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Biodiversity, traditional practices and sustainability issues of East Kolkata Wetlands: A significance Ramsar site of West Bengal, (India)

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ABSTRACT

The East Kolkata Wetlands (EKW), an important Ramsar site situated on the eastern fringes of the Kolkata city, India, form a part of the extensive inter-distributory water networks of the Gangetic Delta. The 12,741-hectare area is a part of the lower deltaic plain of the *Bhagirathi–Ganga* river system and is generally flat in nature. It serves as a 'Natural Kidney' for Kolkata, receiving 250 million gallons of anthropogenic wastewater daily and has the capacity to remove around 237 kg. of BOD per day. The resource recovery systems developed by the local people through the ages has saved Kolkata city from the costs of constructing and maintaining wastewater treatment plants. It is the largest ensemble of sewage fed fish ponds in the world and also very rich in biodiversity and genetic resources. 74% of the working population of the adjoining areas depends on fish farming, agriculture and horticulture for their survival. Urban expansion, industrial pollution, siltation, weed infestation and the changed land use patterns are continuously damaging the ecological health of EKW. Implementation of sustainable policies can maintain the ecological equilibrium of these valuable water bodies, which, in turn, can enhance social, environmental and economic security of Kolkata in future.

KEYWORDS

Wetland;
Biodiversity;
Wastewater;
Pollution;
Sustainability.

INTRODUCTION

Wetlands are ecotones or transitional zones that occupy an intermediate position between dry land and the open water bodies. Water is the main dominating factor for controlling the unique characteristics of wetlands. The three main features of wetlands are: (1) groundwater at the surface or within the soil root zones (2) specialized wetland vegetation (hydrophytes), and (3) hydric soils. They execute both the characteristics of the terrestrial and aquatic ecosystems and also have some unique characteristics of their own. In most parts, they are covered with water either temporarily or permanently. With the help of the incoming solar radiation and existing nutrients, varieties of plants can flourish in the wetlands, which, in turn, can support the lives of secondary and tertiary producers[12]. India by virtue of its extensive geographical and climatological variations can support a rich diversity of inland and coastal wetlands which harbour rich biodiversity.

Ramsar is a city in Iran where the first World Convention on Wetlands was held on 2 February 1971. India has been a participating country in Ramsar Convention since 1981 and has important activities for the conservation and wise use of wetlands. The main focus of the first Ramsar Conference was largely on the role of wetlands as waterfowl habitat. Over last 30 years, the perception of Ramsar convention has undergone significant changes[12]. The convention gradually followed the holistic outlook of wetland management that includes fisheries, tourism, bio-diversity conservation, waste recycling, pollution mitigation etc. The universally accepted definition of wetlands according to the Ramsar Convention is: 'Wetlands are area of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres'[17].

The social, economic and ecological values of the wetlands are increasingly receiving due attention as their ecological contributions are significant for maintaining a healthy environment in multidimensional ways. They can perform numerous valuable functions such as nutrient recycling, water purification, ground water recharge and sustainable sources of drinking water, flood management, stabilization of coastal areas and soil, biogeochemical cycles functioning, carbon sequestration and also the sources of biological and genetic resources[16]. They retain water during dry periods and can keep the water table high and relatively stable. They can mitigate flood by trapping suspended solids and attached nutrients. Chemical conditions in the soils and water allow proper cycling of nutrients[15]. The nutrients can be used by plants for growth or can be released into the atmosphere as well. Wetlands are also important feeding and breeding grounds for wildlife and can provide ecologically sound habitats for maintaining species diversity[16]. The negative interactions of man with wetlands during the last few decades have been of serious concern largely due to the rapid population expansion, industrial development, unsustainable resource exploitation and pollution. More than 50% wetlands of the world have been destroyed in the 20th century, especially in developing countries, largely due to of industrialization.

The East Kolkata Wetlands, situated on the eastern fringes of the Kolkata city, India, form a part of the extensive inter-distributory water networks of the Gangetic Delta. It has been designated as 'wetlands of international importance' in November 2002 by the Ramsar Convention on Wetlands on the basis of wise use to produce a range of goods and services, sustainable and eco-friendly system of sewage treatment and a habitat for diverse flora and fauna including waterfowls[12].

LOCATION, HISTORY AND CLIMATE OF EAST KOLKATA WETLANDS

Kolkata can be considered as ecologically subsidized city for its two special geographical features. One is the existence of the Hooghly River on the west and the other is the vast low lying area on the east towards which the city is inclined and plays the role of a sink. The wetland area exists approximately between latitudes 22º25' to 22º40' north and longitudes 88º20' to 88º35' east[14]. The wetlands system is the example of the largest and perhaps the oldest integrated resource recovery practice of the world which based on a combination of agriculture and aquaculture practices. Over 20,000 low income and economically marginalized families depend on the various biological products of the wetlands including fish and vegetables for livelihood[12].

The East Kolkata Wetlands are basically a part of the mature delta of the river Ganges. The process of land formation in this region has largely been influenced through centuries by the Ganges river system where upland and tidal depositions continue to create land. The tributaries and distributaries of the river were active in this area many years ago. Before the establishment of Calcutta, the salt-water lake formed here was a backwater swamp and spill area of the *Bidyadhari* river[10]. Before 1830, these low-lying regions were utilized for cultivation of brackish water fishes such as Bhetki (*Lates calcarifer*), *Parse* (*Mugil parsia*), *Bhangar (Mugil tade*) and Prawns *(Macrobrachum rosenbergii)*[11]. Until 1830, the *Bidyadhari* river was an active navigation route which helped to connect Bay of Bengal with Kolkata[7]. The tidal flow from the Bay of Bengal was the main source of salinity in water in these areas. With the death of the *Bidyadhari* river, the process of natural silt deposition and raising the level of the spill area completely stopped since the end of the

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19th century[10]. Anthropogenic activities further reduced the spill area and the channel beds. This led to the formation of the vast saltwater marsh to the east of Kolkata between the levee of the Hugli on the west and the Kulti Gong on the east[11]. During early days of settlements, the British people were very active about transportation of goods for commercial purpose from the hinterlands of Bengal (like Assam, Chandpur, Khulna, Dhaka or Barisal). Over a period of time, to support the waste management systems of the Kolkata city, the East Kolkata Wetlands transformed from brackish water lakes to sewage fed fish farms and the large areas were converted for human settlements and agriculture development[12]. With the diversion of city sewage and storm water into the salt lakes and the deterioration of river Bidyadhari there was a gradual decrease in salinity in the aquatic environment[12]. For the expansion of the urban area in the post independence era, 1,000 ha of the northern portion of the wetlands were used for establishment of the Salt Lake City. The gradual reduction in area within the wetlands for economic and social purposes has reduced its capacity to recycle wastes and to attenuate floods. Despite having a large direct catchment of 1,625 sq km (including the basins of *Kulti, Piyali Bidyadhuree, Adiganaga* rivers), the wetland inflows are mainly controlled by the sewage generated from the Kolkata Municipal Corporation (KMC)[19].

The hot, monsoon climate of the East Calcutta Wetlands is largely governed by the North Himalayan mountains, the North-eastern Meghalayan plateau and the Bay of Bengal[14]. The climate of the East Calcutta Wetlands broadly resembles that of Kolkata City. Temperature remains high throughout the year in the wetlands with minor variations and the climate resembles the features of a tropical region with sufficient sunlight and vast water regime[14].

BIODIVERSITY OF EAST KOLKATA WETLANDS

Wetlands are the rich sources of biodiversity. Varieties of plants and animals including birds, mammals, reptiles, amphibians, fish and invertebrate species can flourish in these ecologically favourable habitats. It has been estimated that freshwater wetlands hold more than 40% of the entire world's species and 12% of all animal species[20]. Individual wetlands can be extremely important in supporting high numbers of endemic species.

Over last hundred years or more, the East Kolkata Wetlands have undergone drastic changes in floral and faunal diversity in response to changes in salinity regimes. The wetland once supported a rich floral and faunal diversity when connected to the freshwater and tidal regimes. Over the years, changes in salinity, land use-land cover, industrial pollution and other developmental activities, the species diversity has been reduced significantly[8].

Wetland is a complex and dynamic environment in which biological activity is mostly governed by microorganisms. The beneficial effects of wetland microorganisms can be executed in multidimensional ways such as nitrogen fixation, organic matter decomposition, breakdown of metabolic by-products and agrochemicals, enhancing the bioavailability of nutrients and essential metals[13]. Studies revealed that East Kolkata wetlands have varieties of microbial population with diverse genetic characters including spore formation for stress adaptation, versatile enzymatic and metabolic activities, high pH and temperature tolerance, nitrogen fixing abilities and the capacity of bioremediation of different toxins, heavy metals and pollutants[13]. A few examples of the microbial population include *Rhodococcus sp.*, *Bacillus sp.*, *Pseudomonas sp.*, *Azotobactor sp.*, *Aeromonas sp.* etc. Plant roots grown in these areas release compounds including simple sugars, amino acids, aliphatics, aromatics that can stimulate the growth and metabolism of specific microbial communities which accelerate the bioremediation processes[13].

In the early phase of the 20th century, 70 species of plants were recorded from various zones which were distributed within embankments (*Fimbristylus ferruginea, Suarda maritime, Acanthus illicifolius, Excoecaria agalocha, Avicennia officinalis*), main wetland (different species of algae, *Phragmites karka, Aegiceras majus, Typha elephantine* etc.) and terrestrial area (oligihaline and mesohaline shrubby plant species and several halophytic trees like *Sonnerata apetala, Avicennia officianalis*)[2,5] recorded 97 plant species among which, 34 species were confined to saline water habitat. He also mentioned the existence of mangrove plants in these regions. This study strongly indicated the presence of saline condition in the wetlands which has changed through time. A recent study,

however, reported 106 aquatic plants belonging to 70 genera and 36 families. Among the vegetations, there are very few submerged vegetations remain in the core fishing area except the plankton communities.

East Kolkata wetlands harbour variety of economically important plant species. Some of these plants have rich medicinal values and have been used traditionally by the local communities over a long time. Besides several plant species such as *Bacopa monnieri, Enhydra fluctuans, Ipomea aquatica, Marsilea minuta* are used as vegetables by the local communities[12]. *Cyperous rotundous, Phragmities karka and Typha angustifolia* are used by the local communities for thatching as well as for pulp, fiber and other uses. Several aquatic plants are used as green compost and manure apart from their utilization as fish food and for water purification[8].

Previously the fish fauna in the East Kolkata Wetlands system included both brackish water and fresh water forms. The low-lying regions with saltwater lakes were ideal for farming of brackish water fishes. Among the cultured fishes, *Bhetki* (*Lates calcarifer*), *Parse* (*Mugil parsia*), *Bhangar* (*Mugil tada*) and Prawns (*Macrobrachium rosenbergii*), etc. were common[11]. Indigenous species *Nandous nandus* and *Xenentodon cancila* were abundant during 1980s in these wetlands, but now no records found in support of their existence. Presently, in the *Bheris*, Poly-culture is practiced by the farmers and includes three species of Indian major carps (*Labeo rohita, Catla catla and Cirrhinus mrigala*) along with one minor carp (*Labeo bata*), three exotic carp (grass carp, silver carp and common carp) and two types of Tilapias[12]. However, the presence of invasive exotic fish species is posing great threats to the native fish diversity[12].

The amphibian diversity in the wetlands is rather low and only 4 species recorded so far. The reptiles available include 19 species and are mainly water snakes, monitor lizard, common lizard and fresh water tortoise[6]. The invertebrates, lower vertebrates including fishes and amphibians are the sources of food for the reptilian species.

Zoological Survey of India studied a total of 248 bird species (90 aquatic, 11 semi aquatic and 147 terrestrial species) in East Kolkata Wetlands[10]. About 50% of the aquatic birds were reported to be migratory. The common water-birds of these areas include Cormorants, Herons, Gulls, Terns, Egrets, Snipes etc.[10]. However, the changed environmental conditions over the years have resulted in absence of larger species of birds like the Openbill Stork, Spoonbill, some species of ducks (e.g. Brahminy Duck, the Comb Duck), Red crested Pochard, Tufted Pochard etc.[8]. Additionally, the predator birds like Brahminy Kite, Osprey and Laggar Falcon, Vultures etc. which were the common inhabitants in recent past are now no longer seen. The populations of Gadwals, Garganeys, Snipes, gulls, Terns, Egrets and Cormorants are also declining in population because of lack of niche due to reclamation and hunting, lack of food and overuse of chemicals in agriculture and fisheries[1]. It was also reported that 109 species of birds have become locally extinct, majority of which includes aquatic birds.

The mammal communities include marsh mongoose, an endangered one, which borrows along the slopes of water bodies and eat fishes and aquatic snails in the wetlands[10]. The species however, faces main threat due to habitat loss. Conversion of large parts of wetland areas into aquaculture ponds which are mostly devoid of vegetation is a major stress to foraging of this species. Besides, Common jungle cats, foxes, house rats, and mice are common inhabitants in these areas. Among the rare mammals, small Indian mongoose, palm civet, and small Indian civet are significant in and around the East Kolkata Wetlands[10].

WASTEWATER UTILIZATION AND WASTE RECYCLING IN EAST KOLKATA WETLANDS

Among the Ramsar sites of international significance, East Kolkata wetlands are unique for the wise use of sewage water, mainly for fish cultivation and irrigation for garbage farming. The wetlands consist of about 170 sewage fed fisheries that covers about 7000 acres of areas. The local name of the fish ponds is *Bheri*, which are shallow flat bottomed wastewater fed lagoon type of ponds and the size vary between 40–50 ha with 50 – 150 cm in depth[1]. The entry of the increasing volume of sewages from Kolkata city into this area helps to decrease the salinity which is ideal for pisciculture. The Kolkata Municipal Corporation area generates about 600 million litres of sewage and waste water every day and more than 2500 metric tons of garbage[1].

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The wastewater is led by underground sewerage systems to the pumping stations in the eastern region and then pumped into open channels. The sewage and waste water is drawn into the fisheries of east Kolkata wetlands, where within few days, biodegradation of the organic compounds of the sewage and waste water take place. Retention of wastewater in the ponds before the initial stocking of fish for a considerable period of time allows bacterial population to metabolize the organic matters of the sewage and to decompose the organic wastes[12]. The growth of these beneficial bacteria is supported by the algae that thrive in these shallow ponds in presence of sufficient sunlight. The biochemical reactions occurring in the wastewater ponds include photosynthesis, aerobic oxidation, organic acid formation, methanogenesis, nitrification and denitrification[1].

The basins of the *Bheris* are shallow which allows full vertical circulation of water to the surface where algal blooms occur. This is highly favorable for photosynthesis, as this depth gives a better ratio between pond volume and pond surface than a deeper pond. This helps to create sufficient oxygenation, which, in turn, can reduce BOD (Biological Oxygen Demand) and faecal coliform load[8]. The photosynthetic activity in the pond is one of the reasons for the purification of sewage. The water from the Raw Sewage Canal is drained into the *Bheris*, where it undergoes purification before being used for irrigation. The water hyacinths grown in these areas have also major role in water purification and stabilization. They can leach out heavy metal ions from the contaminated water as their roots are efficient absorbers of heavy metals present in sewage water[1].

This system supports the recycling of the wastewater as well as the fish cultivation. The fishes maintain proper balance of the plankton population in the ponds and also convert the available nutrients of the wastewater into readily consumable form (fish biomass) for human consumption. Kolkata city receives about one third of its daily requirements of fishes from the sewage fed fisheries of the East Kolkata Wetlands[8].

Another system of waste recycling in the East Kolkata Wetlands is the use of garbage and waste water as manure and water for irrigation in paddy and for vegetable farming. The old solid waste dumping grounds have been converted into cultivable lands. The garbage farms can produce 150 tonnes of vegetables daily and the paddy fields can produce 16,000 tonnes of winter paddy varieties cultivated during post monsoon period annually. Different varieties of green leafy vegetables like *Amaranthus caudatus, Amaranthus blithum* and *Spinacia oleracea* are cultivated in these areas[12].

Livelihoods of the East Kolkata Wetlands communities are distinctly linked to wetland resources. About 74% of the local working population depends on fish farming, agriculture and horticulture in these areas[12]. These creative and sustainable practices are developed by the local people and have been carried over generation after generation. These wetlands have been preserved and nurtured by the local communities, mostly belonging to the poorer and weaker sections of the society. These wetlands execute one of the biggest examples of low cost alternatives in municipal waste management that can ensure sustainable recovery of nutrients available in waste.

THREATS TO EAST KOLKATA WETLANDS: FEW OBSERVATIONS

In spite of being the only Ramsar site in West Bengal, the East Kolkata Wetlands are now facing several natural and anthropogenic stresses which altogether can lead to social, biological and economic degradations of the water bodies and adjoining areas. Some possible threats are discussed below:

A.) Unsustainable use of groundwater in the East Kolkata Wetlands due to rapid urbanization, agricultural and industrial development has posed a risk of land subsidence. The subsurface geology of the area consists of quaternary sediments comprising a succession of clay, silty clay and sand layers of various grades[19]. Groundwater occurs mostly under confined conditions except in those places where the top aquitard has been obscured due to the scouring action of past channels. Currently, the hydraulic head shows a falling trend and it may be accelerated due to further overuse of groundwater, which, in turn, may lead to land subsidence. The groundwater of the East Kolkata Wetland areas should be developed cautiously based on the groundwater potential to minimize the threat of land subsidence[19].

B.) There has been a progressive shift in the land use within the wetlands leading to a gradual dominance of agriculture, which accounts for around 40% of

the wetland areas. The areas under fish farms have reduced from 7,300 ha in 1945 to 5,842 ha in 2003. Construction of fish farms bunds and roads within the fish farms have further reduced the effective area under waterbodies to 2,481 ha. The gradual reduction in hydrological regimes within the wetlands has reduced its capacity to recycle wastes and attenuate floods[12].

C.) There has been a rapid change in biodiversity associated with the wetlands due to changes in hydrological regimes and land use. Similarly, there has been significant loss of floral diversity, particularly those of mangroves and other brackish-water species. The local population depends on the vegetations of the wetlands for food, some of which are threatened due to environmental and anthropogenic stresses. The disappearance of these plant species will surely affect the food security of the low income local inhabitants in future.

D.) Increasing concentrations of heavy metals in the sewage used in the wetlands attributed to unregulated discharge of industrial pollution poses a major threat both to the ecosystem as well as to the local communities. Several researchers have showed that some plants and animal species including fishes can bioaccumulate the heavy metals like chromium, lead, mercury etc. from the wastewater and industrial effluents of the East Kolkata Wetlands, which can create health hazards[3]. However, some researchers also reported that the accumulation level is not significant enough to for creating health hazards[3].

E.) Increasing siltation in the canals and fishponds has subsequently reduced the quantity of sewage flowing to the fisheries and made many of the fish ponds much shallower; which, in turn, have declined the fish production.

F.) While environmentalists are giving efforts for the preservation of the East Kolkata Wetlands, profit intensive people are increasing pressure for the right to develop areas for residential and industrial purposes. The wetlands are very close to Kolkata city, and The Eastern Metropolitan Bypass has made the area accessible and Salt Lake City apparently provides additional social and economic infrastructures. It is becoming difficult to protect the wetlands from developers and real estate agents. Public agencies have also shown a tendency to encroach upon the wetland areas for various developmental activities such as establishment of industries, commercial hubs or public utilities. It is increasingly apparent that the existing legal provisions and agencies responsible for implementing them are unable to prevent such encroachment. Constructions in the wetland areas can eventually hamper the recharging of the groundwater and can also increase the incidence of flood. Development can also cause fragmentation of east Kolkata wetlands, which will increase social, ecological and environmental imbalances in local areas.

G.) The sewage fed fisheries of the wetlands has been constrained due to inadequate management of water regimes, technology integration and weak marketing, post marketing and value addition opportunities. Management inefficiencies such as failure to properly maintain sluice gates and to run the pumping system, regulating the storm weather flow and the dry weather flow channels of the Kolkata drainage system in line with the requirements of farmers in these areas is gradually collapsing the system. The current farm management systems are executing a biased outlook towards the large private farmers and against the small and medium size cooperatives.

SUSTAINABLE MANAGEMENT OF THE EAST KOLKATA WETLANDS: KEY ISSUES

It is the need of the hour for our society to stop further deterioration of the East Kolkata Wetlands and to protect and restore their original characters. Inappropriate understanding of the significance of these wetland practices has led to gradual loss of system efficiency. Based on assessment of hydrological, ecological and socio economic aspects and analysis of management practices, following key issues have been identified to for the conservation and management of East Kolkata Wetlands:

A.) For proper maintenance and functioning of the wastewater recycling process in the wetlands, all drainage channels and distributaries within the wetlands should be brought under a comprehensive action plan and restoration of the vital drainage structures is essential. Desiltation of the inflowing sewers can enhance water circulation and flushing

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in the wetlands systems. Improved waste segregation, proper handling of wastes and sustainable waste management strategies can help to mitigate pollution in the landfill areas.

B.) The industrial effluents, especially those released from the nearby tanneries, can cause undesirable impact on the fish and vegetables grown in the wetlands. It is essential to identify such industrial units and to bring them under the strict regulations of pollution control. Common in-situ effluent treatment plants for the polluting industries can be effective for mitigating the pollution problem.

C.) Farmers should be provided with a list of safe species that can be grown in the garbage farms in these areas and the extent of food chain contamination of heavy metals and industrial pollutants through different species should be evaluated in details for human health security. Focus should be given on proper identification and scientific uses of the bio-indicator species of these wetlands and the applications of the species in pollution management. Hyperaccumulators of the pollutants should be cultivated in the contaminated zones to remove the same. Restriction should be imposed for using insecticides, pesticides and other harmful chemicals in culture ponds of threatened species.

D.) A detailed biodiversity and genetic database of the wetlands should be made, which, in turn, can give the scope for using varieties of resistant and tolerant genes for research purposes. Isolation and culture of microbial strains will be beneficial for implementing bioremediation strategies. Comparative vulnerability studies of the wetland species will help to implement preferential conservational strategies based on the degrees of sensitivities. Applications of biotechnological and microbiological research methods along with the applications of remote sensing and GIS are essential for these studies.

E.) Populations of all breeding waterbirds species should be increased through improvement of breeding habitats and conditions. Proper understanding of population dynamics, feeding habits, and specific requirements of key bird species is essential for their conservation. Focus should also be given on the conservation of native and endemic species, including the fishes cultured in the fisheries.

F.) Enhancing the water use efficiency in irrigation systems, diversification of cropping patterns in the wetlands areas and the implementation of rainwater harvesting structures in agricultural fields can stabilize the groundwater system and also can enhance the water security of the local people.

G.) The main objectives of the management plans should focus on ecosystem conservation, sustainable resource development and livelihood improvement. Institutional development, communication, education and public awareness are also the key management components which will promote sustainability. Ecotourism development and enhancement of the social and economic security of the local people is essential for proper execution of the holistic outlook of wetland conservation.

CONCLUDING REMARKS

Unfortunately, in spite of important progress made in recent decades, wetlands continue to be among the world's most threatened ecosystems. Development as expected has increased consumerism in a small section of the society, but it has degraded and depleted invaluable natural resources like wetlands. Wetlands functions, values and attributes can only be maintained if the ecological processes of wetlands are allowed to continue functioning. East Kolkata Wetlands system is a unique example of environmental protection and development management that is in harmony with nature and benefits are achieved at a much lower cost. Knowledge about development and environment is not enough, rather the upsurge of the common people and pushing the principles of environmental security and justice are extremely important to conserve this important Ramsar site of West Bengal.

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