Metal Halide and LEDs.

Horizontal Illuminance on road surface surrounding the stadium was of different values because of presence of different tree branches below the road lighting luminaire (lighting unit) and presence of different types of light sources; High pressure Sodium vapor, Metal Halide and LEDs.

While taking the measurements from the top of green room at Rabindra Sarovar Stadium during football match, few photographs were taken and are shown in Annexure 4.

9.5. References

Light Pollution handbook by Kohei Narisada and Duco Schreuder published by Springer

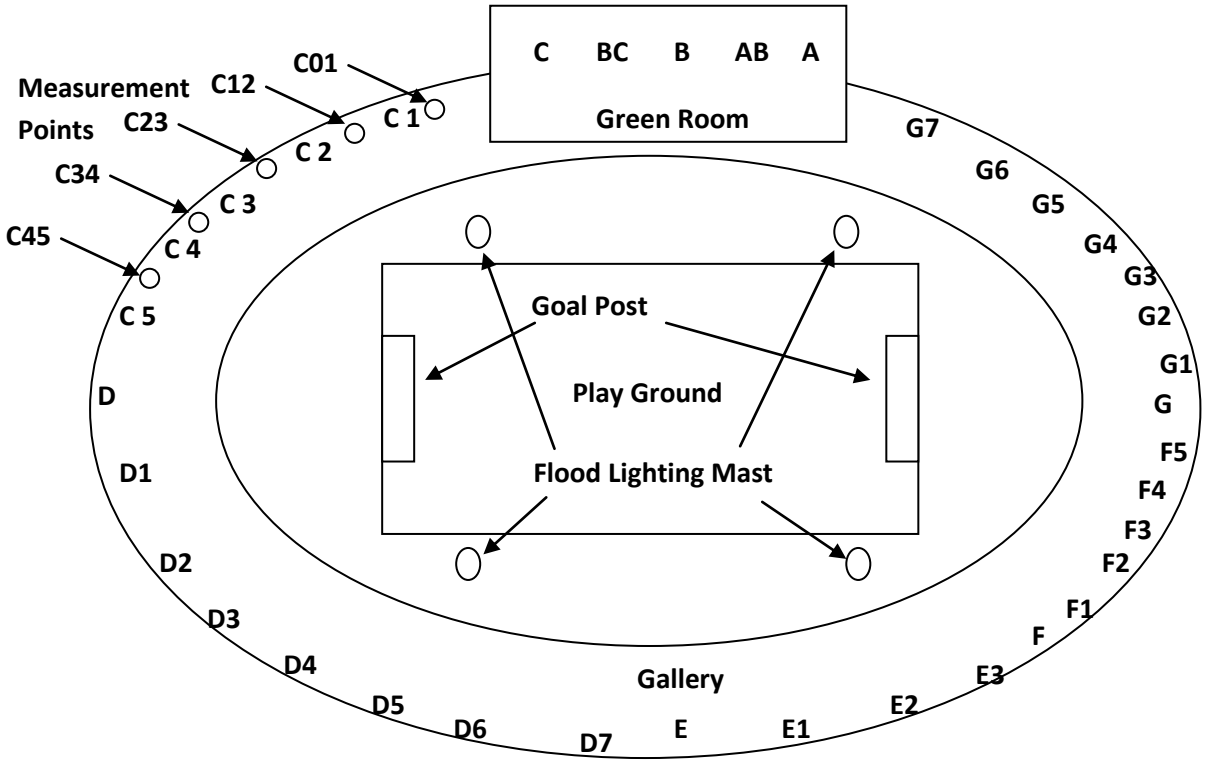

Figure 9.1. Schematic diagram of measurement points in the stadium

Appendix – 1

Vertical **illuminance values measured on the black light guard from the gallery**

Measurement Taken on 18/02/2017

Time	Measurement point	Vertical Illuminance values (Lux)
5-50 pm	A	163
5-54 pm	B	152
5-58 pm	C	172
6-03 pm	C1	192
6-02 pm	C2	163
6-04 pm	C3	173
6-05 pm	C4	169
6-06 pm	C5	174
6-07 pm	D1	136
6-08 pm	D2	145
6-09 pm	D3	144
6-10 pm	D4	128
6-11 pm	D5	143
6-12 pm	D6	140
6-13 pm	D7	228
6-14 pm	E1	224
6-15 pm	E2	234
6-16 pm	E3	212
6-17 pm	F1	241 (max)
6-18 pm	F2	203
6-19 pm	F3	203
6-20 pm	F4	181
6-21 pm	F5	150
6-22 pm	G1	128

6-23 pm	**G2**	**120**
6-24 pm	**G3**	**112 (min)**
6-25 pm	**G4**	**142**
6-26 pm	**G5**	**135**
6-27 pm	**G6**	**187**
6-28 pm	**G7**	**188**

Measurement Taken on 28/02/2017

Time	Measurement point	Vertical Illuminance values (Lux)
5:45 pm	**C5**	**198**
5:45 pm	**C45**	**193**
5:45 pm	**C4**	**191**
5:45 pm	**C34**	**213 (max)**
5:50 pm	**C3**	**63**
5:50 pm	**C23**	**65**
5:50 pm	**C2**	**90**
5:50 pm	**C12**	**76**
5:50 pm	**C1**	**59**
5:50 pm	**C01**	**49 (min)**
6:00 pm	**C**	**192**
6:00 pm	**BC**	**160**
6:00 pm	**B**	**145**
6:00 pm	**AB**	**141**
6:00 pm	**A**	**130**

Illuminance values (in lux) measured at the play ground outside the stadium at a height of five feet from ground level during the football match measured on 18th February, 2017.

	A		B		C		D		E	
	H	**V**	**H**	**V**	**H**	**V**	**H**	**V**	**H**	**V**
1	12	43	13	47	11	38	13	33	9	27
2	13	51	12	51	9	39	6	32	7	28
3	15	51	12	47	13	47	10	37	6	34

H – Horizontal Illuminance level

V – Vertical Illuminance level

Appendix – 2

Horizontal light level measured on the pathway surrounding the stadium.

Illuminance Values are in Lux

	A	B	C	D
1	25	27	27	23
2	21	24	25	22
3	14	17	17	15
4	12	12	11	9
5	8	8	7	7
6	7	7	7	7
7	7	10	8	4

	A	B	C	D
1	40	42	35	23
2	35	39	37	25
3	29	37	38	30
4	25	28	30	30
5	21	28	28	28

6	20	29	31	28
7	6	26	28	30

Layout of the illuminance level measurement grid points upon the road surface between two street lighting poles.

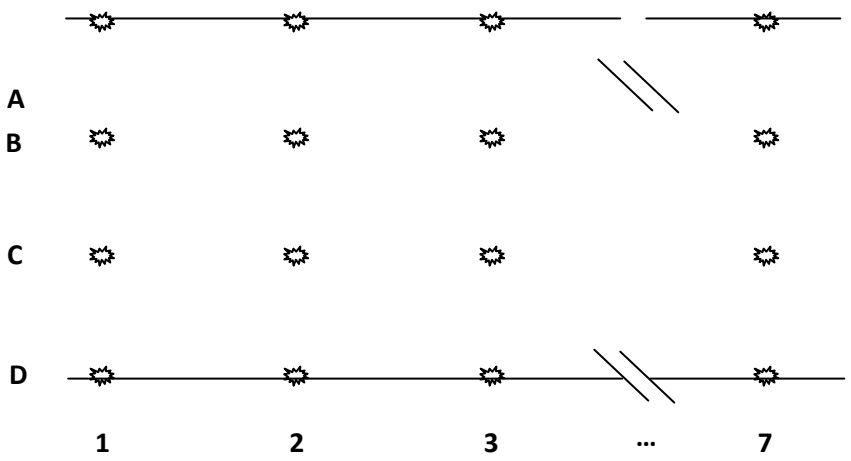

Figure 9.2. Schematic diagram of the grid points on the road surface for illuminance measurement

10.0. Trophic status of the lake

Trophic status is a useful means of classifying lakes and describing lake processes in terms of the productivity of the system. An oligotrophic lake has low nutrient concentrations, low level of phosphorus enrichment, clearer water, low algal growth, and has low productivity; a eutrophic lake has high concentration of nutrients, depleted oxygen in bottom layers, murky or less clearer water due to planktonic and algal growth and has high phosphorus enrichment; whereas mesotrophic lakes have characteristics somewhere in between eutrophic and oligotrophic lakes.

Eutrophication, being of autocthonous and/or allocthonous origin, the progress of a lake toward a eutrophic condition, is often discussed in terms of lake history and management. A typical lake is said to age naturally from a young, oligotrophic state to an older, eutrophic state. Besides natural change of trophic status, presently cultural eutrophication of lakes by anthropogenic acceleration of their natural rate of nutrient inflow are seen globally as major cause of loss of lakes' ecological equilibrium. In the present study, the trophic status of Rabindra Sarobar is being investigated.

10.1. Materials and methods

The hydrophytes and colour of the water were studied during the visits to the Rabindra Sarobar. Phytoplankton/ algal samples were collected and studied. The trophic status of the lake was studied based on the calculation of Trophic State Index (TSI) of three parameters of Secchi disk depth, Chlorophyll-a content and total phosphorus content of the lake water following Carlson (1977). For calculation of Secchi disk depth, the instrument was immersed in 6 sampling sites (SU1-SU6) (fig. 1) of lake water body until the black and white areas of the disk were indistinguishable and the depth was measured. Water samples collected from 6 sampling sites (SU1-SU6) (fig. 1) and were analyzed for Chlorophyll-a content using UV-VIS spectrophotometer (Model LASANY double beam LI-2800). The data on the total phosphorus of the water during the study period (SU1,SU2,SU6 and SU7) were provided by West Bengal Pollution Control Board. The trophic state classification of lake based on TSI as adopted by (KDHEKS, 2000) was followed. Methodology adopted for sampling and analysis of water were developed in-house with the methods published in the manual of American Public Health Association for analysis of water and wastewater. For Dissolved Oxygen (DO) profiling, the measurements were made at a single point (Near Bengal Rowing Club), where the water samples were collected from 1 foot depth every 2 hours from 1200 hrs. of 07 April to 1000 hours of 08 April, 2017. As the ambient temperature on this date the air temperature was 32˚C and the water temperature was 30˚C. Water quality analysis was performed on the collected fresh water within 2 hours of the collection. The equation for calculation of TSI (Carlson, 1977) was put in MS Excel with following representation:

TSI(SDD)=10(6-ln(SDD)/ln2)

TSI(Chl-a)= 10(6-(2.04-0.68*ln chl-a/ln2))

TSI(TP)=10(6-(ln(48/TP)/ln2)

Where SDD= Secchi Disk Depth in meter, Chl a=value of Chlorophyll a in mg/m^3, TP=value of total phosphate in mg/m^3

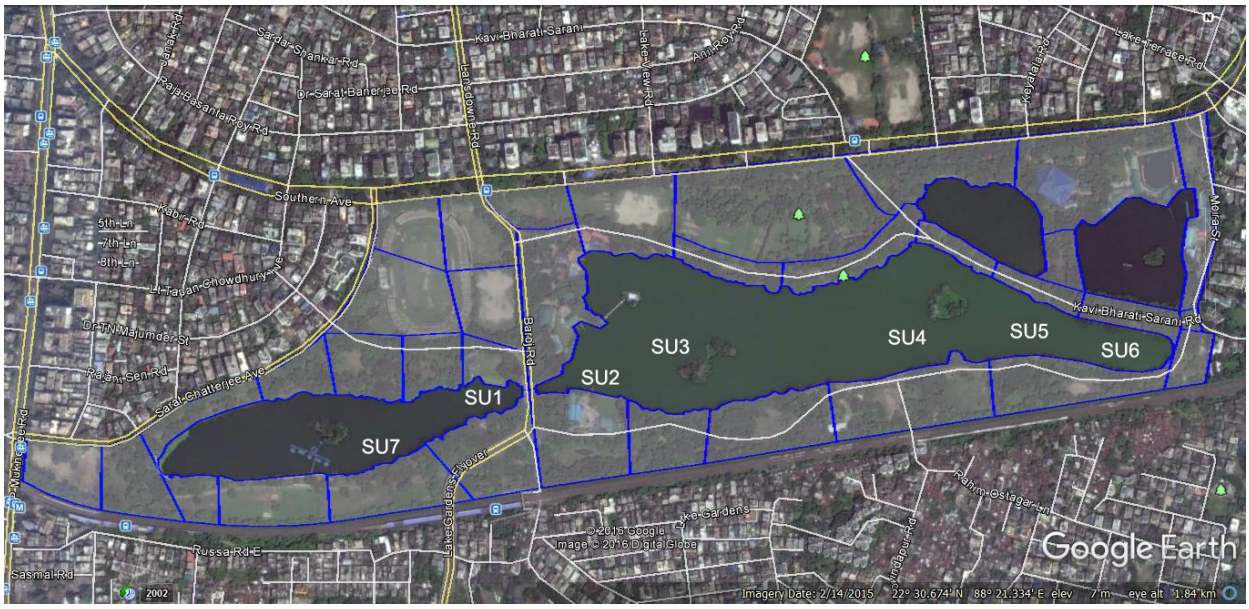

Fig. 10.1. Sites for collection of water samples for calculation of Trophic State Index (TSI) of Rabindra Sarobar water body (Image source: Google Earth).

Results and discussions

Rabindra Sarobar water body has diverse submerged aquatic macrophytes like *Hydrilla verticillata*, *Vallisneria spiralis* in the littoral zones of the lake. Sometimes *Ceratophyllum demersum* was found to be suspended sporadically in the lake. Among floating ones, *Lemna perpusilla* along with *Spirodela polyrrhiza* and *Azolla pinnata* are also distributed sporadically in the entire lake but sometimes clumped at the edge region. Interestingly *Wolffia arrhiza* is also dominant in certain region of the water body, indicating nutrient enrichment.

The present study reveals presence of 87 species of phytoplankton and other algal components in Rabindra Sarobar, distributed under 52 genera, 40 families and 10 classes. The most species rich genera was *Scenedesmus* (11 species), followed by *Aphanocapsa*, *Euglena* and *Merismopedia* (4 species each); *Coscinodiscus*, *Gomphonema* and *Tetrastrum* (3 species each); *Chodatella*, *Encyonema*, *Lyngbya*, *Navicula*, *Pediastrum*, *Pseudanabaena*, *Schroederia*, *Spirogyra*, *Tetraëdron* and *Trachelomonas* were represented by 2 species each and rest 35 genera were represented by single species only. The most diverse families were Scenedesmaceae (14 species), Merismopediaceae (8 species), Euglenaceae (6 species), Gomphonemataceae and Hydrodictyaceae (5 species each) and Coscinodiscaceae (3 species), while, rest 12 families had two species and 22 families had one species. Amongst the classes, the most diverse was Chlorophyceae (36 species), followed by Cyanophyceae (18 species), Bacillariophyceae (12 species), Euglenophyceae (7 species), Trebouxiophyceae (5 species), Coscinodiscophyceae (4 species), Conjugatophyceae (Zygnematophyceae) (2 species), while Dinophyceae, Mediophyceae and Xanthophyceae were represented by single species only.

Quantitative samples were used to calculate density and frequency class of Phytoplankton. Phytoplankton community of the lake reveals that maximum population was attained by the members of Cyanophyceae (58.3 no./l) and Chlorophyceae (50.7 no./l) followed by Bacillariophyceae, Coscinodiscophyceae, Trebouxiophyceae, Euglenophyceae, Conjugatophyceae and Mediophyceae.

Table 10.1. The density of phytoplankton studied was found to be as follows.

Class	**Density (no./l)**
Cyanophyceae	58.3
Chlorophyceae	50.7
Bacillariophyceae	4

Coscinodiscophyceae	3.56
Trebouxiophyceae	2
Euglenophyceae	0.86
Conjugatophyceae	0.73
Mediophyceae	0.2

Members of Cyanophyceae are reported to dominate in eutrophic water, whereas Chlorophyceae are less tolerant of nutrient overload (Rawson, 1956). Inspite of maximum population contributed by Cyanophyceae, most of the Chlorophycean members have also good population size in Rabindra Sarovar. Among the members of Cyanophyceae, *Merismopedia punctata* and *M. convoluta* were most common.

Rawson (1956) opined that the presence of *Melosira*, *Fragilaria* of Diatomaceae are indicative of eutrophic condition, and their presence in Rabindra Sarovar hints towards the same. The phytoplanktonic population of Rabindra Sarovar reveals that the density of two Cyanophycean members - *Merismopedia punctata* (141 no./l) and *M. convoluta* (109.6 no./l) are among the phytoplankton indicating the eutrophic nature of the lake which is corroborated by the study of Caljon (1983).

The levels of Secchi Disk Depth (SDD) was found to be 0.762 m (2.5 ft) AMRI towards gate side to 1.397 m (4.58 ft) towards Calcutta University Rowing Club (Table 2). As per NHDES (2017), SDD value of <10 ft is considered to be eutrophic. Trophic State Index based upon values of SDD **(**Table 3) also points towards the water body of Rabindra Sarobar to be very eutrophic to fully eutrophic based upon the trophic status classification by KDHEKS (2000) (Table 4-5).

Chlorophyll-a content was found to be 44.1 mg/m^3 towards Calcutta University Rowing Club to 166.4 mg/m^3 towards AMRI gate (Table 2). As per NHDES (2017), a water body where Chlorophyll-a content is >5 mg/m^3 is regarded to be eutrophic. Trophic State Index based upon values of level of Chlorophyll-a (Table 3) also pointed out that Rabindra Sarobar is a hypereutrophic as per trophic status classification of KDHEKS (2000) (Table 4-5).

Total phosphorus (TP) was found to be in the range of 80 mg/m^3 towards Calcutta University Rowing Club and 220 mg/m^3 towards AMRI gate (Table 2). As per NHDES (2017), a water body where TP level is found to be above 12 mg/m^3, then it is considered to be eutrophic. Trophic State Index based upon values of level of TP (Table 3) also points towards the water body of Rabindra Sarobar to be hypereutrophic based upon the trophic status classification by KDHEKS (2000) (Table 4-5).

Table 10.2. Showing Secchi Disk Depth (SDD), Chlorophyll 'a' content (Chl a) and total phosphorus content (TP) of water body of Rabindra Sarobar from the present study. (SU=Sampling Unit)

	SU1	SU2	SU3	SU4	SU5	SU6	SU7
SDD (m)	1.397	1.016	0.7874	0.9144	0.762	0.9144	N.A.
Chl a (mg/m3)	44.1	125.2	125.2	67.5	165	166.4	N.A.
TP (mg/m3)	80	220	N.A.	N.A.	N.A.	200	220

Table 10.3. Showing Trophic State Index based upon values of SDD, Chl 'a' and TP in Rabindra Sarobar from the present study. (SU=Sampling Unit)

	SU1	SU2	SU3	SU4	SU5	SU6	SU7
TSI(SDD)	55.18	59.77	63.45	61.29	63.92	61.29	N.A.
TSI(Chl a)	76.77	86.98	86.98	80.93	89.69	89.77	N.A.
TSI(TP)	67.37	81.96	N.A.	N.A.	N.A.	80.59	81.96

Table 10.4. Table showing various levels of TSI with corresponding trophic status (KDHEKS, 2000).

Sl. No.	**Trophic status**	**TSI level**
1	Oligotrophic	TSI < 40
2	Mesotrophic	TSI: 40 - 49.99
3	Slightly Eutrophic	TSI: 50 - 54.99
4	Fully Eutrophic	TSI: 55 - 59.99
5	Very Eutrophic	TSI: 60 - 63.99
6	Hypereutrophic	TSI>64

Table 10.5. Showing trophic status of sampling sites at Rabindra Sarobar based upon the corresponding TSI based upon (KDHEKS, 2000).

Parameter	SU1	SU2	SU3	SU4	SU5	SU6	SU7
SDD	Fully Eutrophic	Fully Eutrophic	Very Eutrophic	Very Eutrophic	Very Eutrophic	Very Eutrophic	N.A.
Chl a	Hypereutrophic	Hypereutrophic	Hypereutrophic	Hypereutrophic	Hypereutrophic	Hypereutrophic	N.A.
TP	Hypereutrophic	Hypereutrophic	N.A.	N.A.	N.A.	Hypereutrophic	Hypereutrophic

Oxygen dissolved in water ensures the supply of oxygen to all aquatic living organisms. Higher dissolved oxygen in water bodies indicate less pollution by organic degradable materials. Bhatnagar and Devi (2013) have mentioned that the Dissolved Oxygen of 5.0 mg/l or more is a compulsory requirement for healthy fish growth, whereas, when this level falls below 3.0 mg/l, the survival of fish becomes difficult.

The diurnal behavior of the DO in lake water is a very important parameter which indicates environmental health of the Rabindra Sarovar lake. During the late noon (16:10 hours), the DO value of highest 11.1 mg/l was recorded, when the Photo-Synthesis reached its maximum, along with the respiration. But during the sunset, the DO value was found to drop to the level of 5.2 mg/l. Later, during the night and early morning hours before the sunrise on the following day, the DO value remained below 4.0 mg/l, reaching below 3.0 mg/l for more than 6 hours between morning 02:00 and 08:00 hours. The low DO is also indicative of ill health of the lake.

Samal et. al. (2009, 2014) have studied DO profiles very recently and they have found out that the Rabindra Sarobar lake exhibits anoxic (DO < 1ppm or 1 mg/l) conditions only during the peak summer and generally to a height of 0.5-0.75 m from the bottom sediment-water interface. The oxic conditions (DO: >5 mg/l) usually occur up to a depth of 2-2.5 m from the water surface with hypoxia (DO: 1-5 mg/l) in between. The hypoxic conditions in general exist within the oxycline layer of the water column.

Samal et. al. (2009, 2014) have noted that Rabindra Sarovar undergoes thermal stratification (from March to mid-June: summer period) which is the result of energy exchanges between water and the surrounding environment, particularly the atmosphere. During this phenomenon, a thermal/density barrier to oxygen transfer between the epilimnion and hypolimnion of a lake is created, thus inhibiting reoxygenation of hypolimnetic waters. Low value of dissolved oxygen near the sediment-water interface develops the hypoxic condition (DO < 5 mg/l) and it gradually extends upward throughout the summer, until early winter, which leads to cutting-off of bottom layer atmospheric oxygen. Further, in the chain of events, the rate of oxygen consumption is rapid in the thermocline zone due to high temperature gradient leading to loss of more DO which might be necessary for chemical oxidation in the band of hypolimnion, resulting in increase in toxicity of the water. The DO value was found to drop below 1.0 mg/l at Rabindra Sarobar from the depth of 3.5 m to the bottom (Samal et al., 2009), which may account for a sudden fish die off. The decreasing DO level (<1.0 mg/l) with hypolimnion depth is indicative of hypolimnetic DO depletion which also suggests a case of eutrophication as per NHDES (2017).

Considering all trophic state indices [TSI(SDD, TSI(Chlorophyll-a and TSI(TP) the trophic status of Rabindra Sarovar lake is highly eutrophic-hyper eutrophic.

10.2. References

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11.0. PUBLIC OPINION

(1) Kolkata Improvement Trust

Several meetings were held with the Secretary, KIT to discuss the responsibilites performed by KIT in the management of R. S. During the meetings the queries raised by the Rabindra Sarobar Monitoring Committee constituted by the Hon'ble Calcutta High Court were also discussed. Later a questionnaire was given to the Secretary, the reply for which is enclosed.

As per the version of the Secretary, KIT is serious in their duties but sometimes due to some unwanted reasons lapses are noticed in maintenance of Rabindra Sarobar.

(2) Rabindra Sarobar Monitoring Committee

The Expert Committee discussed with the members of the Monitoring Committee twice on the matter related to mismanagement of Rabindra Sarobar.. The Expert Committee handed

over a detailed questionnaire to the Monitoring Committee and their reply was received and enclosed.

(3) Authority of the Clubs in the Rabindra Sarovar Premises

The Expert Committee convened a meeting for discussion of the complaints against the clubs in R. S. raised by the Monitoring Committee. Out of 15 clubs 8 attened the meeting and a detailed discussion was held with them. Later a questionnaire based on the discussion was sent to all the clubs and reply from seven clubs have been received and enclosed.

Most of the club authorities denied the complaints against the clubs except a few who sportingly accepted some of the allegations and agreed to not to do the same in future.

(4) Morning & Evening Walkers in the Rabindra Sarovar Premises

Some of the members of the Expert Committee met a few morning and evening walkers in Rabindra Sarobar and asked them about the facilities, problems and environmental changes, if any, in the Sarovar.

Most of them are not aware of the environmental problems there and only mentioned about the amenities urgently required. According to them sufficient arrangement of drinking water, toilets and cleanliness are urgently needed. Some of them also mentioned about entry of antisocials who sometimes cause problem to the visitors.

(5) Rabindra Sarovar Security Staff

While visiting the Rabindra Sarobar premises the Expert Committee members talked to the security staff regarding problems in the Rabindra Sarobar. They mentioned about problems created by some young neighbour.

(6) The neighbouring residents

The Expert Committee members once visited neighbouring houses and discussed the present state of Rabindra Sarobar. None of the residents have any complaints against the maintainance of of Rabindra Sarobar and are satisfied with the management of Rabindra Sarobar by KIT.

(7) Visit in the Clubs and interaction with the staff members there

The Expert Committee members visited four clubs in one evening and interacted with the officials and other staffs there. They were very cordial with the expert members and replied to the queries relating to the club activities, etc. A report on the said visit is prepared and enclosed.

12.0. RECOMMENDATIONS

Flora:

- Green areas and landscaping may be developed with the trees. Indigenous plants should be given importance while introducing plants in the lake premises. Rabindra Sarovar area can be a live repository of indigenous and rare plant species of West Bengal or of Eastern India along with ornamental and avenue trees. For selection of plant species to be introduced in the Sarovar area the authority should consult with prominent Botanist/Botanical Institutes, Taxonomist/Plant conservationist and others.
- Wild indigenous fruit trees having larger canopy to give shelter and food for small animals and birds as well should be introduced.
- There must be regular awareness programmes in the Rabindra Sarovar area to educate people and make the aware about nature, plants, animals and biodiversity. Authority can take up "Lake merchandise/ conservation" measures to make awareness among the masses.
- There need to be set up one interpretation center or at least one small Herbarium with the specimens of plants from Rabindra Sarovar to educate about Biodiversity the students visiting the Lake.
- The area with *Saraca asoca* (Ashok Tree) individuals may be demarcated as **"Ashok Kunja"** and more Ashok saplings may be planted there, and such areas should not be altered for any other purpose.
- As *Pongamia pinnata* (Karanja tree) has good population with old trees and the representative of back mangrove marshy places/ riverine system indicating the ecological history of Kolkata's original habitat, a *Pongamia* zone as **"Karanja Kunja"** may be created in some open places.
- Like the *Pongamia pinnata*, *Barringtonia acutangula* (Hijol tree) is also the indicator of riverine marshy woodland vegetation/ back mangrove swamp having a good lineage of Kolkata's ecological history. So, *Barringtonia acutangula* may be regenerated much more at the bank site or other open places of the premises.
- *Heritiera fomes* (Sundari tree) is growing well in this soil (as evidenced), some more Sundari plants may be planted with some other mangrove associates.
- Trees should be labeled with scientific name and other necessary information in consultation with the experienced botanists/ botanical institutes as part of awareness programme.
- It was observed that, there are many Rain Trees (*Albizia saman* (Jacq.) Merr.) which have died due to some infection without felling. Following due procedure these trees should be removed and new seedlings to be planted in those places. The deasd trees may in near future be the abode of various pest species.
- Drip irrigation/ low-volume, angle sprinkler system shall be used.

Fauna:

- The land and water bodies forming open space of Rabindra Sarovar play a very important role in the metropolitan city of Kolkata. The environmental imbalance that

has occurred in the Rabindra Sarobar deserves special consideration and steps have to be taken by the Rabindra Sarobar authority to control the situation and to restore the original ambience as well as aquatic and terrestrial biodiversity of the Sarovar area.

- It is recommended that the three islands in the middle of the lake which are the nesting habitats of many water-birds be kept as such and no kind of developmental activities be allowed on them.
- Tree species like *Pongamia pinnata*, *Barringtonia acutangula*, *Albizia saman*, *Pithecellobium dulce*, *Sterculia foetida*, *Ficus religiosa*, *Azadirachta indica*, *Syzygium cumini* etc. were observed as vital trees where birds were making nest for breeding. Hence these plants should be given priority in introduction and conservation.
- By conserving plant diversity around Rabindra Sarovar, the variety of insect life will also be conserved. The bottom of the lake should be cleaned of garbage and pollutants as the lake water is vital for the survival of aquatic animals like turtles, amphibians and fishes.
- A Butterfly park with their host and nectar plants may be established.

Air Quality:

- The results obtained in the present study suggest that the Sarovar's air quality is impacted by events like football matches in the Stadium as indicated by rise in level of PM10 by 11-32 mg/m^3 compared to non-event days, while other parameters like PM 2.5, SO_2 and NO_2 of Rabindra Sarovar were well below the Kolkata city average.
- The rise of PM 10 in Stadium area compared to Kolkata city average is 20 mg/m^3 during event days, strongly suggests the regular air quality control measures should be undertaken, and should specially be focused on control of PM 10, especially in Stadium premises.

Water Quality of the Sarovar (Lakes):

- Sewage should be strictly discharged into underground drainage line of the municipality. Any sewage or garbage generated in clubs and/or in other areas should never be discharged /deposited in the lakes.
- Water from water bodies should be recycled completely atleast in every six months after treating it using automatic/ semi-automatic self –cleaning high velocity filters and chlorination/ chemical free ozonation system.
- As the **lake water is highly eutrophic**, the source of nutrient enrichment both allocthonous and autocthonous must be regulated through regular monitoring. The organic matter deposited at bottom sediment along with other solid waste like plastics, broken glass etc. should be removed immediately to check the anoxic condition of the bottom sediment *vis a vis* the maintenance of oxygen oscillation which would be helpful for sustaining the biodiversity of the lake.
- The lake bottom is should be cleaned immediately. All the broken glass, plastics and concrete debris should be removed and the soil bottom to be exposed. Dredging should not be done.

- Nutrient ingress in the lake water from the Club eateries should be restricted, and to restrict this any open air eating, in whatsoever manner, organized by the clubs or taken by the lake visitors should be restricted. In such cases stringent actions should be taken as per Rules.
- pH of lake water was very high which indicated unhealthy status of the lakes. KIT authority should take measures to ascertain the causal factors for such unusually high pH value of the Sarovar water, and go for its remediation on war footing.
- Phasing out of chlorination for disinfection of the swimming pool water may be practiced and introduction of ozonization should be introduced in that place.

Lake sediments and sub-surface soil

- Anthropogenic activities in the lake area should be restricted.
- Choking and ageing of lake must be restricted by checking the eutrophication.
- Desiltation practice should be maintained periodically to lessen the eutrophication/algal bloom.
- Slum dwellers from the neighboring area should be restricted for using the lake water.
- Bathing and washing clothes and utensils in the bank should be completely stopped.
- Toxic metal in the lake water which enters through the bright paints and colors varnish of the idols which are immersed in the lake during the festive season must be completely stopped.
- To maintain the pristine quality of the lake water and for the long term sustainability of the lake, anthropogenic activities have to be controlled to a large extent and retrieval strategies to remove immersed idols need to be undertaken to prevent the loading of toxic metal ions into the lake water.

Noise:

- Acoustic enclosures should be installed at all noise generating equipments such as DG sets, air conditioners, etc. to mitigate the impact of noise.
- The overall noise level in and around the project area (stadium Nazrul Manch) should be kept well within the prescribed standard by providing noise control measures including acoustic insulation, hoods, silencers, enclosures, vibration dampers, etc. on all sources of noise generation, the ambient noise levels should confirm to the standards prescribed under the Environment (Protection) Act and Rules.
- Based on observed continuous sound levels before, during and after football matches and also on event (football match held) and non-event days (no football match) at Rabindra Sarovar Stadium and reported effects of sound on birds in available literature, it is pertinent to consider that football matches are held occasionally in this stadium and for about 2 hours only per day when organized. The matches could indeed cause disturbances or affect some behavioral shifts and physiological changes in birds in the immediate vicinity of the ground and therefore the effects may be transitory. Since there is no previous data available on bird population in the immediate nearby areas when no football match was held or if at all there are other

factors that could be responsible for birds' death or decline in population (if at all found so) in this area, **it is premature to conclude at this point of time that football matches must be banned to restore bird's habitat, nesting and behaviour in the Rabindra Sarovar area.** However, considering the significant augmentation of noise level during foot ball matches and associated activities, use of loud-speakers (other than required for PA system), having only amusement value to selected population during the match period, before and after may be discontinued or be used at regulated noise level as per the Rules.

Illumination:

- The height of the black light guard installed during the last ISL match should be increased at least to six feet.
- If the matches end before 6.30 pm, the light pollution will be minimum.
- Similar type of light source with low mounting heights may be used for pathway/street lighting luminaires.
- Different types of bollards and street lights (as per in Appendix 3 of chapter on Illumination) may be used to illuminate the pathways to reduce light pollution.

Mega events like Cricket and Football matches:

- No mass eatery and/or canteen should be allowed in the stadium premise during Football match, nor should the spectators be allowed to carry food material inside the lake premise. Organizers should arrange for safe drinking water for the spectators as well other professionals (technicians, commentators, journalists etc.).
- As per the observations mentioned by the scientists in their reports (see above), it would be better if such megaevents are banned. But considering the urgent need, the events can be organised preferably in day time. If at all night matches are to be organised, the match should be strictly completed by 6.30 / 7.00 p.m. to avoid disturbances to the biodiversity due to high intensity noise and light. Bursting of crackers during and after making should be completely banned. Other conditions noted above under 'recommendations' should be strictly followed. Further, the recommendations noted in the Order No. PRO/NGT/EZB/KOL/2016/422, dated 06.10.2016 issued by the Hon'ble NGT (EZB) should be followed.

Chhat Puja festival & Picnic:

- During Chhat Puja festival, as reported, 40000 – 50000 people enter the Sarovar premises. This causes massive loss of biodiversity. Further the rituals pollute lake water with flowers, and also the soil is polluted and wasted due to ghee, oil, etc. Cracker bursting and emission of high intensity noise also greatly disturb biodiversity.
- From the observations mentioned above, it is clear that the activities during Chhat Puja pollute the Sarovar and land areas. It is, therefore, suggested that KIT along with appropriate public institutes should first make the people who practice Chhat puja in the R.S. premises aware of the problems resulting from Chhat Puja there. This awareness generation programme should be started a month before Chhat Puja and

convince them not to come to R.S. and go to River Ganges or any other suitable water body. Picnic inside the R.S. premises is to be banned completely.

- The complaints made in the appeal are addressed in the respective chapters and recommendations.

Rabindra Sarovar Lake:

- The results relating to the trophis status of the lake as above clearly show that the lake is in very bad state in respect of pollution. Immediate actions should be taken by KIT to save the lake. For details please see the 'recommendation' part above.

Clubs:

- The Clubs are never be turned into social clubs. It is reported that some of them are regularly holding social functions which cause disturbances to the biodiversity in the R. S. premises due to high intensity noise and bright light. KIT should make a Form which is to be filled in and submitted by the clubs for permission for prior to holding any such functions in the club.

- A fresh agreement between KIT and club should be made mentioning the purpose of establishing the club and commitment towards functioning of the club as per the basic purpose. Besides, each club should get approval from KIT to undertake any other activity which is not befitting with the basic purpose of the club.

- Bar & open eatery in the club houses is against the very purpose of establishing the clubs there in R.S. KIT is therefore advised to look upto the matter seriously and urgently.

- Clubs authority should take care of parking cars by their members / guests outside the R.S. premises.

Others:

- Common utilities like drinking water facility, toilets etc. should be adequately provided with adequate signage thereof.
- Ozone Depleting Substances (Regulation and Control) Rules should be followed. The existing air conditioning system in the Sarovar should be modified, if required.
- No further expansion/ construction/ modifications in the Sarovar likely to cause environmental impacts shall be carried out without obtaining prior approval from the concerned.
- It should be mandatory for the KIT to submit annual compliance report in respect of the stipulated prior environmental clearance terms and conditions in hard and soft copies to the regulatory authority concerned i.e. West Bengal Pollution Control Board.
- The generators, transformers, motors used in the Sarovar area should have minimum efficiency of 85%.

- Necessary self-explained display boards depicting information on the Sarovar, biodiversity therein, dos and don’ts at all appropriate places should be provided to create awareness among the visitors.
- Fire safety should be implemented with appropriate monitoring system.
- The solid wastes should be properly and regularly collected and segregated at source. The garbage should be disposed in nearby municipal bins. The recyclable material shall be sold to vendors.
- The rain water harvesting and non-conventional energy generation practices should be undertaken by the clubs.
- No hazardous wastes should be allowed to generate.
- The number of tea vendors should be restricted to five and identity card should be issued to them. They should use large-sized thermo flask containing ready-made tea to stop use of Kerosene stove.
- All types of plastic (throwaway water bottle, food packets & others) should be banned totally in the Rabindra Sarovar premises by the authority and every visitor should be checked at the entry points. Littering of lake premises and dumping of degradable and non-degradable materials into water should be banned. Authority can impose fine to those visitors who don’t comply with the rules. Time to time peripheral cleaning of the lake can make it plastic and pollution free.
- Repeated exposure to vehicular emission due to vehicular movement for parking and other reasons inside the park is hampering the general wellness of the plants. Movement of vehicles and car parking inside the Rabindra Sarovar premises must be banned, except the extra special cases.
- Exposure to short day plants for longer period of light due to different activities like matches, fun programmes may hamper the physiology of the short day plants. **It is therefore required to use light for short period only.**
- **Dumping of plastics and other material in the peripheral zone of the Lake destroy the aquatic vegetation and animal lives of the Lake. Special attention is to be paid on this aspect.**
- Excessive addition of lime into the lake for cleaning of the lake water may lead serious danger to the aquatic community of the lake. **Lime should not be used in excess.**
- The pathways in side the Sarovar premises may be named after plants & animals like Ashok Path , Sundari Avenue, Hijol Path, Karanja Path, Chhatim Path, Barun Pakha (name of a butterfly recorded from R.S.), Basanta Bouri (a bird), Muniya (a bird). The lakes may also be named after eminent persons who were regular visitor.
- Near the Ashok trees a concrete tank is found in an abandoned state. It may be transformed into a water-filled tank with lotus. The tank is to be covered with net to avoid leaf-fall in the tank.
- The boundary wall near Gobindapur Busti should be completed to check entry of unwanted persons.
- Once famous Lili pool should be properly beautified.
- Lady security guards should be engaged.

- Entry by paying nominal fee.
- Entry pass should be issued to the morning and evening walkers.
- As the health of the lake is very bad, fish death may occur. Immediate measures to be taken by KIT.
- Meeting between KIT and the Monitoring Committee should be held at regular interval.

REPORT ON FISH KILLS IN RABINDRA SAROVAR DURING JUNE 2016

The Rabindra Sarovar (22'34'N, 88'23'E), a small and shallow, but highly eutrophic lake is located in the southern part of the metropolis of Kolkata spread over an area of 780,700 m^2 having water area of 295,400 m^2 (or about 38 % of the land area). It is an artificial lake, a major recreational centre of the city. The lake (formerly Dhakuria Lake) was renamed by Kolkata Improvement Trust (KIT) in May 1958 as Rabindra Sarovar in honour of Rabindranath Tagore. The maximum depth and the mean depth of the lake are 5.7 m and 3.5 m, respectively.

It was on 16.6.2016 (Thursday morning) news that hundreds of fish were found dead under mysterious circumstances in the Rabindra Sarobar in Kolkata. As morning walkers took a stroll around the lake, they spotted hundreds of dead fish floating on the surface of the water and informed the authorities (POOJA MEHTA | Thu, 16 Jun 201605:00 pm. Kolkata, dna webdesk). Fish deaths were first reported on Monday (i.e., 13.6.16). Since then, more than 100 fish of varying size and species have been found dead in the waters of Rabindra Sarobar. The dead fish include rohu, katla and khoyra and have been found across the 70-acre water body. There are small fish just a couple of inches long and also large ones that could weigh up to 15 kg. (The Telegraph, Dead fish flotsam swamps Sarobar, Friday, June 17, 2016). Similar fish kills were also noticed in the water bodies of the Victoria Memorial, Kolkata during the same time.

Dead fish floating in the waters of Rabindra SarobarDead Catla catla with typical signs of haemorrhage and scale protrusion Source: The Telegraph, Dead fish flotsam swamps sarobar, Friday, June 17, 2016.

From the published reports, we came to understand that Scientists from the West Bengal Pollution Control Board (WBPCB), Department of Fisheries (DF) and Jadavpur University, Kolkata visited Rabindra Sarobar on Thursday (16.6.16) and Friday (17.6.16) to collect water samples on request from the KIT. The WBUAFS, Kolkata received the request from KIT on 20.6.16/24.6.16 and a team of fish health specialists and research scholars visited the site on 25.6.16 for onsite analysis of fish and collection of fish and surface water samples for laboratory analysis. The detailed results of the surface water quality parameters (samples collected on 25.6.16) are furnished below:

Parameter	Physico-chemical parameters Padma pukur site	Hanging Bridge site
Sampling Time	10.20 a.m	11.00 a.m
Optimum level for fish Water surface	Thin oil-like layer	scum Colour Greenish brown to

		Light green
Odour	Odd offensive smell	No bad smell
Transparency (cm.)	86.0	90.0
pH	8.82	8.29
DO (ppm) (Surface)	5.30	6.00
Total alkalinity (ppm)	235.2	236.0
TDS (ppm)	370.0	370.0
BOD (ppm)	1.44	2.0
COD (ppm)	60.0	33.0
Carbonate (ppm)	24.0	8.0
Total Alkalinity (ppm)	114.0	114.0
Total Hardness (ppm)	87.2	88.0
Total Ammonia (ppm)	BDL	BDL
Nitrate (ppm)	BDL	BDL
Available Phosphorous (ppm)	0.082	0.085
On-site observations made at the lake vicinity	Dead silver carp and floating lab-lab Dead carp, Eichhornia, water hyacinth Thin oil-like layer or scum on the water surface	

On-site observations made at the lake vicinity are furnished below:
Dead silver carp and floating lab-lab Dead silver carp and floating lab-lab
Dead carp Dead carp

Observations and Impression:

- Water quality parameters: Most of the water quality parameters were well within the optimal levels recommended for fish.
- The pH was always above 8.0 and the range of pH observed was 8.20 – 9.15.
- Low dissolved oxygen (below 4.00 ppm) was recorded in certain sites by the Department of Fisheries on 17.6.16 (Report appended).
- The water was almost clear and the Sacchi disc reading was in the range of 86-90 cm, indicating poor productivity.
- The levels of ammonia and nitrate were below detectable level (in all case studies by WBPCB, DF and WBUAFS), thus ruling out the toxic effects of ammonia, nitrite and nitrate for fish kills (report appended).
- Analysis of pesticides by WBPCB, Kolkata revealed no traces of pesticide residues in water, thus ruling out their involvement in fish kills (report appended).
- No conclusion could be drawn from the above water quality parameters, as they were determined from the surface water samples.
- Water quality parameters especially temperature and dissolved oxygen from the bottom water samples would have thrown some light on the observed fish kills.
- It is because of the fact that: Fish kill in tropical regions are frequently attributed to low dissolved oxygen concentrations; however the circumstances causing these events vary considerably.
- The fish kills in ponds and small lakes usually occur during summer and winter stratification and are specially related to critically low oxygen levels; however, pollution, fish diseases and a phenomenon known as turnover can also kill fish.
- It has been observed by Samal et al. (2009) that the lake Rabindra Sarobar exhibits anoxic (DO < 1 ppm) conditions only during the peak summer and generally to a height of 0.5-0.75 m from the sediment-water interface. The oxic conditions (DO: >5

ppm) usually occur up to a depth of 2-2.5 m from the water surface with hypoxia (DO: 1-5 ppm) in between. The hypoxic conditions in general exist within the oxycline layer of the water column.

- Over the years, the lake Rabindra Sarobar shows hypoxic conditions of dissolved oxygen except during the summer season. The Rabindra Sarobar remains completely mixed (about 8 months) frommid-June to February until .the onset of thermal stratification (from March to mid-June: summer period).
- The available scientific data revealed the development of thermal stratification and dissolved oxygen stratification in Rabindra Sarovar (Samal et al., 2009, 2014). The thermal stratification is the result of energy exchanges between water and the surrounding environment, particularly the atmosphere. Low value of dissolved oxygen near the sediment-water interface develops the hypoxic condition (DO < 5 mg/l) and it gradually extended upward throughout the summer. As a result of thermal stratification the bottom layer is cut-off from atmospheric oxygen and oxygenproducing plants.
- The rate of oxygen consumption is rapid in the thermocline zone due to high temperature gradient and contribute to the development of minimum DO and is continued throughout the summer and fall and persisted until thickening of the mixed layer destroyed it in early winter. Low value of DO cannot enhance other chemical oxidation processes in the band of hypolimnion, resulting in increasing the toxicity of the water and the water quality becomes unfit for the sustenance of the aquatic life in the water body.
- The tolerable limit of DO has been prescribed as 40% saturation level or 3.0 mg/l for fish. In a study by Samal et al. (2099), the DO value was found to drop below 1.0 mg/l at Rabindra Sarobar from the depth of 3.5 m to the bottom, which may account for a sudden fish die off. Lake stratification creates a thermal/density barrier to oxygen transfer between the epilimnion and hypolimnion of a lake, thus inhibiting reoxygenation of hypolimnetic waters. The decreasing DO level with depth is indicative of hypolimnetic DO depletion.
- The depletion of dissolved oxygen in the hypolimnion and the variability in water column temperature may be highly dependent and the variability over time series is an indicator of climate change both in tropical and temperate weather conditions
- Formation of a hypolimnion oxygen minimum is of great importance for fishery management.

Source:
Samal et al., 2009: Aquatic Ecosystem Health & Management 12(2): 215-225

Note: Thermocline: an abrupt temperature gradient in a body of water such as a lake, marked by a layer above and below which the water is at different temperatures. Hypolimnion: The lower layer of water in a stratified lake, typically cooler than the water above and relatively stagnant. Epilimnion: The upper layer of water in a stratified lake. Lab-lab: A mass of microscopic algae chiefly of the Myxophyceae found on the mud in fishponds and used as food

The necropsy analysis made on morbid fish such as (i) mrigal carp, Cirrhinus mrigala, (ii) Murrel, Channa sp. (iii) Pangas catfish, Pangasius pangasius and (iv) Catla carp, Catla catla, (v) freshly dead big head carp, Aristichthys nobilis (vi) dead silver carp Hypophthalmichthys molitrix are furnished below:

Argulus infested Cirrhinus mrigala Argulus infested Cirrhinus mrigala with pale gills Gas filled intestine of Argulus infested Cirrhinus mrigalaKidney of Argulus infested Cirrhinus

mrigala Putrid silver carp Hypophthalmichthys molitrix Pangasius pangasius with mouth haemorrhage Pangasius pangasius with pale and comb-like gills Pangasius pangasius with damaged gill filaments Channa sp. with saddle back Channa sp. with saddle back Big head carp, Aristichthys nobilis with haemooragic caudal region Big head carp, Aristichthys nobilis with comb-like gill and mucus secretion Aristichthys nobilis with while patches on gills Emaciated big head carp, Aristichthys nobilis Necropsy of Aristichthys nobilis Necropsy of Aristichthys nobilis Necropsy of Aristichthys nobilis Discoloured kidney Healthy Catla catla Water turbidity measurement with Sacchi disc Disease diagnosis Sl no Fish species examined Clinical signs Diagnosis and Remarks 1 Mrigal carp, Cirrhinus mrigala Ectoparasite (Argulus) infestation, pale gills and kidney, and gas filled intestine Argulosis, respiratory problem/disorder 2 Murrel, Channa sp. Saddle back Columnaris (suspected) 3 Pangas catfish, Pangasius pangasius Mouth haemorrhage, pale and comb-like gills and damaged gill filament Cutaneous haemorrhage, respiratory problem/ disorder 4 Catla carp, Catla catla Healthy Healthy 5 Big head carp, Aristichthys nobilis Haemorrhagic caudal peduncle, emaciation, pale and white patches on gills Columnaris, haemorrhagic septicemia 6 Silver carp, Hypophthalmichthys molitrix Putrid Putrid Detection and confirmation of columnaris Fish species: Aristichthys nobilis (Big head carp) Diagnosis method: Culture independent metagenomic approach using Flavobacterium columnare specific PCR Primers used: Flavobacterium columnare specific primers as below Primers Sequence (5'-3') Amplification size Reference Col-72F GAAGGAGCTTGTTCCTTT 800-1000 bp Triyanto et al., 1999 Col-1260R GCCTACTTGCGTAGTG

Diagnosis: Columnaris disease caused by Flavobacterium columnare
Conclusion: The observed fish kills in Rabindra Sarovar during the mid June 2016 could be attributed to the thermal stratification, dissolved oxygen stratification and associated hypolimnetic dissolved oxygen depletion. The respiratory stress on fish due to low dissolved oxygen has led to secondary infection by Flavobacterium columnare in big head carp and opportunistic Aeromonas spp. as has been observed in catla with typical signs of haemorrhage and scale protrusion. Mortality due to Argulus infestation, a blood sucking crustacean parasite, could not be ruled out as Argulus infestation can cause huge mortalities in fish. It, however, needs to be observed on more number of fish and it cannot be detectable in dead fish.

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Report of investigation of fish mortality in Rabindra Sarobar

ICAR –CIFRI received a request form Kolkata Improvement Trust to examine the water quality and to find out the reason of sudden fish death in Rabindra Sarobar, Kolkata. Based upon the request from Kolkata Improvement Trust, a team of ICAR-CIFRI immediately visited the Rabindra Sarobar to investigate the sudden fish death in the lake. Secondary data obtained from the Sarobar officials present during the team visit revealed that Rabindra Sarobar has an area of 73 ha. Rowing by the club members is a common feature in the lake. It is also a place for picnic & recreation by tourist and morning and evening walkers. The lake is of national importance and was covered under national lake conservation plan. The team had a detailed discussion with the official members of Rabindra Sarobar available on 25th June during the visit. During the discussion, some interesting facts came to the knowledge of the team: • Fish death is a common feature every year immediately after the first monsoon rain. • Death of khaira (Gudusia chapra) is highest among the fish species present in the lake. • However, fish mortality is higher this year in comparison to other years. • Fishing is strictly prohibited in this lake, however stocking is done every year, mostly for the religious purpose. • Death of fish in terms of quantity was Gudusia chapra (khaira)> Silver carp> Grass carp> Catla > Rohu respectively. • Visitors of the lake were found to feed the fish from a suspension bridge. • Fish density in the lake is unknown.

The team had taken water samples from two locations (Sampling site-I and Sampling site-II) of the lake. There is a mosque in the lake's islands, which is connected to the southern shore by a iron suspension bridge and that was one of the sampling sites (Sampling site-I). Lake side near the Buddha temple on the southern fringe was sampling site –II. The water quality parameters at both the sampling sites:

Parameter	Site-I (Near Mosque)	Site-II (Near Buddha Temple)
Sampling Time	4.45PM	5.30 PM
Temperature (Air) °C	35.5	35.00
Temperature (Water) °C	34.6	33.2
Transparency (cm.)	61	55
Depth (feet.)	30.2	31.5
DO (ppm)	12.8	6.6
pH	8.82	8.5
BOD (ppm)	8.1	5.2
COD (ppm)	24.0	24.4
Free CO_2(ppm)	0.00	0.00
Carbonate (ppm)	24.0	8.0
Total Alkalinity (ppm)	114.0	114.0
Total Hardness (ppm)	88.0	92.0
Specific Conductance (mS/cm.)	318.0	316.0
Total Ammonia (ppm)	0.1684	0.24
Nitrate (ppm)	0.01129	0.0128
Phosphate (ppm)	0.1	0.1
Silicate (ppm)	11.73	11.52
Phytoplankton abundance	2125 nos./ml	2125 nos./ml
Zooplankton abundance	9 nos./ml	9 nos./ml

During the visit the team could not find any dead fish in the lake, since mortality occurred around 10 days before the visit. By the time the team visited, dead fishes were removed from the lake and lake was disinfected with lime and potassium permanganate. The lake administration has applied 80 bags of lime (400 kg approx.) and 25 kg Potassium permanganate in the lake. It was also observed that there was excess growth of filamentous green algae (Spirogyra) on bottom sediment towards the bank of the lake (lentic zone) and the growth was very high at the sampling site-II Near to Buddha mandir. Interestingly, the lake bottom (at least up to about 10-15 feet from banks where this study was limited) was devoid of typical soil/sediment, and instead was full of rocks and bricks. With much difficulty only few grams of sediment could be collected by the Lake personnel which was insufficient for detailed study. The hard lake bottom, especially towards the Buddha Temple, was covered with decomposed filamentous algae. The water quality showed analysis showed high BOD and COD levels, more oxygen consumption for decomposition of organic matter in the lake, as well as, presence of ammonia. Biological Oxygen Demand (BOD) level of the lake is more than 6 PPM, indicating the lake is not good health condition. High BOD may create low dissolved oxygen level for the aquatic animal in early hours and this when combined with rainfall might be the reason for recurrent seasonal fish mortality. It was remarkable that DO at site-II (measured at 5:30 pm) (with much decomposed algae at bottom) was only the half of that in site-I (measured at 4:45 pm), suggesting very rapid oxygen depletion from the system.

Inference:

• The lake water has high BOD and COD levels.

• Water is transparent favouring massive growth of filamentous algae/ submerged macrophyte.

• Lack of bottom soil does not allow complexation/binding of deposited organic matter, allowing its fast decomposition, especially during summer.

• Water temperature was high even during late afternoon hours disfavouring oxygen solubility in water, as well as, enhancing organic matter decomposition.

• Presence of rocky/metallic soil bottom may favour excess heat trap in the lake.

Suggestions:

1. Periodic physical removal of the filamentous green algae from lentic and lotic zones of the lake, at least before and during summer.
2. Removal of semi-decomposed filamentous green algae from the lake bottom
3. Prohibiting feeding the fish by visitors and dumping of waste food matter, discharge of waste water etc. in the lake.
4. The team found numerous plastic materials along the bank. The lake administration may place waste bins at different location of the lake and strictly monitor the use of dustbin for waste disposal by tourists.
5. Density of fish in the lake may be assessed. This was only one-time study, after few days of fish mortality in the lake. Hence season wise detailed limnological and fisheries study is recommended for finding out solution for recurrent fish mortality and long term management of the Sarovar.

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Report compiled & Submitted by
(Sanjib Kr. Manna, Pr. Scientist)
https://mail-
attachment.googleusercontent.com/attachment/…0_7EYxmpLRTA2vQQUKsCqFu

Annexure

WEST BENGAL POLLUTION CONTROL BOARD
10A, Block – LA, Sector – III, Salt Lake, Kolkata – 700098
Ph: (033) 2335 9088/6731/0261, Fax: (033) 2335 8073/2813

No: Dated:

Fish Death incident in Rabindra sarobar ::::: 16 JUNE 2016

Water quality parameters determined on 16th JUNE 2016 yielding the following data.

Sampling Location	pH	Dissolved Oxygen (DO) (in mg/l)	Biochemical Oxygen Demand (BOD) (in mg/l.)	Ammoniacal Nitrogen (in mg/l.) (DL = 0.1 mg/L)
Near RC Side	8.97	11.70	4.70	BDL
Near Padma Pukur	9.00	12.40	5.70	BDL
Near Buddha Mandir	9.15	14.50	5.95	BDL
Permissible Standard for use of water for Outdoor Bathing (Organised)	6.5-8.5	5 mg/L or more	3 mg/L or less	1.2 mg/L

Analysis for Pesticide Residues				
Sl.	Pesticides	Near RC Side	Near Padma Pukur	Near Buddha Mandir
1	a-BHC	NT	NT	NT
2	g-BHC	NT	NT	NT
3	MP	NT	NT	NT
4	MALATHION	NT	NT	NT

5	CPS	BDL	BDL	NT
6	Aldrin	BDL	NT	NT
7	ENDO I	NT	NT	NT
8	DIALDRIN	NT	NT	NT
9	Endo II	BDL	NT	NT
10	2,4 DDT	NT	NT	NT
11	p,p-DDT	NT	NT	NT
12	ANILOPHOS	NT	NT	NT
Results are expressed in ppb.				
BDL: Below Detectable Limit (DL - 0.05 ppb)				
NT: Not Traceable				