Reason- A Technical Journal
ISSN 2277-1654
Volume XIII • 2014

MAN-MADE ENVIRONMENTAL DEGRADATION AT SUNDERBANS

Dr. Gautam Kumar Das[1] and Prof. Siddhartha Datta[2]

[1]Honorary Researcher. Email: sunderbans@hotmail.com
[2]Past Pro-Vice Chancellor & Professor
Department of Chemical Engineering, Jadavpur University, Kolkata-700 032.

Paper received on: October 11, 2014, accepted after revision on: February 17, 2015

Abstract: The vibrant ecosystem of Sunderbans with its lush green mangrove forest, various types of aquatic species including many rare endemic flora and fauna, birds, crocodiles and the famous Royal Bengal Tiger is a unique Biosphere Reserve. Unfortunately such a productive ecosystem is now exposed to threats of extinction. Besides the natural global phenomena, the land degrading anthropogenic activity is one of the prime factors for this ecological decline. In a forest-society interface, unplanned over exploitation of natural resources is very common. In the case of Sunderbans also, as a result of continuously increasing population pressure almost half of the mangrove forest have been cut down to supply fuel wood, land reclamation for settlement and aquaculture and various other purposes. The situation has become precarious as there seems to be a striking imbalance between exploitation and replenishment, thereby making the ecosystem most fragile. Indiscriminate prawn seed collection, refuse and sewerage discharge from urban areas, spillage of toxic pollutants as well as trashes in the tourist spots of Sunderbans are other anthropogenic factors responsible for environmental degradation of the area. Suitable strategies for the conservation and maintenance of optimum ecological condition of this unique biodiversity have to be planned involving local people, Government and other social organizations.

Key Words: Sunderbans, mangroves, prawn seeds, shell fish, fin fish, Bidyadhari River, Royal Bengal Tiger.

1. INTRODUCTION

The rich resources of the estuarine and coastal waters are under tremendous pressure not only because of polluted sewage thrown by the man made canal into the Bidyadhari River waters, but for extensive overfishing in the river waters of the Sunderbans. The capture of the post larval penaeid prawns that are potentially quite high and commercially exploitable from the salt water courses of the deltaic Sunderbans even just a decade ago are presently showing a dwindling trend. The fishing pattern of the post larval stage of penaeid prawns along the marginal waters of salt water courses of the deltaic Sunderbans caused further hazards in the form of bank erosion and impediment in nutrient recycling. The fringy mangrove belts which act as the chief source of nutrient supply to these water bodies thus seem to be severally affected both by natural and human activities.

In addition to that the domestic sewage of Kolkata metropolis and the industrial effluents from East Kolkata released on the regular basis in to the river waters of the Bidyadhari through different canals that ultimately flows to the Sunderbans mangroves zones is the other problem. Mangroves are sensitive to these different types of pollutants which are significant threats to the mangrove ecosystems. Mangroves are further sensitive to oil spills released by the mechanized fishing boats. Vegetations of the Sunderbans are found to be

susceptible to pollution in the form of floating oil, as because it deposits on mangrove roots when the tide drops and contaminates the sediments. Mangroves suffer from suffocating or toxic effects of the oil, or from the dwelling of burrowing animals. The incidence of tiger straying almost regularly for the gradual decreasing of the forest land including Phoenix bushes and the dense jungles, the unique denizen for the Royal Bengal tigers is another effect of the anthropological interferences.

2. PRAWN CAPTURES

Salt water courses of the deltaic Sunderbans are zones of high potential so far as captures of prawn seeds are concerned. However, during last couple of years the dwindling trend is observed regarding the prawn seed capture in this zone. The fishing pattern of the post-larvae stage of penaeid prawns along the marginal waters of the rivers of the Sunderbans caused further hazards in the form of bank erosion and impediment in nutrient cycling. The situation is further aggravated as large numbers of brackish and marine fishes are encountered in this process along with the rampant exploitation of the prawn seeds. Geomorphic mapping of the river catchment areas of the Sunderbans has been done on the basis of the toposheets of the Survey of India. All the physical and chemical parameters of the soil and waters are estimated following standard methods. Statistical surveys of the collection pattern of the prawn seeds are undertaken from different collection centers of Sunderbans. Rising scarcity of prawn seeds leads to sharp increase towards expenditure per person for harvesting of the 1000 seeds per day. There is a decreasing trend in the rate of mortality of the prawn seeds. With passage of time number of seeds transported to different fisheries has also been depleted considerably, sometimes to the tune of tenfold as evidenced from the data of 1998 and 2010. The proliferation of the prawn seeds requires favourable physico-chemical, compositional and textural parameters of sediments, geomorphology of the drainage system and tidal cycles within them. Data reveal that the destruction of the encountered species disturbs a bulk of the population of the coastal water biotic community and as a consequence brings about an imbalance in the food webs on the water dwelling biota and enormous stress because of rampant exploitation.

The mangrove belts of Sunderbans which act as the chief source of nutrient supply to those water bodies also get badly affected by artificial means of fishing in addition to natural hazards arising from meteoric storms and cyclones. The author has tried to identify and delineate the geomorphic situations and other physico-chemical environments that control the prolific occurrence of the post-larvae of prawns in the rivers of Sunderbans which are later used for culture in brackish water coastal fisheries. Certain management measures have been proposed to safeguard the disaster following approaches related to morphological and hydrodynamic appraisement.

3.ENVIRONMENTAL REQUIREMENTS FOR HABITAT

- Salinity ranges between10 and 25 parts per thousand (ppt).

- Optimum temperature range for good growth and survival rates of tiger prawn is 25-30°C.
- Minimum acceptable Dissolved oxygen (DO) level is 3-4 mg/L.
- Water pH of 5 and below is lethal to prawns like tiger prawns. pH range of 7 to 8.5 is optimal for growth and development of prawn.
- Presence of Hydrogen Sulphides (H_2S) and low Dissolved Oxygen (DO) level are detrimental to their survival as tiger prawns are the bottom dwellers [1].

3.1. Sediment Composition

The penaeid prawns are detritus feeder and so the detritus inherently present in the sediments has a vital role for their growth and proliferation. The detritus materials are recycled through physical and biological processes. Compositionally, the sediments collected from the river flood plains composed of both lithogenic (85-90%) and biogenic (10-15%) components and dominantly made up of quartz, mica, rock fragments and clay minerals. Texturally sediments are mostly silty (90%) with subordinate fine sand and clay constituting the rest.

3.2. Physico-Chemical Control for Sustainability of Prawn Seeds

The physico-chemical parameters like salinity, water depth, light penetration, pH, total organic matter, nutrient concentration (NPK) etc control the growth and proliferation of penaeid prawn seeds. The study area typically belongs to the tropics with average maximum temperature of winter and summer months ranging from 20^oC to 35^oC respectively, the annual rain fall between 1900 and 2100 mm. The sediment salinity of the study area of Sunderbans ranges between 4.93 and 5.8 ppt and the pH is slightly alkaline ranging between 8.0 and 8.3. Chemical analyses of the collected sediments samples reveal that the available nitrogen (Av.N) ranges from 880 to 1540 kg/ha, available phosphorus (Av.P) varies from 11.4 to 26.0 kg/ha and available potash (Av.K) ranges from 2083 to 2957 kg/ha. The organic Carbon shows a range between 0.38 and 0.69% and the total organic matter in sediments ranges from 0.66 to 1.19%. It is found that the ambient environment supplies the plenty of nutrients that requires for the natural growth of mangroves of the Sunderbans [2]. Water salinity varied from 18 to 25 ppt as compared to the water temperature 18 to 21^0C during post-monsoon session. The pH values remained almost constant ranging from 7.3 to 7.7. The dissolved oxygen (DO) content varied from 3.0 to 7.2 mg/L. Monsoon season shows a marked difference in the hydrological parameters from other seasons due to heavy rainfall and land run-off.

4. GEO-HYDROLOGICAL CONTROL RELATED TO CAPTURE

Geo- hydrology of the rivers of Sunderbans controls the density of occurrence of prawn broods and the related fishing methods practiced along the salt water courses of the deltaic Sunderbans. Geomorphology of the drainage systems has tremendous role over population density of penaeid prawns in specific zones of the typically meandering saline or brackish water courses. The longitudinal flood and ebb-flows and the transverse helicoidal flows

in meandering systems also add to the drifting behaviour of the prawn seeds (Fig. 1). The complicated process of hydrodynamics and sediment supply in meandering water courses regulates deposition of point bars on the inner convex banks erosion scarps on the outer concave sides.

The phenomena of undercutting on the outer concave banks and subsequent collapsing bring about a constant modification of the river morphology by laterally shifting its course. On the other hand, mangrove forests commonly fringe the natural levees and the upper reaches of intertidal point bars of the river and help stabilization of the river courses. The seasonal shading off litters is carrying out constant recharging of nutrients in the water by the mangrove plants. Field observations reveal that areas of marginal waters up to a depth of 2m along the erosional, outer concave banks of the rivers are more suitable for the potential occurrence of the penaeid larvae. The association of mangrove forests in the nearby areas plays a significant role contributing the nutrients in the ambient waters [2].

5. SEED AVAILABILITY

Thakuran, Jhilla, Bidya, Saptamukhi rivers yield lower percentage (64 – 69%) of shell fish seeds, mullets (7-8%) and thread fins (3-5%). The contribution of miscellaneous species is naturally higher (15-24%) in these river estuaries. The annual average of fin and shell fish seed catch is 10,077 nos./net/day of which 65-75% is comprised of shell fish, 3-5% tiger shrimp and 20-30% fin fishes. The peak period of seed availability particularly for the period from June to September recording average total catch between 9750 nos./net day and 19,110 nos./net/day of which tiger prawn between 377 nos./net/day and 960 nos./net/day. Availability of seeds remains almost constant in the rest period of the year in the estuarine Sunderbans.

6. SEED COMPOSITION

The seeds available in the river waters are composed of fin and shell fish seeds in the estuarine Sunderbans (Table 1). About 72% shell fish species, 10% mullets and 7% thread fins are the principal constituents of the seed composition. The other species contributing the total seeds collected from the system are T ilisha (0.3%), L. calcarifer (0.9%), M. gulio (1%), H. neherius (1%), T. jarbua (0.5%) and miscellaneous (8%).

7. DRIFTING PATTERN

The post larvae of prawn swarms appear in coastal waters and move shoreward up to two weeks in their post larval stage. They continue migration towards mangrove swamps and other brackish water salt marshes, which serve as their nurseries or feeding grounds [3]. The species are omnivorous and feed at the bottom of the muddy swamps and marshes. This is evidenced by the presence of very minute vegetable and animal matters and detritus constituents in their guts. Because of their detritivorus feeding behaviour the seeds occur abundantly along margins of the river point bars often girdled by fringing mangroves. The point bars are generally accretionary where loose sedimentary particles are reworked by every tidal cycle. The typical helical flow in the meandering channel systems help drifting the prawn

seeds from these accretionary zones towards the opposite erosional portions of the meander bends [4]. Being planktonic, the seeds are also drifted by the dominating tidal currents.

8. DIFFERENT PHASES OF PRAWN SEEDS (P. monodon)

SPAWNING: Mating of Penaed soon after molting is occurred. As the mature female lays the eggs, the spermatophores stored in the seminal vesicle are simultaneously released and the eggs thus fertilized.

METAMORPHOSIS OF PRAWN

NAUPLIUS: The eggs of P monodon hatch into nanplius within about 13 to 14 hours after spawning, which feed on the yolk, stored in the body and do not feed on an external diet.

ZOEA: Nauplius transform in to zoea in 36-37 hours after hatching. They feed on planktonic larvae. The body length of zoea varies between 0.092 mm to 2.24 mm from 1st to 3rd stage.

MYSIS: When zoea molts for the 3rd time and changes into mysis, the morphology resembles that of adult prawns. They feed on planktonic larvae and then transform into the post larval stage.

POST LARVAE: Mysis molt three times in 3 days and transform into the post larval stage. When the post larvae molt 10-12 times, they are able to move on sand like the adult prawns. Again, larvae, which have molted about 20 times, are called juvenile prawns.

9. COLLECTION METHOD

Generally drag net is used in the lower reaches of the Sunderbans for P. monodon fry collection. It is a rectangular net of length 3.0 m and width 1.5 m, made of fine nylon net clothes. All four ends of net are firmly stitched around a rectangular split bamboo frame (1.25 ×0.75 m). Both ends of the net are attached to a long nylon rope and one-person generally teenage girls holding both nylon ropes together and dragging the net from behind and operate the net in the shallow water areas. The nets are generally operated in waist-to chest deep water. Sometimes prawn seeds are collected through stationary gears by operating nets from the country boats (Fig. 2).

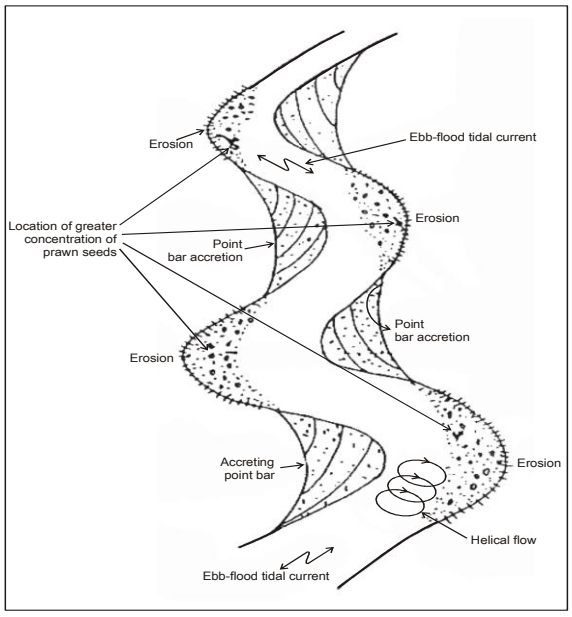

Fig. 1 Meandering course of river showing erosion and accretion sites and related concentration of prawn seeds

10. ENCOUNTERED SPECIES

The total number of encountered species belonging to the shellfish and finfish has been given in Table 1. Of the total important 23 species 5 fin fishes (Leiognathus daura, Liza sp., Corica soborna, Trypanchenicthys suratensis and Stolephorus sp.) and 3 shell fishes (Metapeneus lysianassa, Metapeneus

monoceros and Acetes sp.) appear to be the most dominant encountered species in the present study area. Synthesis of data depicts the year wise variation from 1998 to 2010 of the dominant encountered species against the frequency of the species taking average of three seasons in a year. Data reveal that the destruction of the encountered species during sorting (Fig. 3) disturbs a bulk of the population of the coastal water biotic community and as a consequence brings about an imbalance in the food webs of the water dwelling biota. Though not very pronounced the year wise count of the most dominant species also reveals a declining trend.

Fig. 2 Collection of prawn seeds using stationary gears in the river waters of Sunderbans

11. TRANSPORT OF SEEDS

Large quantities of prawn seeds (P. monodon) are assembled at Nazat in North 24 Parganas District, the biggest tiger Shrimp fry market in the country from various collection centers in the Sunderbans. All the collections are transported by the mechanized boats locally called as vatvati. At first prawn seeds are brought in open containers to market or collection center. The traders purchase the seeds from the collectors in the fry market. Then the fisheries owners or their representatives come to purchase fry. The fry are transported to the far off fisheries after examination of the fry and negotiation of price with the traders.

Table 1 List of the encountered species collected from the trash after sorting from the river waters of Sunderbans

Fin Fish	Shell fish
Setipinna phasa	Metapeneus monoceros
Corica soborna	Metapeneus lysianassa
Anguilla bengalensia	Metapeneus mogiensis
Reconda rusheliana	Parapeneopsis stylifera
Cynoglossus arel	Palaemon (Exopalaemon)
Liza tade	Stylitera
Leiognathus daura	Alphaeus Sp.
Pellonaditchela	Acetes Sp.
Ophisthopterus tardoore	
Coilia dussumiery	
Hilsa ilisha	
Stolephorus bucaneeri	
Neenchelys buitendijki	
Strongylura strongylura	
Trypanchenichthys suratensis	

Thousands of people of Sunderbans under below poverty level have found their income like daily wage system in prawn seeds collections. The Directorate of Fisheries, Govt. of West Bengal reported after their survey in 1991 that fry collectors belonging to 3025 families in the seven blocks of Sagar, Namkhana, Kakdwip, Diamond Harbour, Kulpi, Kultali, and Canning were engaged in this profession of fry collection and annually collected 429.1 millions of prawns fry, 78.3 million of these during lean season. Of these families, more than half had a per capita annual income between Rs. 401 and Rs.1200. On an average they collect about 2500 prawn seeds a day of 8

hours netting operation [1] in the monsoon times.

12. OBSERVATIONS

The monsoon is the best collection season for the prawn broods; pre-monsoon and post monsoon periods come next in succession. The tidal cycle also show a correlation with seasonal yield of the prawn seeds. The ebb-tidal cycles yield the maximum throughout the seasons. Again, in the first phase of flood tides during the pre and post monsoon periods and the entire spring tide period of the monsoon, the yield is quite significant. The rate of seasonal collection and the number of seeds transported to the rearing ponds are just sufficient for their commercial exploitation (Table 2). The following observations seem to be relevant in this regard:

- Despite application of advanced and skilled netting procedures there is a decreasing trend of capture of prawn broods per person per day (Table 2).
- With more and more scarcity in the collection of seeds, amount paid to persons per day per 1000 prawn seeds harvested increases sharply (Table 2 & Fig. 4).
- There is a decreasing trend in the rate of mortality of the prawn seeds (Table 2 & Fig. 5).
- A large number of other species of fin fishes and shell fishes (Table 1) are also destroyed during processes of random exploitation of the prawn seeds [4].
- Number of seeds transported to different fisheries center decreases rapidly to the tune of 1/10th of that in 2010 compared to 1998 (Table 2).

Fig. 3 Sorting of prawn seeds going on after the catch

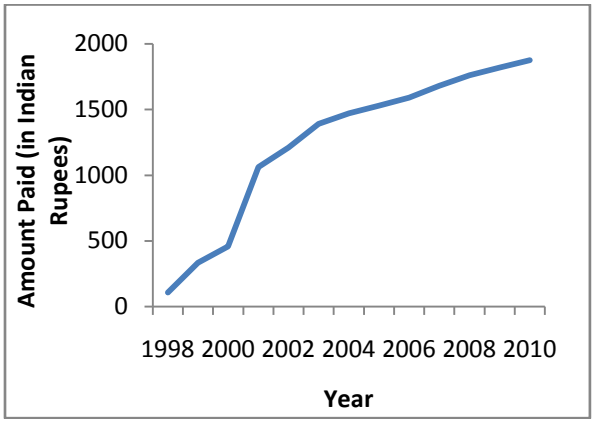

Fig. 4 Annual variations of amount paid to the collectors for 1000 prawn seeds in the collection center

13. MANAGEMENT PLAN

All these deleterious operations are currently continuing in most areas of Sunderbans, which, in turn, during the recent decades, have been bringing about a serious change in the geomorphology and hydrodynamics of the watercourses together with an obvious change in the nature of nutrient recycling. Again, the declining trend in the collection and rate of mortality of the prawn broods may have a direct relation with this unwise fishing method adopted in the sensitive geomorphic zones of the river systems. Thus, the author suggests management plans along to

safeguard these highly productive and biologically sensitive areas.

- A minimum knowledge of salt-water course morphology should be disseminated among inhabitants.
- Data on the hydrodynamics of the watercourses must be collected prior to any attempt towards commercial exploitation.
- Systematic monitoring of the areas is badly needed for maintenance of the bank-binder mangrove saplings and marsh vegetation.
- Textural data of bed material, to the proportion of sand, silt and clay, their sorting and other mass properties should be collected in order to understand the physical properties of the substrate material.

14. IMPACT OF SEED CAPTURE

The geomorphological and geohydrological set up of meandering tidal rivers, creeks and inlets of the Sunderbans also plays a significant role in this regard. The population density of the post larva penaeid prawns and their catch or effective netting areas are mostly confined to the outer concave erosional banks having water depth of less than to the accretionary inner concave banks with point bar deposits. Nutrient recycling from the fringing forests further helps towards their proliferation. The crude fishing technique together with improper knowledge about sensitive sites of fishing needs special attention and motivation for future management. Disturbance in these sensitive geomorphic zones by intervention of the inhabitants of the Sunderbans will not only jeopardize the prawn seed population, but also will bring about severe damage to the water courses leading to bank erosion. Several causes of erosion in these areas include i) felling of immature mangrove plants ii) destruction of newly sapling and iii) activities of man causing undercutting of banks.

Table 2 Annual variation in collection, transport, rate of mortality and amount paid for collection of prawn seeds from tidal rivers of Sunderbans

Year	Avg. No. of seeds captured/ person/ day	Avg. No. of seeds collected/ transporter/ day	Avg. No. of seeds transported from station/ day	Avg. Mortality rate (%)	Amount paid for collection of 1000 seeds (in Rs.)
1998	225	55×10^3	90×10^3	45	106.00
1999	130	28×10^3	84×10^3	28	333.00
2000	105	23×10^3	62×10^3	22	457.00
2001	50	14×10^3	59×10^3	19	1060.00
2002	46	9×10^3	46×10^3	16	1210.00
2003	38	7×10^3	41×10^3	18	1390.00
2004	33	5×10^3	36×10^3	15	1470.00
2005	31	5×10^3	34×10^3	14	1530.00
2006	29	4×10^3	31×10^3	15	1590.00
2007	26	3.2×10^3	19×10^3	17	1680.00
2008	22	2.6×10^3	18×10^3	12	1760.00
2009	17	2×10^3	14×10^3	10	1820.00
2010	14	1.7×10^3	12×10^3	7	1875.00

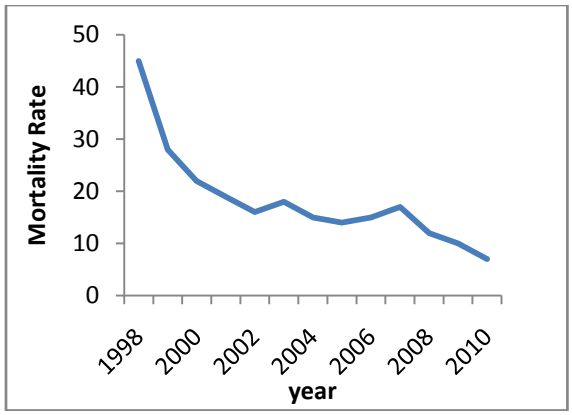

Fig. 5 Average mortality rate of prawn seeds during transportation to the rearing tank

15. WATER QUALITY OF BIDYADHARI RIVER

Water quality of adjoining wetland ecosystem of Bidyadhari river basin gradually has been worsened due to admixture of industrial effluents with domestic sewage released from the Kolkata metropolis as well as from the different industries of Kolkata east through different canals (Fig. 6). Pollutants from industrial sewage may cause biological magnification that ultimately leads to carcinogenic effect in the human body. Attempts are made to record some physico chemical parameters from six different stations of Bidyadhari River. It is now urgently needed for mapping of Bidyadhari river course through physico-chemical parameters to let the local people know the water quality of Bidyadhari River in different sectors for their benefit in application of water of Bidyadhari River in agriculture and aquaculture.

Bidyadhari River has a very circuitous tidal course in the district of North 24 Parganas, West Bengal. It has the special characteristic of carrying the tidal domestic sewage along with others which are thrown by a series of artificially made canal named Bagjola Khal, Bhangor kata khal, Central Lake canal, Krishnapur canal etc. All these canals now carry effluents from different industries. Bidyadhari River is tidal almost of its entire length within its upper limit up to Tehatta at the upstream.

Fig. 6 Sewage passes through the sluice gates of the canal into the Bidyadhari River

16. THE RIVER SYSTEM

The Bidyadhari has a very circuitous tidal course. It begins as a drainage channel, called Nona Gang, a little north-east of Dogachia, which occupies a low interfluves between the the Sunti and the Padma. It flows south past Jessore road and Barasat-Basirhat rail track. Just south of this rail track the Haroa gang meets the Nona gang on the right and the combined stream is known as Bidyadhari. The Haroa itself serves as drainage outlet of the extensive swamps to the east of the Dhapa bil around Rajarhat-Bishnupur (22°37′N and 88°30′E). The Haroa gang appears on the map as a continuation of the north-south flowing Sunti nadi through these bils. Further south (about 20 Kms) it receives the Bhangar kata khal (which drains the salt water lakes of East Culcutta) on the right bank and the Kulti (or Chaumuha gang) on the left

bank. Below this confluence, the Bidyadhari flows south as the tidal Kumarjol gang. The Bhangar kata khal in its turn is linked with the Krishnapur canal, Circular canal and New-cut canal on the north eastern periphery of Calcutta. The sewage and storm water of Calcutta is canalized through two different channels into the Central lake canal, which empties into another branch of Bidyadhari south of Bamanghata ($88^0 29^{'}$E and $22^0 31^{'}$ N). The head water portion of this branch has largely silted up. It flows south east, receiving the Tolly's Nullah from the east and giving off the tidal Piyali River flowing south from its right bank before reaching Port Canning where it receives the other branch, i.e., Kumarjol gang referred earlier. This south flowing branch has other names – Khurti, Karats, Kuriabhanga and Kartoya. The united streams form the Matla River or rather estuary, which is navigable up to Canning.

Beginning in the Sunderbans, tidal Bidyadhari in the past flowed north-east past Haroa where it was known as Haroa gang, and then bent westwards, and was joined by the Nona khal. After this, it flowed south-westwards to the junction of the Beliaghata canal and Tolly's Nullah, and then southeast to Matla or Canning, where it was joined by the Karatoya and Atharonbanki rivers. The united streams formed the Matla River, which flowed south to the sea and was navigable by river steamer up to Canning [5].

The portion of the Bidyadhari River near Kolkata, which at present serves as an outfall channel for the storm water and sewage of the city, has for some years past been silting up at a rapidly increasing rate. The acceleration of the silting process is attributed mainly to works in connection with local fisheries and to the reclamation of portions of the salt water lakes for rice cultivation, the effect being to decrease the spill of water from the river over the adjoining land and, consequently, to increase the deposit of silt in the river bed. Other contributory causes have been the construction of the Dhapa lock, the closing of tributaries in each of which the tide used to flow and ebb freely, and the canalization of the Bhangar khal.

16.1. Decline of Bidyadhari River

It was observed during the span of 1901–1912, the bed of the Bidyadhari river had risen about 8 m in eight years a 1.6 km below Bamanghata while cross-sectional area had been reduced from 715 sq m giving a mean rate of contraction of 45 sq m and it was concluded from Hooghly–Bidyadhari Canal Enquiry Division that the Bidyadhari had a very short remaining lease of life, and that in six year time periodicity it would be useless as an outfall channel for the sewage of Calcutta unless remedial measures were taken. It was also suggested that the only practicable way of dealing with the situation was to canalize the channel of Bidyadhari from Dhapa to the off take of the Piali River, 15 km below Bamanghata, and the channel of the Piali River from its head to its outfall into the Matla River.

The Government of Bengal, acting on expert opinion, decided it would stop maintaining the river any further in 1928 and it was declared useless. The sewage of the then Calcutta metropolis was decided to be discharged into Kulti

in 1935. Bidyadhari was absolutely dead without any chance of revival by 1942. The decline of Bidyadhari is due to various manmade and natural causes. Human intervention, especially, fishery and constructions of canals and embankments have accelerated the pace of degeneration of the river.

16.2. Present State of Bidyadhari River

As a result the sewage-laden brackish water moves towards extreme upstream up to Tehatta -that lead to no use of river water for domestic as well as agricultural purposes.

Water quality gradually worsens due to admixture of industrial effluents with the domestic sewage that pass through the different canals which ultimately finds its opening in the Bidyadhari main stream. It is observed that the industrial effluents play an important role in the adjoining wetland ecosystem as the discharges are being productively utilized in the aquaculture and are also in demand to irrigate the adjoining lowland agricultural efforts [6]. Present inclusion of industrial effluents in the domestic sewage may start the appearance of heavy metals in the water or nutrients that may cause biological magnification in both flora and fauna [6]. Accordingly attempts are made to study the physico-chemical and biological conditions of water flowing through Bidyadhari River. Temperature, Conductivity, DO, BOD, COD, TDS, TSS, pH, etc. are recorded from six different spots at the Bidyadhari river namely Haroa (1), Kulti (2), Ghusighata (3), Minakhan (4), Malancha (5) and Dhamakhali (6).

Biological magnification sometimes has harmful effects and even highly carcinogenic to human body. It is now urgently needed to map the upper and lower wetland limits in terms of physico-chemical analysis in Bidhyadhari river basin, which sustain the livelihood of the bulk of population of this area of Sunderbans. Geomorphic mapping will be helpful to the people surrounding the Bidhyadhari River through the sector wise utilization of river water for different purposes. Geomorphic mapping is further helpful by identifying the location area of sewage sludge accumulation. Removal of these sewage sludge from the river bed is not only helpful for easy navigation along the river, it will further act as the bio-degradable fertilizer free of cost to the poor farmer of grass root level.

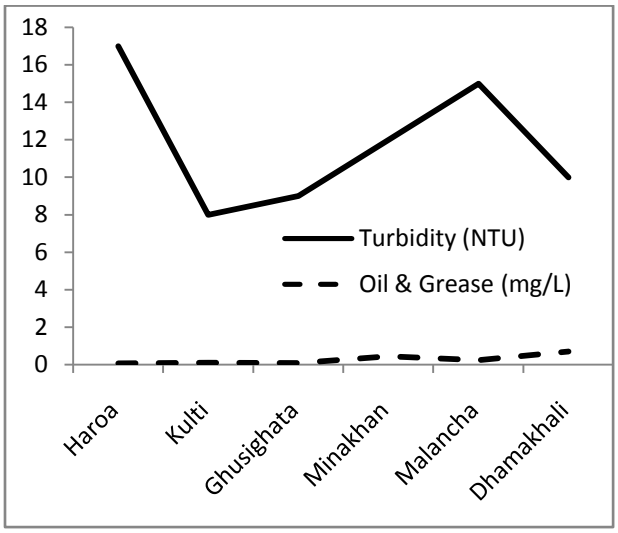

Fig. 7 Values of turbidity and oil & grease at different spots of Bidyadhari river

17. ENVIRONMENTAL PARAMETERS OF RIVER WATERS

Water samples from the six different spots (Table 3) named Haroa (1), Kulti (2), Ghusighata (3), Minakhan (4),

Malancha (5) & Dhamakhali (6) from the north to south direction along the tidal stretch of Bidyadhari river (Fig. 6) were collected for the estimation of physico-chemical parameters of the water. Water of the above said six stations along the tidal river course of Bidyadhari were collected in polythene bottles of 1 liter capacity for the estimation of pH, salinity, conductivity, TSS, TDS, Turbidity, BOD, COD, DO, oil & grease etc [7].

The pH and oil & grease level (Table 3) of the surface water of Bidyadhari River at all sampling points have been observed to be well below the permissible limit (Fig. 7). This favorable pH (Table 3) as wells as the oil & grease concentration helps also the decomposition of organic matter by the microorganisms.

The TSS level in all the sampling points is well below the permissible limit (Table 3). This may be due to the settling of pollutants in all the canals flowing towards the Bidyadhari River. The comparatively higher level of TSS in case of Kulti may be due to unfavorable hydrodynamic condition in that region.

BOD level in all the sampling points is also below the permissible limit (Table 3 & Fig. 8). The surface water flowing through the Bidyadhari River carries some organic waste coming from the different man-made canals. The microorganisms are decomposing these organic matters in presence of sunlight and dissolved oxygen (DO) which are available abundantly in all those canals (Table 6 & Fig. 8). This is the reason of low level of BOD in those regions of Bidyadhari River.

Dhamakhali being nearer to sea shows the highest TDS level. The same is the case for Malancha, Minakhan, Ghusighata and Haroa (Table 3 & Fig. 9). The high level of TDS in case of Kulit may be due to contamination of wastewater of different industries with the surface water of the canal flowing towards Kulti.

Table 3 Analysis of water samples collected from different spots of Bidyadhari river

Sample No. and Location	pH	Salinity (ppt)	Turbidity (NTU)	TDS (ppm)	DO (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Oil & Grease (mg/L)
B1 Haroa	7.25	3	17	460	9.2	0.0355	2.412	20	0.071
B2 Kulti	7.18	4	8	730	0.0	0.3500	4.824	92	0.112
B3 Ghusighata	7.02	4	9	590	0.4	0.0010	4.02	60	0.094
B4 Minakhan	7.14	5	12	670	2.2	0.0015	1.6	72	0.437
B5 Malancha	7.12	5	15	760	4.8	0.0130	4.824	52	0.243
B6 Dhamakhali	7.32	8	10	1950	6.4	0.0100	1.608	68	0.695

The same is the case for COD level at different sampling points of Bidyadhari River except for the Kulti which shows the highest COD level (Table 3 & Fig. 8). This may be due to contamination of industrial wastewater in the surface water near Kulti region of Bidyadhari River.

Scientific information and environment analyses on the concentrations of different pollutants from the domestic sewage by the canal (Fig. 6) into the Bidyadhari River water and the resultant effect on bioaccumulation and biomagnifications are little known till date. The cumulative effects on the consumption of the agricultural and aquacultural products from the wetland areas adjacent to the Bidyadhari River in human body are yet to be studied. It is apparent from the present study that the wetland ecosystem adjacent to the Bidyadhari River plays an important role in pollution amelioration acting as a natural waste treatment plant [8 & 9]. Sunlight and DO help in purifying the waste water which are admixtured to the Bidyadhari River water after being released by several man-made wastewater canals from the greater Kolkata. Feasibility test [10] through analysis of environmental chemistry considering the result of major environment parameters reveals that the water quality of the Bidyadhari River is still tolerable for the existence of living creatures in the riverine aquatic environment. Only the sewage sludge present in the domestic sewage released by the canals causes impediment to inland navigation as well as marks sedimentation on the riverbed. Therefore, political will and social awareness are needed to restrict further pressure on both the products and the producers existing in the adjacent wetland areas of the Bidyadhari River.

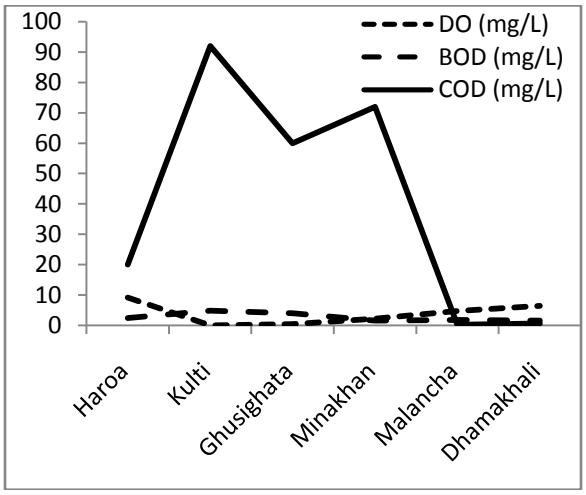

Fig. 8 Values of DO, BOD, COD at different stations of the Bidyadhari River

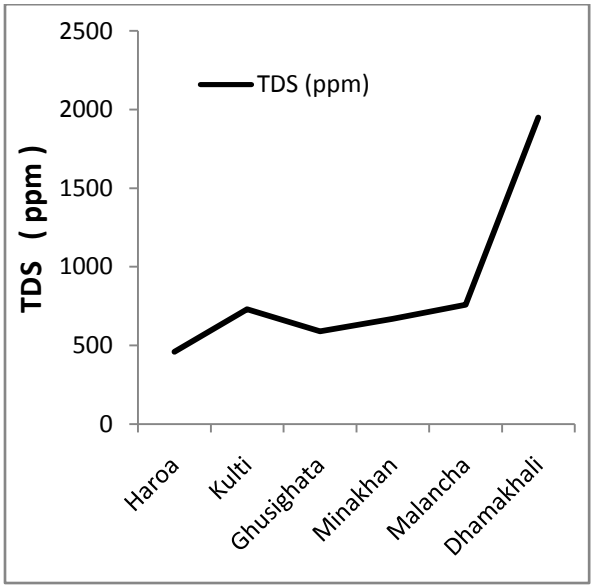

Fig. 9 Values of TDS at different sampling stations at Bidyadhari River

18. MAN-TIGER CONFLICT AND TIGER STRAYING

The mangrove swamp of the Sunderbans is famous for the habitat of the Royal Bengal tiger and their typical characteristics of man-eating habits. The tigers of the Sunderbans choose all

the moving animals as their prey. They even prey upon the crocodiles lying in the river flood plains of Sunderbans. Straying of tigers depends on the physical as well as the biological factors. The age-old tigers are generally disabled for catching a moving wild prey in the forest environment rather than capturing domestic bovides in the locality as their part of menu. They never attack human being as their prey but attack if only the men are seen on their way.

19. CLASSIFICATION OF MAN EATERS

The mother tigress if disturbed by the honey collectors or the wood cutters using the passage through the tiger den, only attacks the intruders like honey collectors, fishermen or wood cutters for the protection of her cubs and these types of man eaters are considered as 'circumstantial man eaters'. Only 1% of this category preferred attacking men as easily available and weak prey are considered as 'designed man eaters'. When this man eating habit is gradually acquired from the mother even by a male cub, they become an 'aggressive man eater' for whom the human beings are their normal preys. The wood cutters fishermen and the honey collectors enter into the tiger den as the trespassers are therefore responsible for the changing the habits of a tiger into a man-eater in the Sunderbans tiger reserves.

20. OCCURRENCES OF MAN EATING

Royal Bengal tigers generally seen to attack in the mangrove swamps with higher saline zone have a positive correlation with the man eating of tigers. Maximum casualties are occurred in the zone of maximum salinity. Further maximum man eating takes place in the pre-monsoon time when salinity in the river waters is maximum. The tiger straying and man eating are therefore directly related with the salinity in the preferable pre-monsoon seasons.

Further if the honey collectors move frequently in the mother tiger den living with cubs in search of honey comb without the knowledge of the presence of tiger den, the tigers attacks the honey collectors for the protection of cubs and becomes a man eating tiger.

21. MEASURES FOR MINIMIZATION OF CONFRONTATION

Permission for harvesting of Phoenix paludosa is restricted as the continuous groves of this bushy species, the natural and preferred denizen of tiger den is disturbed no more. Electrified dummies of fishermen, honey collectors, wood cutters are introduced. The man eaters, Royal Bengal tigers are pretended after getting shock from those electrified dummies with their necks covering with electric wires having electricity with 230 volts. The man eaters may avoid the men entering inside the forest for collection of honey, wood or fish catch as their prey being lured and pain from getting electric shocks from those human beings like dummies in the forest areas. Honey collectors and fishermen are advised by the forest officials to wear rubber made face mask on the rear side of the head to embarrass the man eaters confusing in taking decisions on side of attack as the Royal Bengal tigers of Sunderbans are habituated to attack from behind the forest goers like wood cutters, honey

collectors and fishermen. Excavation of sweet water ponds inside the forest is another way of thoughts to stop the straying of tigers in search of fresh waters to the localities adjacent to the tiger reserves. These ponds in the buffer zone filled with fresh waters from the precipitation by the rain restrict the movement of the tigers within the forest.

At present the entry times of wood cutters, honey collectors inside the forest is restricted as tiger attacks are recorded in between 7 am to 9 am and 3 pm to 5 pm. Casualty in the night time is happened generally after 11 pm when a man eater selects a person sleeping on the boat, then catch him and jumps to the water with the prey holding firmly on his neck. Fences with nylon net and branches of mangrove trees covering those islands opposite to the villages restrict the tigers sometimes not to cross the rivers or creeks to the human habitation zones as they are specially adapted for swimming across the tidal rivers in the Sunderbans.

22. TRASH IN THE COASTAL SUNDERBANS

Fraserganj, a natural solitary sea resort, only 1.2 km west from the well-known Bakkhali sea beach stands at the southern most ends of West Bengal where coastal landmass meets the Bay of Bengal. Fraserganj was so named after the name of Sir Andrew Fraser, the Bengal Governor during 1903-08 who was more famous as the advisor of Lord Curzon for the division of the then undivided Bengal. Andrew Fraser took the project to set up a tourist spot for spending leisure time of the employees specially for the British nationals during the last year of his Governorship in Bengal in the year 1908.

Table 4 Inventory of the litters scattered in the beach

Plastic packets	619	Doll's head	08
Plastic bottles	105	Plastic nine pins	16
Pieces of rope	113	Glue syringe	03
Shoes (not in pair)	52	Used condoms	09
Fishing net balls (punctured)	66	Small gas cylinder	04
Glass bottles	38	Foam pieces	19
Bottle tops	34	Drug syringe with intact needles	08
Pieces of plastic pipes	16	Worker's used materials	27
Jars	07	Plastic coat hanger	02
Broken foreign liqueur bottles	14	Toy (entire)	07
Fluorescent tubes	03	Half a toy	61
Light bulbs	01	Car floor mats	03
Food/drink cans	09	Asthma inhaler	01
Pop tops	02	Ampoules (empty)	38
Dice (Ludo)	01	Jar lids	07
Cigarette lighters (not in use)	17	Buoys: large	01
Cycle tire	01	Crates (bread, bottles)	05

That Fraserganj at the bosom of the Bay of Bengal is one of the most remote and lonely sea resorts situated almost 139 km from the nearest mega city Kolkata. Yet when a survey conducted on July 16, 2009, it was found over 1000 pieces of trash in a 2 km stretch of this beach (Table 4). Anthropogenic causes have the major impact over the accumulation of trashes on the beach. Non-biodegradable trashes particularly the

plastic end up in the sea coming from the lands [11].

23. CONCLUSION

Sunderbans therefore, faces different man made problems a few of which is local and the source of the other one is Kolkata mega city that is far away from the Sunderbans [12]. The prawn capture was started only from the late eighties of the twentieth century with the introduction of highly profitable scientific brackish water prawn culture with direct or indirect support of multinational companies. This practice not only diminishing the tiger prawn population but also a large number of fingerlings and seeds of other prawn and fish species get trapped and vanishes from the nature. As a consequence, it affects negatively those animals including big fishes and even crocodiles who take these small creatures as food. The food chain will break up step by step and its deleterious effect may be more harmful in future. The prawn seed collection continues unhindered, it can decrease the density of pneumatophores and the biomass of epiphytic algae causing a change in habitat structure. As a result, trampling in the muddy river banks is a perennial problem. Mangroves of the Sunderbans are under gradual increasing pressure and pollution due to the human activities because of rapid reclamation and encroachment in the coastal areas. Prawn seed collections, refuse disposal, sewage discharge, urban emissions, accidental spillage of toxic pollutants are significant anthropogenic inputs. Over exploitation activities in the Sunderbans have led to large scale mangrove area degradation despite the mangroves have immense direct and indirect uses. The mangrove forest zones have faced changed land use patterns in the form of conversions of mangroves forest lands to agricultural lands, aquaculture farms, and human settlements during the period of last two centuries. The ideal nursery grounds, grazing places and breeding sites for a large number of mangrove dwelling species have gradually been destroying for this human encroachment and interferences. The mangroves forest of the Sunderbans not only serve as the habitat of aquatic species but act as the coastal buffer rendering protection to the coastal region as well as the megacity Kolkata from the severe coastal upsurges and cyclonic storms.

The number of casualties due to tiger attack inside the forest has been gradually diminishing as almost half of the permit holders among the wood cutters, honey collectors and fishermen are happened to be involved in the collections of tiger prawn seeds (Penaeus monodon) in the river waters of the Sunderbans. The right awareness and the involvement of the village people after repeated meetings leads to the less casualties of the tiger straying in the villages. The man-tiger conflict and managing the straying of tigers in the localities are gradually understood through regular meetings held in the forest side villages by the Forest Protection Committee (FPC) and Eco-development Committee (EDC). These committees are formed by the joint membership of the forest officials and the villagers where the concept of eco-friendly relationship in between man and tiger are discussed. The forest officials make the villagers understand – Sunderbans will be saved only if tigers are saved which in turn necessitates a

luxuriant growth of mangrove forest for their dwelling.

Trashes, in particular, in the tourist spot in the coastal Sunderbans pose hazards to the marine life specifically when the animals drown or strangle from being tangled in discarded or lost fishing gear or suffer and even die from swallowing plastic and other garbage. Plastic packets look like jelly fish are taken for feeding by the sharks and turtles.

REFERENCES

[1] Anonymous, The Shrimp Fry By-Catch in West Bengal, Eds. B.K. Banerjee and H. Singh, CIBA. Madras, 1993.

[2] Das, G.K., Impact of Salinity and Nutrients on the Changing Mangrove Floristic- a Case Study from the River Flood Plains of Sunderbans, India, In Biotic Potential and the Abiotic Stress, Lambert Academic Publishing AG & Co. Saarbrucken, Germany, pp.119–129, 2011.

[3] Das, G.K. and Bhattacharya, A., Destruction of Certain Encountered Shelfish and Finish from the Coastal Waters of Sunderbans and its Impact on the Coastal Ecosystem, J. Indian Soc. Coastal Agric. Res., Vol.17, No.1&2, pp.216-218, 1999.

[4] Das, G.K. and Bhattacharya, A., Rampant Exploitation of Post-Larval Penaeid Prawn (Penaeus mondon) from the Salt-water Course of the Deltaic Sunderbans, West Bengal– A Threat to the Balance of Nature, J. Indian Soc. Coastal Agric. Res., Vol.17, No.1&2, pp.219-222, 1999.

[5] O'Malley, L.S.S., Bengal District Gazetteers, 24 Parganas. The Bengal Secretariat Book Depot. Calcutta, 1914.

[6] Chattopadhyay, B., Datta, S., Chatterjee, A. and Mukhopadhyay, S.K., The environment impact of waste chromium of tannery agglomerates in the east Calcutta wet land ecosystem J. Soc. Leather. Tech. Chem., Vol. 84, pp.94 -100, 2001.

[7] Ewing, G.N., Instrumental Method of Chemical Analysis. McGrew Hill Book Company, New York, 1985.

[8] Das, G.K. and Datta, S., Studies on the Impact of Water Quality on the Adjoining Wetland Ecosystem of Bidyadhari River, West Bengal. Indian Science Cruiser, Vol.18, No.4, pp.16-21, 2004.

[9] Das, G.K., Datta, S. and Sanyal, S.K., Need for Geomorphic Mapping in terms of Physico-Chemical Analysis of the Sewage Fed Bidyadhari River Carrying Effluents from the Greater Calcutta, Journal of Indian Soc. Coastal Agric. Res., Vol.22, No.1&2, pp.49-51, 2004.

[10] Ghosh, P., Proceedings of Habitat II Conference, Calcutta, 1999.

[11] Kar, D., Public Access and Importance of Offers to Dedicate on California's Coastline, Journal of Coastal Research, Vol.23, No.2, pp.472–486, 2007.

[12] Das, G.K., Environmental scenario of Sunderbans: Planning and Management in the Anthropeco-logy and Applied Biodiversity, Lambert Academic Publishing AG & Co., Saarbrucken, Germany, pp.1-24, 2014.