

Original Paper

Wetlands, Fishes and Pandemics with Special Reference to India

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Received: August 14, 2021

Accepted: August 21, 2021

Online Published: August 24, 2021

doi:10.22158/se.v6n3p136

URL: <http://dx.doi.org/10.22158/se.v6n3p136>

Abstract

Water is life, life is water. Water is indispensably important for sustenance of life. Wetlands serve as potential water bodies, harbouring coveted bioresources, which sustain animal life. Fish is a significant bioresource for nutrition and avocation of the people. There are various types of wetlands in the Indian sub-continent. India has c 67,429 wetlands covering c 4.1 million ha. Concomitantly, c 21,723 living species of fish have been recorded out of 39,900 species of vertebrates. Of these, c 8411 are freshwater (FW) species and c 11,650 are marine. India recorded c 2500 species of fishes; of which, c 930 live in FW and c 1570 are marine. The hitherto unknown dreadful, virulent, enigmatic Epizootic Ulcerative Syndrome (EUS), has been sweeping the FW fishes in an epidemic dimension, unhindered, unimpeded and unabated, almost semi-globally; and, has been causing large-scale mortality among them, since 1988, rendering many of them endangered. Concomitantly, the outbreak of SARS-CoV-2, among the human, was first reported at Wuhan, China, in late December 2019. The first 54 reported cases of COVID-19 were observed in December 2019 at Wuhan, China, and this, subsequently, had spread across the globe. India has been facing much impacts of COVID19 pandemic since its inception in China.

1. Introduction

India has c 67,429 wetlands covering c 4.1 million ha. Out of these, c 2,175 (1.5 million ha) are natural and c 65,254, (2.6 million ha) are man made wetlands. Wetlands in India account for c 18.4% of the country's geographical area.

Natural wetlands in India are of different types: (A) Himalayan wetlands: (a) Kashmir Valley and Uttarakhand; (b) Eastern Himalayas; (B) Indo-Gangetic wetlands; (C) Coastal wetlands; (D) Deccan Wetlands.

However, at present, only c 50 % of India's wetlands exist. They are being lost @ 2-3% every year. Indian mangrove areas have been almost halved from c 700,000 ha in 1987 to c 453,000 ha in 1995;

and, might have further reduced.

The North-East (NE) India, the hotspot of Biodiversity, having undulating terrains, provides rich potential for fish production, which could supplement its nutritional requirements and could provide with an answer to diminishing protein supply. Further, in Assam, the different kinds of wetlands cover c 100,000.0 ha having been locally named as “Beel, Haor, Anua, Hola, Doloni, Jalah,” etc.; with areas from 35.0 to 3458.12 ha and depth from 0.25 to 3.0 m; although, some may be as deep as 6.0 m at FSL. Concomitant to above: (a) a “Beel”, is a perennial wetland; b) a “Haor”, is a seasonal floodplain wetland; and, (c) “Anua” a a river-formed oxbow wetland. In Assam, there are c 490 Beels, 610 Haors and 290 Anuas. They contain a rich diversity of fish fauna and also other aquatic biota. The wetlands are also associated with the cultural ethos of the people.

2. Some of the Wetlands Exemplified

Among some of the prominent wetlands in India, **Sone Beel** (92° 24' 50" E and 24° 44' 30" N), **3458.12 ha** at FSL having a shoreline of 35.4 km, shore development of 1.69, Volume Development (VD) (0.15) a gross volume of $101.54 \times 10^6 \text{ m}^3$, a mean depth of 0.29 m, maximum depth of 6.0 m; is the biggest wetland in Assam and one of the biggest in India and Asia. The tectonic origin of the Beel is supported by its sediments. The impact of post-tectonic activities is discernible from its shallow plate-like basin characteristics supplemented with low VD. Its shrinkage to 409.37 ha at the DSL during dry season is alarming. The continuous major inflow (River Singla, Max. flow $33.91 \text{ m}^3 \text{ sec}^{-1}$), after its origin as Thing Tlawn Lui in Mizo Hills (374 m MSL, having a maximum silt load of $350.0 \text{ mg lit}^{-1}$), drains-in water and silt into Sone Beel; while, the major outlet (R. Kachua; Max. Flow $87.03 \text{ m}^3 \text{ sec}^{-1}$; having a maximum silt of $216.0 \text{ mg lit}^{-1}$), drains out the water and silt from the Sone Beel into the River Kushiara, which flows into Bangladesh. Thus, there is retention of higher silt load in the Beel through the inlet in contrast to low expulsion through the outlet; thus leading to fast shrinkage of water spread area of the Beel. The values of different limnological parameters ranged from turbidity, 20.56 TU to 185.54 TU; water temperature 18.7 to $32.3 \text{ }^\circ \text{C}$; pH 6.02 to 7.9; DO 2.6 to 5.9 mg lit^{-1} ; DO solubility 9.4 to 11.9 mg lit^{-1} ; % saturation of DO 32.3 to 74.4%; FCO_2 0.9 to 14.5 mg lit^{-1} ; and, TA 25.0 to 76.0 mg lit^{-1} . The conductivity of Sone water was low. The pH of Sone Beel soil ranged from 5.02 to 5.9; OC 0.25 to 1.74 %, available phosphorus from 0.15 to $1.93 \text{ mg } 100 \text{ g}^{-1}$ and available potassium from 1.62 to $24.8 \text{ mg } 100 \text{ g}^{-1}$. The phytoplankton (PP) included 47 forms under 7 families; while, PP density varied from 10 to 5308 units lit^{-1} having abundance of chrysophytes and rarity of pyrrophytes. The zooplankton (ZP) contained 19 forms with the density ranging from 6 to 380 units lit^{-1} . The copepods and cladocerans were the most abundant and the protozoans, the least. There were 23 species of Aquatic Macrophytes (AM) in Sone Beel and the AM biomass varied from 0.50 to 21.90 kg m^{-2} . *Eichhornia crassipes*, *Hydrilla verticillata* and *Trapa bispinosa* were the most abundant species perennially. And, the littoral fauna, represented by both piscian and non-piscian groups, exhibited biomass of the former from 0.05 to 1.53 g m^{-2} while that of the latter from 1.6×10^{-4} to 1.09 g m^{-2} . Of

the 70 ichthyospecies belonging to 49 genera under 24 families, 84.2 % belonged to primary freshwater group while the rest were of peripheral class. The annual average total Fish Yield (FY) from Sone was 335.185 metric tonnes (mt); the trend thereby showed average per hectare (ha) yield of 193.76 kg. *Puntius chola* contributed to the bulk of the Sone fish landing registering an average Annual Relative Yield (ARY) of 24.60 % . The Indian shad, *Hilsa (Tenulosa) ilisha*, with an average ARY of 0.04 %, revealed a single run during the monsoon against two in other water bodies of India. The average total annual landing of Hilsa from Sone Beel was 192.1 kg, the trend, thereby showed per hectare yield of 0.055 kg. The Monthly Relative Yield (MRY) (%) recorded was 0.04 (Apr), 0.028 (Jul), 0.11 (Aug), 0.01 (Sep) and 0.004 % (Oct); and, 0.07 (May), 0.09 (Jun), 0.06 (Jul), 0.04 (Aug) and 0.37 % (Sep) in two successive years. The average total landing of Indian Major Carps (IMC) from Sone Beel was 2571.52 kg (0.73 % of the total fish yield on the average); the trend, thereby depicted average per hectare yield of 0.74 kg. The IMC depicted an average ARY of 0.14 %. The species-wise average MRY recorded were 0.065, 0.072 , 0.255, 0.223 and 0.29 % respectively for *C. catla*, *C.mrigala*, *L. calbasu*, *L. gonius* and *L. Rohita*. Concomitantly, the species-wise average ARY successively were, 0.0125, 0.075, 0.185, 0.23 and 0.235 % for *C. catla*, *C.mrigala*, *L. calbasu*, *L. gonius* and *L. Rohita*. The IMCs entering Sone Beel generally varied in size from 19.0-66.8 cm for *C. catla*, 12.9- 65.0 cm for *C. mrigala*, 15.0-54.3 cm for *L. calbasu*, 6.8-0.0 cm for *L. gonius* and 12.0 – 78.5 cm for *L. rohita*. The study portrayed an overall mixed status of the interrelationship and dynamics of fish population of Sone Beel in respect of various parameters. Study revealed that, of all the predators having average ARY of 3.29 %, *Wallago attu* alone contributed to an average ARY of 2.94 %. Of the four principal fishing communities of the Sone Beel, “Kaibarta” community constituted c 68 % of the total fisherfolk and c 55 % of the Kaibarta fishermen were professional. Among the 26 varieties of fishing gears recorded, Mahajal, Daljal and Chatjal were the monsoon varieties while the hooks and lines, the cages and large-meshed cast net were mainly winter varieties. The gill net and the triangular scooping net had no seasonality. The average CPGH (Catch person⁻¹. gear⁻¹. Hour⁻¹: Dey, 1981) of Mahajal was the highest (1,485 kg) followed by Chinese dip net (0.73 kg), long line (0.6 kg), cage trap (0,38 kg), and gill net (0.17 kg). Sone Beel was recognised by the government of India as a wetland of National Importance on the basis of research findings of the present author (*vide* Assam Govt. Letter No. FRM 41/2008/63-A, dt. 8.9.2008; *vide* Resolution No. 11 dt. 16.10.2008 of the Meeting of the Expert Group of MOEF, Govt. of India, New Delhi).

Concomitant to above, **Sat Beel** (N 24° 50' 4.0" E 92° 49' 20.0"), in Cachar, Assam , is an aggregation of seven wetland units. Study revealed average values of the Limnological parameters of its water to be temperature (T) Air 13.6 - 34.8, T water 13.1- 34.3, Turb 59.0, pH 5.82, DO 6.0, FCO₂ 3.0, TA 55.5; and, Soil Conductivity (SC) 46.0, Soil Phosphorus(P) 0.35, and Soil Nitrogen (N) 0.040.

Concomitantly, **Chatla Haor** (93°15' N to 24° 10' E) , having maximum length, width, depth and area 10 km, 2.5 km, 5.5 m and 1600 ha respectively, is one of the biggest Haor in Assam. A number of small inlets, *viz.*, Jalengachhara, Baluchhara, Salganga brings in water and silt into the Haor; while, the major

outlet, River Ghagra drains out the Haor water into the River Barak. The Chatla Haor water revealed the following limnological characteristics: temperature (°C) 33, turbidity (NTU) 83.27, pH 6.09, DO, 6.5, FCO₂ 7.59 mg/lit, TA 83.39 mg/lit, Conductivity 142.91 micromhos/cm. Having recorded 18 ZP forms, the total ZP count was 68± 45 units/litre. Further, having recorded 23 species of AM, significant phyto-social association were also observed among *Nymphaea* sp and *Nymphoides* sp; and, among *Eleocharis acutangula*, *Scirpus eriophorum* and *Echinochloa stagnina*. Zoogeographically, the ichthyospecies of Chatla Haor contains 79.62 % of Primary FW fish while the rest (20.38 %) belong to the Peripheral class. Notably, advanced fry of Hilsa, ranging from 4.5. to 22.0 cm, were recorded in Chatla Haor portraying a rare example in wetland domains of the world; and, concomitantly, indicating possible occurrence of breeding ground of Hilsa in Chatla Haor. Moreover, mature hilsa swarms were also recorded in this Haor only between June to September, suggesting a single run of Hilsa contrary to two runs in the rivers.

Further, **Baskandi Anua**, a river-formed oxbow wetland (24° 10' N to 93° 15' E), in Cachar, Assam., having L,W and A respectively 2.230 km, 205 m and 39.2 ha at FSL and 2.090 km, 190 m and 36.7 ha at DSL; depth 0.25 m to 5.85 m at FSL (Jun-Sep) and from 0.14 m to 4.12 m at DSL (Nov-Apr); portrayed the occurrence of 16 species of **AM** containing 6 free-floating (*Azolla pinnata*, *Echhornia crassipes*, *Salvinia cucullata*, *Lemna paucicostata*, *Pistia stratiotes*, *Wolfia* sp); 2 rooted submerged (*Hydrilla verticillata*, *Vallisneria spiralis*); 6 rooted with floating leaves (*Nymphaea nouchali*, *Nymphoides indicum*, *N.cristatum*, *Trapa bispinosa*, *Euryale ferox*, *Nelumbo nucifera*); and 2 rooted emergent (*Jussiaea repens*, *Muradania nudiflora*); and, wet AM biomass ranged from 4.4 to 11.4 kg/m².

3. The Pandemics

3.1 Epizootic Ulcerative Synarome (EUS)

Concomitant to above, pandemics in the form of Nature's fury are not new on the earth. Two devastating pandemics have, probably been indelibly engraved in the minds of people. These are the Epizootic Ulcerative Syndrome or EUS (among the fishes) and the COVID19 (among the humans).

The *hitherto* unknown dreadful, virulent, enigmatic **Epizootic Ulcerative Syndrome (EUS)**, which has been sweeping the FW fishes in an epidemic dimension, unhindered, unimpeded and unabated, almost semi-globally, has been causing large-scale mortality among them, since 1988, rendering many of them endangered; causing fear psychosis among the fish-eating people; causing untold misery to the fishermen, fish farmers; and, devastating the economy of the nation. Our studies, involving aspects like limnology, chemistry, physics, bacteriology, mycology, and virology including tissue culture and electron microscopy, revealed interesting findings including isolation of a virus. There is urgent need for managing this unimpeded fish disease

3.2 Summary of EUS Investigation

EUS, since 1988, has been initially affecting four species of fishes very widely. These were *Puntius conchoni*, *Macrognathus aculeatus*, *Mystus vittatus* and *Channa punctata*. Our study revealed fluctuation in the intensity of the disease in relation to species affected. Large haemorrhagic cutaneous ulcers, epidermal degeneration and necrosis followed by sloughing of scales are the principal symptoms of EUS. Low Total Alkalinity (TA) of water recorded, which could be a pre-disposing “Stress factor”. Sick fishes show low haemoglobin and polymorphs, but high ESR and lymphocytes. Communicative nature of EUS revealed variation in time gap between fish and infection in different species. Inoculation of microbes into the test animals did not reveal any sign of ulcerations for two years. Bacterial culture revealed occurrence of haemolytic *E. coli*, *Aeromonas hydrophila*, *Pseudomonas aeruginosa*, *Klebsiella* sp, *Staphylococcus epidermitis* in the surface lesions as well as in the gut, liver, gills, heart, kidney and gonads of sick fishes, all of which were found to be sensitive to Chloramphenicol, Septran, Gentamycin, etc. Fungal isolation revealed the occurrence of *Aphanomyces* sp with concomitant occurrence of the same fungal genus in histological sections of EUS-affected fishes. Histopathological (HP) studies showed focal areas of increased fibrosis and chronic inflammatory cell infiltration in muscles; focal areas of fatty degeneration of hepatocytes surrounding the portal triads in the liver.

Inoculation of 10 % tissue homogenate of EUS-affected *Clarias batrachus* into 80% confluent monolayer form BF2 and RTG fish cell lines in Leibnitz L-15 medium, revealed progressive CPE which was passable in subsequent cultures; thus, indicating the “isolation” of virus (Kar, 2015). The filterable biological particles were different from those described by Frerichs *et al.* (1986). Further, recent studies revealed the detection of Ranavirus infection in cultivated carps of North-East India (Kar, 2007, 2013, 2015, 2019; Riji *et al.*, 2016). Electron Microscopic studies with the ultra-thin sections of still-occurring EUS-affected fish tissues, revealed the presence of virus-like particles (inclusion bodies); and, preliminarily, the picobirna virus has been electron microscopically identified as the primary aetiological agent of EUS (Kar, 2015).

3.3 SARS CoV2 (COVID-19)

Notwithstanding the above, the outbreak of SARS-CoV-2 was first reported at Wuhan, China, in late December 2019; and, this, subsequently, had spread across the globe. The affected population included people from Western Pacific, including regions like, China, Republic of Korea, Australia, Malaysia, Japan, Singapore, New Zealand, etc.; in Europe, including Italy, Spain, Germany, the UK, Norway, etc.; in SE and South Asia including Indian sub-continent; the Eastern Mediterranean Region; in the Americas, including North and South America; and, in the African region including South Africa, etc. India has been a victim of COVID19 since its inception. The infection had spread to > 100 countries within c 2 to 3 months and affected innumerable people

Initially, the infection emerged as viral pneumonia from unknown microbial agents (Lu *et al.*, 2020). The Chinese had identified the virus as novel coronavirus from the throat swab sample of an infected patient.

Prof. Yong Zhang, *et al.*, were the first to publish the genome of COVID-19 in January 2020 (Adhikari *et al.*, 2020; Chen *et al.*, 2020). Later, WHO declared the disease as Public Health Emergency of International Concern in January 2020 and officially named the disease caused by the novel CoV2 as SARS CoV2 coronavirus disease 2019 (COVID-19) in February 2020.

The severity of the infection usually increases due to ability of the virus for human-to-human transmission mainly through contact and through large droplets. Moreover, it could also be transmitted through aerosols and fomite and cause infection (Perlman, 2020).

This effective monitoring helped in achieving a declining trend in COVID-19 positive cases; as well as, in containment of the virus. Additionally, several governments (including WHO) have developed different types of tools to continuously monitor and update the current status of COVID-19 cases. However, there had been recurrence of COVID19 amidst uncertainties.

Atmospheric Particulate Matter (PM) could form a suitable medium for transportation of the virus to greater distances. Incidentally, a positive correlation was observed between air transmission of the virus and air pollution. Further, the lung findings detected in hybrid images may help in the early diagnosis of pulmonary involvement. In fact, infected cases may be asymptomatic and could unknowingly disseminate the virus to surrounding people.

Further, confirmed COVID19 patients may also have acute bacterial infection. Moreover, acute COVID-19 patients may also suffer from invasive mycoses.

The high potential of COVID-19 in human to human spread may be neutralized by following effective one to one physical distance and sanitization. Governments, from time to time, may have to impose lockdown, etc., for strict implementation of effective physical distancing to reduce the spread of the infection. Effective surveillance at the global level is to be continued to track the epidemiological spread of COVID19.

3.4 A View

Based on the long experience of the present author in dealing with pandemics, he convincingly feels that, the present unabated global spread of COVID19 indicates that the multiplication of the virus (es) is supported by the present state of the environment, particularly, air temperature and humidity. It is quite understandable that, there has been change in the atmospheric temperature due to global climate changes, particularly, global warming. And, this altered temperature (and along with humidity) has, most probably, been supporting the prolific multiplication of the virus and its uncontrollable spread. Else, the virus ought to have been totally obliterated had environment not supported its multiplication. Therefore, parallel to efforts related to vaccine formulation and production, immediate research works are to be done to ascertain which particular temperature (and humidity) is supporting the prolific multiplication of virus and its spread globally like wild fire, This information should be extremely valuable; particularly, in foretelling the impending occurrence/recurrence of the viral infection. Concomitantly, there could be a predisposing “stress factor” in the environment which could initiate COVID19 infection. In the case of EUS fish pandemic, we could confirm that, low Total Alkalinity (TA) of water serves as a predisposing

stress factor in the initiation of EUS disease in the fishes. These are important inputs which the world is looking forward to.

4. Conclusion

Information on the hydrobiological conditions of any water body is of prime necessity before endeavouring to utilize it as a productive fishery. Proper planning depends on the availability of reliable data.

Wetlands have been derelicted and transformed by activities like unplanned urban and agricultural development, industrial sites, road construction, impoundment, resource extraction, etc., causing substantial long-term economic and ecological loss. There have been records of *c* 147 wetland sites in India. Approx. Records of wetland losses are: *c* 32% primarily through hunting and associated disturbances; *c* 22% due to human settlements; *c* 19% due to fishing and associated disturbances, and, *c* 23% through drainage for agriculture; *c* 20 % due to pollution from industries; *c* 15 % due to catchment vegetation denudation followed by soil erosion and siltation; and, so on. Further, *c* 4000 km² of mangrove area is said to be in existence in India. Wetland loss in India and in many other countries could lead to serious consequences; as, large human populations and many other biota depend on these wetlands.

Notwithstanding the above, wetlands have been an integral part of the social and cultural ethos of the Indians; and, their life have been very closely associated with the wetlands since time immemorial. People living close to wetlands follow the natural cycle of floods and adjust themselves to the seasonal movements of the fish. The fishes are harvested based mainly on changing water levels. However, due to poor resource base and livelihood insecurity in some parts of the country, there is generally irrational harvest from the wetlands. Such activities lead to rapid degradation and destruction of the wetlands.

It is, therefore, imperative to conserve the wetlands and protect their unique biodiversity. The wetlands could and do serve as the source of livelihood for a large number of people. So, they are to be properly conserved and managed. Moreover, if the natural environmental conditions are improved, there could be less probability of large-scale pandemics to occur.

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