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East Kolkata Wetlands: A Resource Recovery System Through Productive Activities

Nitai Kundu[1], Mausumi Pal[2] and Sharmistha Saha[1].
[1]East Kolkata Wetlands Management Authority, Department of Environment, Govt. of West Bengal, B 4, LA Block, Sector III, Salt Lake, Kolkata – 700 098,India.
[2]Institute of Environmental Studies & Wetland Management, Department of Environment Govt. of West Bengal, B 4, LA Block, Sector III, Salt Lake, Kolkata – 700 098, India.
**Corresponding author: Email: npk1967@yahoo.co.in*

ABSTRACT

The East Kolkata Wetlands (EKW) comprises a large number of water bodies located in the districts of 24 Parganas North & South, West Bengal. It is adjacent to the eastern part of Kolkata and borders on the Salt Lake Township on the one hand and the upcoming new township at Rajarhat on the other. The multifunctional wetland ecosystem consists of an area of 12,500 hectares. It comprises 254 sewage fed fisheries, small agricultural plots and solid waste farms. Besides, there are some built up areas also. The EKW nurtures the world's largest wastewater fed aquaculture system. The goods and services provided by this wetland include, in addition to fisheries, a very cheap, efficient and eco-friendly system of solid waste and sewer treatment system for the city of Kolkata, habitat for waterfowl and housing for a large flora and fauna. However, because of increasing pressure of urbanisation, change in the quality and quantity of the solid waste and sewer, as also human neglect this Ramsar site is under threat. To stop further deterioration of the system and to protect and develop its original character, it is therefore necessary to prepare a comprehensive and integrated management plan in keeping with basic guidelines of the Ramsar Protocol, and to implement it.

This paper summarizes the methodology that has been followed in this direction and outlines the broad recommendations that have already been made. The greater emphasis in drawing the management plan has been on the participation of various stakeholders. In doing so our understanding of the system and its people has been immensely enriched. We started with the assumption that to save the wetland it is necessary to save the people. After intensive interaction we have come to reformulate the principle as save the people to save the wetland.

INTRODUCTION

The increased awareness and valuing of wetlands over the past fifty years has in a large part been due to people experiencing and connecting with these areas. Every person learns about, experiences and enjoys wetland in different ways. Change and diversity are central themes in wetlands, whether they are natural or man made. The use of a range of dynamic, innovative, interactive and practical techniques is fundamental to fully engage people's senses, understanding and appreciation of wetlands.

The present study of East Kolkata Wetlands (EKW) is a unique example of innovative resource reuse system through productive activities. It is situated at the eastern outskirt of the metropolitan city Kolkata and thus called East Kolkata Wetlands. The EKW is stretching over two districts viz. North 24 Parganas and South 24 Parganas covering 12,500 hectares area. This area includes around 254 sewage fed fisheries, agricultural land, garbage farming fields and some built up area. 45.93% area of EKW is manmade water area. The resource recovery system, developed by the local people through ages using wastewater from the city, is the largest in the world and unique of its type. Long back this area used to be a buffer zone; later the urban waste, both solid garbage and sewage started to be dumped here. Consequently the practice of sewage fed pisciculture and agriculture made this area a natural waste-recycling region. Waste water flows through fishponds covering about 4,000 ha, and the ponds facilitate a wide range of physical, biological and chemical processes which help improve the quality of the water. Consequently this wetland system is popularly known as the kidney of the city and has been described as "*one of the rare examples of environmental protection and development management where a complex ecological process has been adopted by the local farmers for mastering the resource recovery activities*" by Ramsar convention on Wetlands. In August 2002, the East Kolkata Wetland area has been included in the 'List' maintained under the **Ramsar Bureau** established under the Article 8 of the Ramsar Convention that has given this wetland the recognition of a *"Wetland of International Importance"*.

Geographical Information

The EKW is situated at 880 20' E - 880 35' E and 200 25' N -200 35' N. Climate here is more or less

sub-tropical with the annual mean rainfall around 200 cm. The maximum temperature during summer rises around 39^0C. while minimum temperature during winter is around 100C. The average temperature during most part of the year is around 30^0C during day time with a fall in temperature of 50-6^0C at night. Hydrology of this wetland is particularly different from any other aquatic systems. The wetland has as such no catchment area of its own, although an estimated amount of approximately 250 million gallons of sewage per day is being charged into it. So far as ground water is concerned, there is hardly any good aquifer up to a depth of 400 feet. Water is present in basically perched aquifers. The total dissolved solid content sometimes exceeds 1800 ppm. The water table stands at a depth of 8m.with a downward fluctuation of 1-2m. during summer. (Garg *et. al.*, 1998). In the fishery water the average pH is 7.5. In the fisheries the BOD remains within the range from 35 to 50 ppm. & COD remains within the range from 55 to 140 ppm. (Saha and Ghosh, 2003). As regards the soil, there is no manner of doubt that it has very high moisture content of a mixed clay and alluvium type.

Table 1. Land Use Status In EKW Area

Land use	Area
Substantially Water body-oriented Area	5852.14Hectare
Agricultural Area	4718.56 Hectare
Productive Farming Area	602.78 Hectare
Urban/Rural Settlements	1326.52 Hectare (91.53 ha. Urban+1234.99 ha. Rural)
Total Area	12500.00 Hectare

Land Use Pattern:

The total EKW area can be divided into four types of land use classes. These are (i) Substantially Waterbody Oriented area, (ii) Agriculture area, (iii) Productive Farming or Garbage Farming area and (iv) Settlement area (table -1). The Settlement area can be sub divided into Urban Settlement area and Rural Settlement area. The lion share (47%) of the EKW is occupied by the substantially water area. Agriculture area consists of 38% while productive farming or garbage farming takes place in 5% land and rest 10% area is under settlement. There are a number of canals flowing through this region. Some are wide and deep and used for fetching the city sewage to this area and taken care of by the Irrigation & Waterways Department, Govt. of West Bengal and the other lot which mainly consists of narrow canals are basically owned and maintained by fishery owners or fishery cooperatives. The garbage dumping ground is falling under the jurisdiction of Kolkata Metropolitan Area (KMA) and Kolkata Municipal Corporation (KMC) manages the solid garbage dumping activity in this area.

Biodiversity

The East Kolkata Wetlands confirms its suitability for conservation of diverse elements of flora and fauna. It is unique in terms of peri-urban wetland providing a multidimensional profile in terms of both wise use, complying with fish criteria and waterfowl habitat. The area is also well known for migratory birds. Aquatic vegetation in the sewage fed ponds is mainly dominated by some floating microphytes. Sometimes, at the edge some emergent microphytes also cover the wetlands, which are not used in the fishery purposes but harbor mixed types of wetland vegetation with major growth forms.

Table 2. Phytoplanktonic Diversity in EKW

Myxophyceae	Chlorophyceae	Bacillariophyceae
Anabaena Sp	Closterium Sp	Navicula Sp
Agmenellum Sp	Tetraedron Sp	Nitzschia Sp
Microcystis Sp	Cosmarium Sp	Fragillaria Sp
Spirulina Sp	Euglena Sp	Diatoma Sp
Oscillatoria Sp	Chlorella Sp	Synedra Sp
Schizothrix Sp	Planktospherica Sp	Pleurosigma Sp
Closteropsis Sp	Chodatella Sp	Cocconeis Sp
Glotrichia Sp	Phytoconis Sp	
Calothrix Sp	Scenedesmus Sp	
Lyngbya Sp	Actinastrum Sp	
Phormidium Sp	Asterionella Sp	
	Schroederia Sp	

Flora:

In 2004 summer the Institute of Wetland Management and Ecological Design (IWMED) which is now named as Institute Of Environmental Studies and Wetland Management (IESWM), working under the Department of Environment, Govt. of West Bengal conducted a biodiversity study in the EKW area. The study shows 30 genera of **phytoplankton** of which Myxophyceae, Cholorophyceae and Bacilliariophyceae contained 11, 12 and 7 genera respectively (table -2). From the different locality of the study area 96 species of **vascular plants** encountered which were mainly growing in wetlands and bank regions. These species were under 79 genera and 38 families. The vascular plants contained 62 species under 53 genera and 25

families of dicotyledon, 31 species under 23 genera and 10 families of monocotyledons and only 3 species under same number of genera and families of pteridophytes. The diversity of wetland plants showed a total number of 55 species under 41 genera and 26 families. The wetland floral diversity shows several economically important wetland plant resources of which the numbers of species are in use of medicine, paper pulp, thatching materials, vegetables, food for water fowl, as green manure and compost, water purifies and fodder etc (table-3). Floristic component along the bank of any aquatic system have very significant role for their existence and sustenance through checking erosion and rapid eutrophication, supplying essential nutrients and harbouring innumerable biodiversity. Most of the helophytic plants are integrated with bank flora. Other than helophytes around 41 species of herbaceous flora found in EKW give a confident stability to its banks.

Fauna:

The planktonic diversity study reveals 17 species of **zooplanktons**, which are commonly found in fresh water bodies (table-4). 3 Cladoceran species are common to fresh water and not found in the sewage fed fisheries. All the 5 Rotifern species are common to sewage fed fisheries. Previously the **crustacean** in the EKW system was composed of both brackish water and fresh water forms. But after the large scale intervention by the owners for cultivation of only few numbers of fresh water fish species and through sewage fed fisheries, diversity of brackish water crustaceans have disappeared from the wetland system. In EKW area aquatic insect species belong to 4 orders viz. Hemiptera, Coleoptera, Odonata, and Diptera (table-5).

Table 3. Floristic Diversity of Economic Importance

BOTANICAL NAME	USED PARTS	USED AS / USED IN
1) Aeschynomene aspera L.	Root	Jaundice.
2) Bacopa monnieri (L.) Pennell	Leaf / whole plant	Nerve tonic, Epilepsy, Bronchities, Skindisease, Biliousness, Dyspepsia, Flatulence, Diuretic, Asthma, Rheumatism, Cardio-tonic.
3) Canna indica L.	Root, Rhizome &Scape leaf	Diaphoretic, diuretic, dimulcent, Stimulant,Dropsy, Fever.
4) Centella asiatica (L.) Urban	Leaf	Antidysenteric, Mouth and throat ulcers, Appetizer, Leprosy, Eczyma, Psoriasis,Cervicites etc.
5) Ceratophyllum demersum L	Whole plant(Plant paste)	Antidote to Scorpion sting.
6) Colocasia esculenta (L.) Scott	Petiole	Styptic, Astringent.
7) Commelina benghalensis L.	Whole plant	Leprosy, Demulcent, Refrigerent, Laxative,Dropsy.
8) Commelina diffusa Burm.	Whole plant	Burns, Itches & Boils.
9) Cyperus rotundus L.	Tuber	Cooling agent.
10) Dentella repens (L.) J.R. et.J.G.A.Forster	Whole plant	Poulticing agent.
11) Eclipta prostrata (L.) L	Leaf & Whole plant	Jaundice, Hair-tonic, Anti-inflammatory,Anthelmintic, Anoxia, Vulneary, Opthalmic,Digestive, Carminative, Diuretic, Aprodisiac, Deobstrruent, Depurative, Skin disease.
12) Eaichhornia erassipes (Mart) Solms. Laubach.	Plant juice,Root	Stomachic, Toothache, Goitre.
13) Enhydra fluctuans Lour.	Leaf	Laxative, Antibilious, Demulcent, Cutaneous& Nervous affection.
14) Grangea maderaspatana (L.)Poiret.	Leaf	Antispasmodic, Stomachic, Deobstruent,Menstrual disorder, Ear-ache.
15) Heliotropium indicum L.	Whole plantLeaf-rootFlower	Skin disease, Eye complain.Urticaria, Fevers, Cough & Fever. Emmenogogue, Abortificient.
16) Hygrophila schulli M.R. etS.M. Almeida	Whole plantStemLeaf	Aphrodisiac, Cough, Anaemia, Uro-genitaldisease, Anti-inflammatory, Hyperdypsia,Jaundice, Flatulence, Dysentery.

Table 4. Planktonica diversity &load

Sites	Planktonia Groups	Species	Abundance
Mahisbathan (Frish Water)	Rotifer	1.Asplanchanasp.	++
	Cladocera	1.Diaphanosoma excisum	++
		2.Monia micrura	++
	Copepoda	1.Mesocyclops hyalinus	++
		2.Diaptomus sp.	+
	Others	Cypris sp.	+
Mahisbathan (Sewage Fed Fishery)			
	Rotifer	1.Asplanchana	+
	Copepoda	1.Mesocyclops hyalianus	+
Bantala (Fresh Water Fishery)			
	Rotifer	1.Asplanchana sp	++
	Cladocera	1.Diaphanosoma excisum	++
		2.Diaptomus sp.	+++
	Copepoda	1.Mesocyclops hyalinus	+
		2.Diptomus sp.	++
	Others	1.Cypris sp.	++
Bantala (Sewage Fed Fishery)	Rotifer	1.Filinia sp.	+++
		2.Asplanchana sp	++
	Copepoda	1.Mesocyclops hyalius	+
		2.Diaptomus sp.	+
		3.Cyclops nauplius	+
Jhagrasisa (Fresh Water Fishery)	Cladocera	1.Moina mirura	+
			+
	Copepoda	1.Mesocyclops hyalinus	+
		2.Diaptomus sp.	+
		3.Mesocyclops leucarti	++
		4.Nauplius larvae	+
	Others	1.Cypris sp.	

Table 5. Checklist Aquatic Insects in the East Calcutta Wetlands.

Sl. No.	*Scientific Name*	Abundance	CB	BT	JS	SM	MB
A.	Hemiptera						
1.	Gerris spinolae	Common	√	√	√	√	√
2.	Sphaerodema annulatum	Common	√	√	√	√	√
3.	Ranatra elongata	Common	√	√	√	√	√
4.	Ranata varips	Common	√	√	√	√	√
5.	Laccotrephes griseus	Common	√	√	√	√	√
6.	Diplontchus annulatus	Sporadic	√	√	√	√	√
7.	Diplonychus Molestrum	Sporadic	√	√	√	√	√
B.	Coleoptera						
8.	Canthydrus laetabilis	Common	√	√	√	√	√
9.	Cybister tripunctatus	Sporadic	√	√	√	√	√
10.	Hydrocoptus subvittatus	Sporadic	√	√	√	√	√
11.	Hypoporus bengalensis	Rare	√	√	√	√	√
12.	Eretes sticticus	Common	√	√	√	√	√
13.	Hydrophilus olivaceus	Common	√	√	√	√	√
14.	Berosus indicus	Common	√	√	√	√	√

The fish species in wetlands largely depend on plankton in their younger stage. With the age and growth size, these tend to feed on larger prey and organic matter from the sewage water. Previously the fish fauna in the EKW system was composed of both brackish water and fresh water forms. But after the large-scale intervention by the owners through sewage fed cultivation of only few number of fresh water species diversity a swell as population has changed. (Table-6).

The EKW system offers suitable habitat for **amphibian** species – as they prefer impounded water

for breeding, water body with submerged vegetation for development of young and cover on the bank vegetation to hide and feed. (table-7). The types of reptiles found in EKW area a re mainly water snakes, other snakes, monitor lizards, common lizards and fresh water tortoise. The invertebrates as well as lower vertebrates provide food to the carnivore reptilian species. Latest survey shows 19 reptilian species representing 13 snake species, 2 monitor lizards, 3 common lizards and 1 fresh water tortoise. (table-8). During summer around 66 species of birds is noticed in the wetland area while on an average more than 125 species of birds (both migratory and non migratory) are found throughout the year. (table-9).

As wetland areas offer suitable habitat to mammals for diversity of different niches – water body for aquatic mammals and grassland, scrubs and orchards for others EKW is no exception. Wetland dependent species are Mongoose and Fishing cat, other carnivores and rats and mice prefer grassland and scrubs around the wetland. 16 of mammalian species recorded from the wetland area represent 8 Carnivores species, 2 bat species, 6 species of Squirrel, Rat, and Mouse. Out of these 16 species, 9 are common, 1 is sporadic and rests 6 are rare. One mammalian species is endemic to EKW i.e. Marsh Mongoose. (table-10).

Table 6. Checklist of Fish fauna of East Calcutta Wetlands

Sl. No.	Scientific Name	Common Name	Abundance	CB	BT	JS	SM	MB
A.	Cultured Fish							
1.	Catla catla	Catla	Common	√	√	√	√	√
2.	Labeo rohita	Rui	Common	√	√	√	√	√
3.	Cirrhinus mrigala	Marigel	Common	√	√	√	√	√
4.	Labeo bata	Bata	Common	√	√	√	√	√
5.	Labeo calbasu	Kalbos	Rare	√	√	√	√	√
6.	Hypothalmicthyes molithrix	Silver Carp	Sporadic	√	√	√	√	√
7.	Crenopharyngodon idelea	Grass Carp	Rare	√	√	√	√	√
8.	Aristichthysnobills nobilis	American Rui	Sporadic	√	√	√	√	√
9.	Oreochromis mossambica	Telapia	Common	√	√	√	√	√
10.	Oreochromis nilotica	Nilotica	Common	√	√	√	√	√
11.		Briget	Common	√	√	√	√	√
12.		Hybrid Magur	Rare	√	√	√	√	√
13.	Lates calcarifer	Bhetki	Rare	√	√	√	√	√
14.	Liza parsia	Parse	Rare	√	√	√	√	√
B	Wild Fish							
15.	Puntius chila	Punti	Rare	√	√	√	√	√
16.	Puntius guganio	Punti	Rare	√	√	√	√	√
17.	Amblypharyngodon mola	Murala	Rare	√	√	√	√	√
18.	Glossogotius giuris	Belay	Sporadic	√	√	√	√	√
19.	Salmostomabacaila	Chala	Rare	√	√	√	√	√
20.	Aploeheilus panchax	Techoka	Common	√	√	√	√	√
21.	Mystus vittatus	Tangra	Rare	√	√	√	√	√
22.	Mystus	Tangra	Sporadic	√	√	√	√	√
23.	Channa striatius	Sol	Rare	√	√	√	√	√
24.	Channa gachua	Chang	Rare	√	√	√	√	√
25.	Channa punctatus	Lata	Rare	√	√	√	√	√
26.	Clarias batrachus	Magur	Rare	√	√	√	√	√
27.	Heteroneustes fossilis	Singhi	Rare	√	√	√	√	√
28.	Mastacembetus panalus	Pankal	Sporadic	√	√	√	√	√
29.	Mastacembetus armatus	Ban	Sporadic	√	√	√	√	√
30.	Pisodonophis boro	Kucho	Rare	√	√	√	√	√
31.	Ophisternon bengaense	Bero		√	√	√	√	√
32.	Chanda nama	Chanda	Rare	√	√	√	√	√
33.	Chanda ranga	Ranga Chanda	Rare	√	√	√	√	√
34.	Notopterus Notopterus	Falui	Rare	√	√	√	√	√
35.	Anabas testudineus	Koi	Sporadic	√	√	√	√	√
36.	Badis badis	Banda	Rare	√	√	√	√	√
37.	Unidentified species probably exotic (ZSI)			√	√	√	√	√

Table 7. Checklist of Amphibian fauna

Sl No	Scientific Name	Common Name	Abundance	CB	BT	JS	SM	MB
1.	Rana tigrina	Bull Frog	Common	√	√	√	√	√
2.	Rana hexadactyla	Green Frog	Sporadic	√	√	√	√	√
3.	Rana limnocharis	Cricket	Common	√	√	√	√	√
4.	Bufo melanostictus	Common Toad	Common	√	√	√	√	√

Table 8. The checklist of the Reptilian Species

Sl No.	Scientific Name	Common Name	Abundance	CB	BT	JS	SM	MB
1.	Naja naja naja	Ghokro	Rare	√	√	√	√	√
2.	Naja kaonthia	Keutiya	Rare	√	√	√	√	√
3.	Bungarus fasciatus	Sankamute	Rare	√	√	√	√	√
4.	Vipera russelli	Chandra Bora	Rare	√	√	√	√	√
5.	Lycodon aulicus	Ghar Chiti	Rare	√	√	√	√	√
6.	Ptyas mucosus	Daras	Sporadic	√	√	√	√	√
7.	Xenochropespiscator	Jal Dhora	Common	√	√	√	√	√
8.	Amphiesma stolata	Helay	Common	√	√	√	√	√
9.	Dendrelaphis tristis	Bet Achra	Rare	√	√	√	√	√
10.	Typhlops porrectus	Puo	Rare	√	√	√	√	√
11.	Ahaetula nasutus	Laudoga	Sporadic	√	√	√	√	√
12.	Enhydris entrydris	Metuli	Common	√	√	√	√	√
13.	Boiga trigonata	Kard Sap	Rare	√	√	√	√	√
14.	Mabuia caranata	Anjani	Rare	√	√	√	√	√
15.	Calotes versicolor	Girgiti	Common	√	√	√	√	√
16.	Varanusbengalensis	Go Sap	Sporadic	√	√	√	√	√
17.	Varanus flavescens	Go Sap	Rare	√	√	√	√	√
18.	Hemidatylusflaviviridis	Tiktiki	Common	√	√	√	√	√
19.	Melanochelystricarinata	Kachap	Rare	√	√	√	√	√

Table 9. Checklist of bird species recorded

Sl. No.	Common Name	Scientific Name
1.	Lesser goldenbacked woodpecker or Blackrumped flameback	Dinopium
2.	Large green barbet or brownheaded barbet	Megalaima zeylanica
3.	Coppersmith Barbet	Megalaima haemacephala
4.	Common Hoopoe	Upupa epops
5.	Whitethroated or White breasted Kingfisher	Halcyon smyrnensis
6.	Pied Kingfisher	Ceryle rudis
7.	Green bee-eater or Small Green Bee-eater	Merops Orientalis
8.	Common hawk cuckoo or Brain-fever bird	Hierococcyx varius
9.	Asian Koel	Eudynamys scolopscea
10.	Greater coucal or Crow pheasant	Centropus sinensis
11.	Rose ringed Parakeet	Psittacula krameri
12.	Asian palm Swift	Cypsiurus balasiensis
13.	Rock pigeon	Columba livia
14.	Eurasian collared dove or Ring dove	Streptopelia decaocto
15.	Laughing dove or Little brown dove	Streptopelia senegalensis
16.	Spotted dove	Streptopelia chinensis
17.	Yellow-footed green pigeon	Treron phoenicoptera
18.	White breasted water hen	Amaurornis phoenicurus
19.	Common moorhen	Gallinula chloropus
20.	Common snipe	Gallinago gallinago

21.	Wood sandpiper or Spotted sandpiper	Tringa glareola
22.	Little stint	Calidris minuta
23.	Black-winged stilt	Himantopus himontopus
24.	Pheasant-tailed jacana	Hydrophasianus chirurgus
25.	Bronze-winged jacana	Metopidius indicus
26.	Little ringed plover	Charadrius dubius
27.	Black naped tern	Sterana aurantia
28.	Gull billed tern	Gelochelidon nilotica
29.	River tern	Sterna auratia
30.	Pariah kite or Black Kite	Milvus migrans
31.	Black shouldered kite	Elamus caeruleus
32.	Little grebe or Dabchick	Tachybaptus ruficollis
33.	Little cormorant	Phalacrocorax fuscicollis
34.	Large or Great cormorant	Phalacrocorax niger
35.	Shag or Indian cormorant	Phalacrocorax niger
36.	Little Egret	Egretta garzetta
37.	Intermediate or Median egret	Mesophoyx intermedia
38.	Large or Great Egret	Casmerodius albus
39.	Cattle egret	Bubulcus ibis
40	Indian pond heron	Ardeola grayii
41.	Grey Heron	Ardea cinerea
42.	Asian openbill or Openbill stork	Anastomus oscitans
43.	Brown shrike	Lanius cristatus
44.	Bay-backed shrike	Lanius vittatus
45.	Rufous treepie or Treepie	Dendrocitta vagabunda
46.	House crow	Corvus splendens
47.	Jungle or Large-billed crow	Corvus macrorhynchos
48.	Ashy swallow shrike or Ashy woodswallow	Artamus fuscus
49.	Black Drongo	Dicrurus macrocercus
50.	Oriental magpie robin	Copsychus saularis
51.	Asian pied starling or Pied myna	Sturnus contra
52.	Common myna	Acridotheres tristis
53.	Bank myna	Acridotheres ginginianus
54.	Jungle myna	Acidotheres fusus
55.	Wire-tailed swallow	Hirundo smithii
56.	Red-vented bulbul	Pycnonotus cafer
57.	Plain prinia	Prinia inornata
58.	Paddyfield warbler	Acrocephalus agricola
59.	Blyth's reed warbler	Acrocephalus dumetorum
60.	Clamorous reed warbler or Great reed warbler	Acrocephalus stentoreus
61.	Common tailor bird	Orthotomus sutorius
62.	House sparrow	Passer domesticus
63.	Yellow wagtail	Motacilla flava
64.	Citrine wagtai	Matacilla citreola
65.	Paddyfield pipit	Anthus rufulus
66.	Baya weaver	Ploceus philippinus

Evolution of EKW as a Waste Recycling Region

Since the establishment of Kolkata city, the drainage problem has been a major issue. In the initial stage, Kolkata used to discharge its sewage into the river Hooghly. But subsequently it had become clear that the existing system neither helped drain out the city's sewage nor discharge the annual inundation. This was due to the defective drainage system that could neither answer the purpose of cleaning the town nor of discharging the annual inundation occasioned by the rise of the river or by excessive rainfall during the south west monsoon. The health of the town was directly linked to this malfunctioning drainage system. Moreover as the sewage was discharged in to the river Hooghly, so also were thrown other waste materials like dead bodies and corpses. So the contamination of Hooghly water became acute. It was felt that the mistake was committed by directing the city drainage towards the river. It was believed that the level of the country inclines towards the salt water lake in the eastern part of the city and consequently the principal channels of public drain ought to be conducted in that direction. Accordingly, a committee was set up by the Governor General to report the means of improving the drainage facility of the town. The consensus of opinion of the eminent engineers of that time was that – an underground system of drainage for the city would be the best solution.

Table 10. The checklist of the Mammalian Species

Sl. No.	Scientific Name	Common Name	Abundance	CB	BT	JS	SM	MB
1.	Herpestes auropunctuatus	Beji	Common	√	√	√	√	√
2.	Herpestes edwardsii	Neul	Rare	√	√	√	√	√
3.	Viverricuka indica	Gandha Gakul	Rare	√	√	√	√	√
4.	Paradoxurus hermaphroditus	Bham	Rare	√	√	√	√	√
5.	Felis chaus	Khatas	Sporadic	√	√	√	√	√
6.	Canis aureus	Seal	Rare	√	√	√	√	√
7.	Lutrogale perspicillata	Bhodar	Rare	√	√	√	√	√
8.	Pteropus giganteus	Badur	Common	√	√	√	√	√
9.	Pipistrellus coromandra	Chamchika	Common	√	√	√	√	√
10.	Funambulus pennantii	Kathbiral	Common	√	√	√	√	√
11.	Mus booduga	Metho Indur	Common	√	√	√	√	√
12.	Bandicota bengalensis	Dhera Indur	Common	√	√	√	√	√
13.	Bandicota indica	Indur	Common	√	√	√	√	√
14.	Mus platythrix	Nangti Indur	Common	√	√	√	√	v
15.	Sucks murinus	Chuchu	Common	√	√	√	√	√
16.	Herpestes palustris	Marsh Mongoose	Rare	√	√	√	√	√

In 1857 the drainage committee considered Mr. William Clark's scheme to be the best that could be devised for conveying the sewage to the eastern side of the city with of course some modification in the levels and with an increase in the number of pumping stations. In the later period, the high boom of the population, increasing rate of the water supply, the gradual filling up of the reservoir of rainwater led to an excessive increase in the volume of the sewage. Due to this reason, the Govt. compelled the Kolkata Corporation to discharge the rainwater into circular canal. In 1891, the drainage system was extended to the suburbs, which also help to alleviate the sewage and rainwater disposal problem to a great extent.

The new system involved draining the city sewage to the south east into river Bidyadhari, from there into the river Matla and finally into the Bay of Bengal. The scheme involved a complicated series of canals and lock gates due to tidal influxes. The system drained the city via the Beliaghata canal into the Bidyadhari river approximately 8 km east of Kolkata. The sewage was stored in reservoirs and released at low tide.

Within ten to twenty years Bidyadhari began to silt up heavily due to lock gate at Dhapa. This gate was used to synchronize the release of the sewage with low tide. This greatly reduced the spill area of the Bidyadhari and led to heavy siltation of the river. Other interventions to the tidal flood system such as damming of some of the Bidyadhari's channels and the excavation of navigation canals in the area led to further deterioration of the river. Consequently the river was dredged and the sluice gates were opened to save the river but gradually it was declared undrainable and dead.

Therefore, it can be concluded that a large part of the Salt Lake was used as reservoir of sewage disposal from the urban and suburban areas and for the rainwater, which was flushed by the ebb tide of the Bidyadhari. This marshy land was thus used as:

- A water route for transportation of the goods.
- A drainage basin.
- A dumping ground for the city refuses.

During 1860s, sewage-fed fish farming was tried to be introduced but the attempt was not successful in this area. In 1872, a fish Ghat was constructed on the Raja's Khal which was closely followed in 1887 by the establishment of a flourishing fish market at Pagladanga. A navigation channel was constructed to connect the market to the town reservoir. So some informal aqua farming was started, but Mr. Bidhu Bhusan Sarkar undertook the first formal effort of sewage fed aqua farming in 1918. Later, the land was taken to construct SWF (storm water flow) canal, which caused disruption to both the fish canal and market. However, the discharge of sewage carried through SWF canal in the brackish aqua-bodies reduced the salinity of the water. Since the water in the bheries changed from saline to non-saline gradually over the passage of time, carp culture was started with regular sewage inflows from the year 1929. In this way, thus, the fresh water fishing was gradually colonized in these lagoons. Subsequently, construction of Dr. B. N. Dey's Outfall Scheme also encouraged the local people to adopt the wastewater fed aquaculture. In 1929, sewage-fed aquaculture was practiced for commercial purpose for the first time. After that, people understood the profit generating potentiality of this economic activity and from then on sewage-fed aquaculture gained momentum.

Fish cultivated in EKW fisheries

Local fish market in EKW area

Mechanism of Wastewater Treatment in Fishponds

The unique feature of the EKW is sewage treatment through pisciculture. The wetlands are, in fact, waste stabilization ponds (WSPs). Here we will discuss the functioning of waste stabilization ponds and the role that fish play in removal of waterborne contaminants.

In this waste recycling region the slow moving canal system functions as anaerobic and facultative ponds, while the fisheries are maturation ponds. The anaerobic character of the canals leads to unsightly and smelly canals within the city. The fish ponds, however, do not smell and have the characteristic green algae.

Basic WSPs have been demonstrated to be very effective for removing BOD and pathogens, particularly in warm climates (Mara 1997). Fish ponds further improve the treatment efficiency of WSPs by stirring sediments trapped in the pond floor (Edwards 1992) and incorporating nutrients and carbon into their body mass.

The general removal mechanisms for BOD, nitrogen and phosphorus are:

- Settling into the pond sediments,
- Incorporation into algal biomass,
- Incorporation into fish biomass,
- Volatilization.

The Kolkata Municipal Corporation (KMC) area generates roughly 600 million liters of sewage everyday and more than 2500 metric Tons of garbage. The wastewater is led by underground sewers to the pumping stations in the eastern limit of the city, and then pumped into open channels. There are six terminal pumping stations in KMC area, viz. *Bagjola* Pumping Station, *Chowbaga* Pumping Station, *Topsia* Pumping Station, *Dhapa* Lock Pumping Station, *Ballygunj* Pumping Station, and *Palmer Bazaar* Pumping Station (table-11). The responsibility of the Kolkata Municipal Corporation ends with the reaching of the wastewater to the outfall channels through these pumping stations. Thereafter, the sewage and wastewater is drawn into the fisheries of the East Kolkata Wetland by the owners of the fisheries, where within a few days' detention, bio-degradation of the organic compounds of the sewage and wastewater takes place. Organic loading rate on these fish ponds appears to vary between 20-70 kg. per hectare per day (in the form of bio-chemical oxygen demand). There are networks of channels that are used to supply untreated sewage and to drain out the spent water (effluent).

Table 11. Catchment Basin Data.

Sl. No	Name of Basin	Area of the Basin (Sq. km)	Terminal Pumping Station
1	Town System	19.13	Palmer's Bridge Pumping Station (PBPS)
2	Suburban System	25.69	Ballygunge Drainage Pumping Station (BDPS)
3	Maniktala System	8.91	Dhapa Lock Pumping Station (DLPS)
4	Tangra-Topsia System	5.17	Topsia Pumping Station & others
5	Tollygunge-Panchannagram System (i) Tolly's Nallah Basin (ii) Panchannagram Basin	 4.00 32.00	 Chowbaga Pumping Station
6	Bagjola Basin	6.07	Bagjola Pumping Station

The cumulative efficiency in reducing the B.O.D. (a measure of organic pollution) of the sewage wastewater is above 80% and that in reducing the coliform bacteria is 99.99% on an average. The solar radiation here is about 250 langleys per day, and is adequate for photosynthesis to take place. In fact, the sewage fed fishery ponds act as solar reactors. Solar energy is trapped by a dense population of plankton (figure - 1). Plankton is consumed by the fishes. While the plankton plays a highly significant role in degrading the organic matter in the wastewater, it becomes a problem of pond management to tackle the phenomenon of plankton overgrowth. It is at this critical phase of the ecological process that the fishes play an important role by grazing on the plankton.

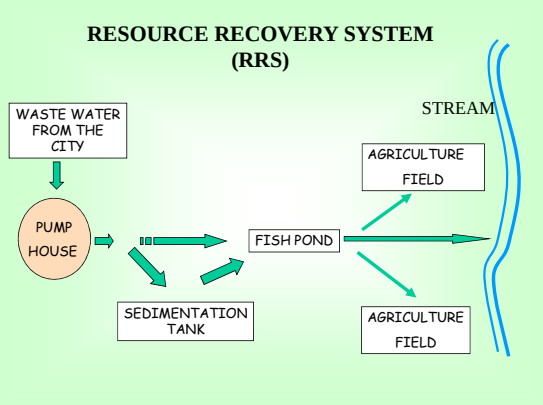

Figure 1. Resource Recovery System In EKW.

The two fold role played by the fishes is indeed crucial – they maintain proper balance of the plankton population in the pond and also convert the available nutrients in the wastewater into readily consumable form (viz. fish) for the humans. This complex ecological process has been adopted by the fish farmers of the East Kolkata Wetlands, who have developed such a mastery of these resource recovery activities that they are easily growing fish at an yield rate and production cost unmatched in any other fresh water fish ponds of this country.

On the other hand, the conventional technology options for the treatment of municipal sewage and wastewater have been found to be excessively capital intensive, operationally unreliable and highly energy expensive comparing with the city of Kolkata which gets its huge volumes of daily sewage treated at no expense and getting in addition substantial daily supply of highly edible freshwater fish (a very essential protein supplement in their daily food). In fact, Kolkata city receives about one third of its daily requirement of fish from the sewage-fed fisheries (about 11,000 metric tonnes per annum).

Fish vendors gathered in wholesale market

The waste recycling region (WRR) demonstrates effective BOD treatment. In winter, summer and the fall, BOD falls by a factor of three to four. In the monsoon season, BOD is much lower than the other seasons and only falls by about 40%. This may be due to very high volumes of water leading to dilution and reduced hydraulic residence times. Also, during the monsoon, more wastewater than normal bypasses the fisheries due to the high flow rates in the dry weather flow (DWF) and storm weather flow (SWF). BOD levels at the outfall are about the same level as the receiving body but are still in excess of guidelines from the Central Pollution Control Board of India (table-12).

The WRR treats COD effectively. In the fall and winter, COD levels are reduced by about a factor of three bringing them to about the same levels as the receiving body. During monsoon and summer COD levels are only reduced by a factor of two. During these seasons, COD levels at the outfall are substantially elevated compared to levels in the Kulti River.

Total inorganic nitrogen (TIN) (primarily ammonia and nitrate) levels are somewhat reduced by the WRR. TIN falls dramatically during the fall by a factor of almost three. During the winter, TIN is reduced by almost 50%. In the monsoon, TIN reductions are more modest, about 10% to 15%. During the summer, TIN levels actually rise in the WRR. During most seasons, TIN levels at the outfall are in excess of the levels in the receiving body.

TON levels are nearly uniform for winter, summer and fall. During these seasons, TON levels drop by almost a factor of two. However, the TON levels at the outfall are still in excess of those in the *Kulti* River. During the monsoon, TON levels actually rise in the WRR.

Total dissolved phosphorus increased by a factor of about three during summer and fall. The drop during winter and monsoon is about 50%. In all cases, the level at the outfall exceeds those of the receiving body.

Table 12. Waste Water Characteristics

	BALLYGUNJ PUMPING STATION	BANTALA / CLC	GHUSHIGHATA
NH4-N	12.84	6.96	1.86
COD	303.80	166.60	78.40
BOD	155.42	50.00	27.50
Phenol	0.032	BDL	BDL
Cd	0.006	0.006	0.006
Pb	0.010	0.087	0.078
Cr	1.991	0.058	0.075

This is a sample taken on 30th Nov. 1998 by the WBPCB

	BALLYGUNJ PUMPING STATION	BANTALA /CLC	GHUSHIGHATA
NH4-N	31.100	19.400	12.300
COD	558.600	117.600	68.600
BOD	275.000	18.750	12.500
Phenol	0.440	0.230	0.090
Cd	BDL	BDL	BDL
Pb	0.300	BDL	0.015
Cr	3.200	0.520	BDL

This is a sample taken on 4th Dec. 2001 by the WBPCB

Crop storage in villages

Lock gate in fishery feeding canal

Typically fecal coliforms are reduced by three log orders, except during the monsoon when the reduction is about one order. During summer and fall, the outfall levels are similar to levels in the receiving body, while during the monsoon and winter, outfall levels are about an order of magnitude greater.

Salt Lake Reclamation and Calcutta High Court's Verdict

In 1945, there were twenty thousand (20,000) acres of wetlands of which nearly eighteen thousand (18,000) acres were used for sewage fed pisciculture by around 350 fisheries. After independence, West Bengal was flooded with a great number of refugees from Bangladesh and Myanmar. Kolkata, the capital of the state of West Bengal, faced the major influx of the population. This led to various health, sanitation and slum area related problems. To find the solution, the then Chief Minister Dr. Bidhan Chandra Roy proposed to build a new satellite township named Salt Lake in the peri-urban region. In 1956, the Salt Lake Reclamation Scheme (SLRS) was accepted and an acquisition was given for nearly half of the wetland area. Between 1962 and 1967, nearly 3000 acres lake was filled up with silt from the Hooghly River to convert the wetland into major residential area, i.e. Salt Lake City. Between 1967 and 1972, another 800 acres of low land was converted to high area for the expansion of the Salt Lake City. In 1972, 11,480 acres of land was left which was being used for sewage-fed aquaculture. Of this remaining part of the wetland area 1,650 acres was reclaimed in 1972 for the East Kolkata Township. A new township at Patuli was proposed to be developed, which demanded 600 acres of land. So, another 600 acres of land was reclaimed for real estate development. However, since 1978, there was no major conversion

for real estate development but it was observed that the wetland was gradually being converted for paddy cultivation. In addition, a part of the wetland was taken away for the construction of the Eastern Metropolitan Bypass (EM Bypass) in 1980 and a part of the wetland area was converted into the Municipal Solid Waste Disposal Ground. At present, nearly 6,500 acres of wetlands is left and is engaged in sewage fed aquaculture and other allied activities like garbage farming and paddy cultivation, etc.

The process of urbanization always requires vast stretch of land and the first targets are the wetlands, wherever available. The wetlands are very vulnerable as most people are ignorant of the important purpose they serve as in case of the East Kolkata Wetland. In the year 1992, it was proposed to convert 800 acres of the East Kolkata Wetland areas for different developmental activities including further expansion of the Salt lake city and later on also for the construction of the World Trade Center. Consequently, in the year 1992, a Public Interest Litigation (PIL) case was launched by a Kolkata based NGO, People United for Better Living in Calcutta (PUBLIC) against this proposed plan to convert the 800 acres of wetland area. The High Court verdict delivered by Justice Umesh C. Banerjee goes like '*….Incidentally, it was contended that from 20,000 acres the Calcutta's wetlands gradually shrank to 10,000 acres out of private initiative only and private initiative are now much more stronger than before.'*

'….Here, However the question is not as simple as the city losing a portion of its fish and vegetable supply from its backyards, but it is a question of social and economic cost benefit involving much larger and intricate issues.'

'There can't be any matter of doubt that the Calcutta Wetlands present a unique ecosystem apart from the materialistic benefit to the society at large.'

The Hon'ble Court used a sketch map (affixed in Annex C), which showed the waste-recycling region of Kolkata as the East Kolkata Wetlands area. This was widely considered as a landmark judgment but doubts have been expressed regarding its implementation. The verdict ruled that no government or non-government body can reclaim any more wetlands, on the eastern fringes, where wetlands are defined in terms of being wet for six months or more in a year. The Land and Land Reforms Department and the Department of Environment, Government of West Bengal, later accepted the map, by a government order that identified 32 mouzas coming under it (table-13).

This land schedule and a report describing the uniqueness of EKW were sent to the Ramsar convention by the Govt. of India for considering it as a "wetland of international importance". As a consequence the Ramsar Convention has declared this wetland as a Ramsar site on 19th August 2002. It has been designated as Ramsar site no 1208 and has been included in a list as 19th Ramsar site in India.

Conservation and Management Initiative of State Govt

After the Ramsar declaration of East Kolkata Wetland (EKW) as an important site the state government of West Bengal has formed a management committee under the chairmanship of the Chief Secretary. The objective of this committee is to look after the conservation and management of the wetland. Under the management of this committee the whole area has been delineated plot wise and area wise using the high-resolution satellite data. The management committee has formed a sub – committee for formulation of the outline management plan for the conservation of EKW. The various land uses identified in the EKW systems are Substantially Waterbody-oriented Area, Rural and Urban Settlements, Agricultural Area and Productive Farming Area.

Sewage fed fishery

Peri-urban wetland

Table 13. List of Mouzas involved in Ramsar Designated East Kolkata Wetland

District	Police Station	Sl no.	Mouza	Jl No.	Status
South 24 Pgs	*Tiljola*	1.	Dhapa	2	Part
		2.	Chowbaga	3	Full
		3.	Bonchtala	4	Part
		4.	Dhalenda	8	Full
		5.	Paschim Chowbaga	9	Full
	Sonarpur	6.	Chak Kolar Khal	1	Full
		7.	Karimpur	2	Full
		8.	Jagatipota	3	Full
		9.	Mukundapur	4	Full
		10.	Atghara	5	Full
		11.	Ranabhutia	6	Full
		12.	Kantipota	7	Full
		13.	Bhagabanpur	8	Full
		14.	Kharki	9	Full
		15.	Deara	10	Full
		16.	Kheadaha	11	Full
		17.	Khodahati	12	Full
		18.	Goalpota	13	Full
		19.	Kumarpukuria	14	Full
		20.	Tardaha	15	Full
		21.	Tihuria	16	Full
		22.	Nayabad	17	Full
		23.	Samukpota	91	Full
		24.	Pratapnagar	92	Full
		25.	Garal	93	Full
	Kolkata Leather Complex	26.	Hatgachha	4	Full
		27.	Hadia	5	Full
		28.	Dharmatala Pachuria	6	Full
		29.	Kulberia	7	Full
		30.	Beonta	27	Full
		31.	Tardaha Kapashati	38	Full
North 24 Pgs	South Bidhan nagar	32.	Dhapa Manpur	1	Part

Added Mouzas

District	Police Station	Sl no.	Mouza	Jl No.	Status
South 24 Pgs	Purva Jadavpur	33.	Kalikapur	20	Part
	Kolkata Leather Complex	34.	Dakshin Dhapa Manpur	1	Full
		35.	Kochpukur	2	Part
	Tiljola	36.	Nonadanga	10	Part
North 24Pgs	Rajarhat	37.	Thakdari	19	Part

There are certain strips that may be added to the boundaries of the EKW systems, so as to maintain the integrity of the whole system. The objective is to promote its wise use, encourage socio-economic development and conservation. The area aggregates to **12,500 Hectare**. This outline management plan has been sent to Govt of India as well as the Ramsar bureau for endorsement. The theme of the outline management plan goes like:

a) In no case, and under no circumstances any water area will be allowed to be converted;

b) In each case relating to a development proposal, prior permission of the Environment Department or its designated delegated Authority will be required (now EKWM Authority).

c) The waste recycling practice may be allowed in areas other than substantially waterbody-orientated area, on case to case basis, to be examined by the dept. of Environment or its designated delegated authority.

d) *Excavation of new channels or Desiltation of the silted channels for the purpose of sewage flow may be allowed for promoting sewage fed pisciculture. The proposals should however be examined beforehand by the*

Environment Department or its designated delegated authority.

Present Conservation Status of EKW

The East Kolkata Wetlands (Conservation and Management) Ordinance, 2005 came in force on 16th November 2005. on 31st March 2006, the West Bengal Legislature has passed this ordinance into an Act namely East Kolkata Wetlands (Conservation and Management) Act 2006, which allowed the State Govt. to form an Authority called East Kolkata Wetlands management Authority (EKWMA) under the chairmanship of Chief Secretary to the Govt. of West Bengal. This Authority consists of the Secretaries of various lying departments (Department of Environment, Urban Development, Irrigation & Waterways, Fisheries, Forest, Municipal Affairs, Land and Land Reforms, *Panchayat* and Rural Development), Chairman & Member Secretary, West Bengal Pollution Control Board District Magistrates of concerned districts, CEO of KMDA, Commissioner of KMC, Wetland Management experts of IESWM, representatives of local NGO and Co-operatives. As per the provisions of section 4(m) of the Ordinance 4 expert committees have been formed viz. 1) Standing Committee on Sewage and Fisheries, 2) Standing Committee on Land Management, 3) Standing Committee on Hygiene, sanitation and Welfare, 4) Standing Committee on Biodiversity Conservation consisting experts from various departments.

Some important functions and powers of the East Kolkata Wetlands Management Authority as described in the Act mentioned above are:

a) To take measures or make an order to stop, undo and prevent any unauthorized development project in, or unauthorized use of, or unauthorized act on, the East Kolkata wetlands.
b) To make an order directing demolition or alteration of any hoarding, frame, post, kiosk, structure, neon signed or sky-sign, erected or exhibited illegally for the purpose of advertisement on any land within the East Kolkata wetlands.
c) To make an order to prevent, prohibit or restrict any mining, quarrying, blasting or other operation of like nature, for the purpose of protecting or conserving the East Kolkata wetlands.
d) To take measure to abate pollution in the East Kolkata wetlands and conserve the flora, fauna and biodiversity in general.
e) To prepare action plans conforming to the resolutions taken and recommendations made from time to time under the Ramsar convention and update the land use maps of the East Kolkata wetlands.
f) To implement and monitor the activities specified in the action plans.
g) To promote research and disseminate findings of such research among the stakeholders.
h) To raise awareness about the utility of the wetlands in general and the East Kolkata wetlands in particular.
i) To promote basic conservation principles like sewage fed pisciculture and eco-tourism in the East Kolkata wetlands.
j) To enforce land use control in the substantially water body oriented areas and other areas in the East Kolkata wetlands.
k) To detect changes of ecological character and in land use in the East Kolkata wetlands.

CONCLUDING REMARKS

Based on above discussion it is quite understandable that East Kolkata Wetlands need proper conservation and management measures which have been already initiated by the State Government. Preparation of the Management Plan has already been started where focus will be given on: 1) conservation of biodiversity, 2) improvement of livelihood of local people, 3) management of wetlands complying the Ramsar Convention guidelines.

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