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RESEARCH ARTICLE

SALINITY RISE IN AND AROUND KOLKATA: AN EFFECT OF GLOBAL WARMING

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ABSTRACT

Global warming is giving rise to accelerated sea-level rise. Sundarban being a subsiding delta such rate of sea-level rise shows compounded effect which is much more than the eustatic average rate. Sundarban delta is facing gradual inundation of islands on one hand and a gradual increase of surface water salinity on the other. Effect of rising salinity has of late became apparent even at the upstream of river Hoogly within the stretch of Kolkata where during last seven years true mangrove species like *Sonneratia caseolaris* has started appearing along with other back mangals. IPCC findings indicates a higher rate of rise of global average temperature since the year 2000 resulting in greater acceleration of rate of sea level rise. The nature's signature of such rise in salinity in the tidal Hoogly river is the appearance of mangroves within its Kolkata stretch on both the banks. Further, it is apprehended to jeopardise the ground water of the thickly populated Kolkata city, which calls for immediate massive rainwater harvesting to delay such saline incursion.

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INTRODUCTION

Sundarban represents the estuarine phase of Ganges-Bramhaputra river delta. Huge quantities of sediments are transported by this rive system (1670 million tons per year) causing subsidence of the delta (McDowell, 1995). This is causing a higher rate of sea-level rise than the accelerated global average rate resulting from Global warming. As a result salt wedge from the sea is gradually extending upstream of the river Hoogly. During 4000 years Before Past (BP). mangrove line in Sundarban came down to Kakdwip-Namkhana area and the line more or less coincide with *Kakdwip-Basirhat-Dhaka* lineament (which is collateral with the well known Dampier-Hodges line that marks the northern boundary of the present Sundarban Biosphere Reserve) (Banerjee *et al*., 1984; Morgan *et al*., 1959). There is a cretaceous crack in the continental shelf along Bengal basin. Along this "Hinge line" the Bengal basin suffers eastward tilting (Stanley *et al*., 1999), due to increasing load of huge sediment deposition. Surface waters of Sundarban creeks and rivers are gradually getting more and more saline (Milliman John and 1989). The tidal river Hoogly is also affected by the extending salt wedge from the estuary. As a result the river water side adjacent to Kolkata is registering mangrove invasion.

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MATERIALS AND METHODS

During the 16th - 18th century Bengal basin suffered a neo-tectonic movement when there was an easterly tilt along a hinge zone, starting from Sagar going north of Malda and then curving east towards Dhaka (Stanley *et al*., 1999). Another observation pertains to trend of surface elevation contours ENE-WSW (Hazra Sugata *et al*.,). As a result the present course of Ganges started flowing along the river Padma within Bangladesh leaving Hoogly the erstwhile course as a mere tidal channel. The tidal excursion of Hoogly reaches 281 Km. upstream up to Nabadwip. During the period 16th to 18th century innumerable back water channels of Indian Sundarban were formed.

John Milliman (IPCC, 2007), from his core sample studies established a threat of global sea-level rise along Bangladesh Sundarban. He identified the following threats:

- Bangladesh coast is subsiding @ 10 mm / y which accelerate the minimum estimate of Global Sea-Level Rise @ 2.20 mm / y.
- There is a tendency of northerly shift of present mangrove vegetation due to rapid development of shallow marine conditions created due to this accelerated rise of Sea-level.
- Delta progradation in Bangladesh side stopped during last 200 years.
- Salinity increased in creek waters.

- Salt water intrusion is taking place within coastal ground water aquifer which has been augmented due to a five fold increase in bore wells.
- The dense habitation of reclaimed Sundarban may be more vulnerable to inundation.

Table 1. Time series trend of salinity of river Hoogly the combined data of CPCB and CICFRI shows as follows for the Sagar Point

Trend of Salinity (ppt)in The River HOOGHLY (winter) Source: CPCB(1999)			CICFRI(2004)	SOS/JU
LOCATION / YEAR	1995	1997	2000	2009
Sagar(south)	17	22	22.24	26

SOS : School of Oceanographic Studies, Jadavpur University
Above increasing trend is significant with R^2 value of 0.7984.

Table 2.

Location	Year/Salinity (ppt) Source: CICFRI Annual Report[11]			
	1985	1995	2005	2013
Uluberia	0.028	0.042	0.094	0.132

McDowell, (1995) estimated the sediment load of Ganga-Brahmaputra river system to be 1670 million tones per year which is only 2nd to Yellow river of China. But Milliman estimated seaward directed suspended sediment load of $1060x10^6$ t/year[7]. However, this huge sediment load is causing easterly subsidence of the Bengal basin along the hinge line containing the Sundarban Delta (Stanley *et al*., 1999). The globally accelerated sea-level rise due to global warming causes a coupling effect with the subsiding large deltas of the world. In case of Sundarban delta the minimum rate of sea-level rise measured at Sagar point on the western edge shows 3.14 mm/y as against highest eustatic average rate of 2mm/y[8]. Further eastward of this easterly tilting basin the rate of sea level rise increases to 5mm/y at Pakhirala (Hazra Sugata *et al*.,), to 10mm/y at Khulna[7] due to subsidence aided sea-level rise. During last seven years when rate of increase of global surface temperature became steeper (Al Gore, 2007) (Sharma, 2000) rate of sea level rise also got accelerated.

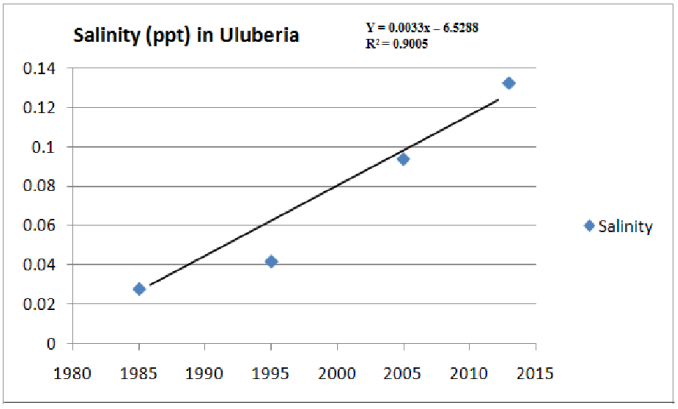


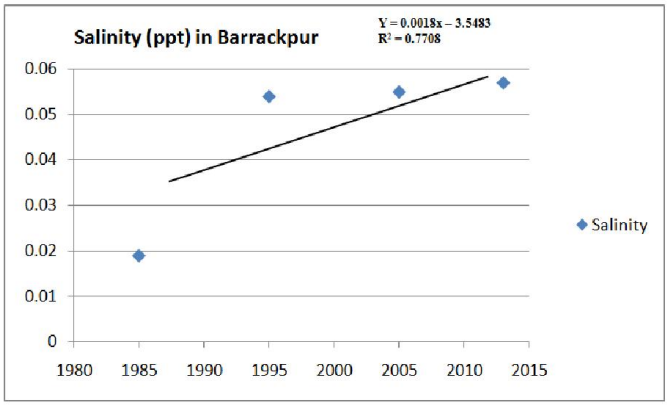
Table 3.

Location	Year/Salinity (ppt) Source: CICFRI Annual Report[11]			
	1985	1995	2005	2013
Barrackpur	0.019	0.054	0.055	0.057

Average salinity of the river Hoogly thus increased as a fall out of this phenomenon. This has become evident from the recent natural regenerations of mangrove plants along the Hoogly river at Kolkata. The natural mangrove plants (*Sonneratia caseolaris*) with prominent pneumatophores on the banks of Hoogly within Kolkata are all less than 7 year old. They are accompanied by the back mangals like *Deris trifoliata, Cryptocoryne ciliata* and occasional *Acanthus illicifolius*

Methodology

Salinity measurements in the river Hoogly are dependent on a) high tide, b) during low tide,c) seasonally, d) during opening of Farakka water,e) during closure of Farakka water. So average salinity of river water is measured during high tide of winter season when Farakka barrage releases water. The measurement of salinity of the river Hoogly at different locations starting from Barrackpore (20 Km North of Kolkata) to Uluberia (10 Km south of Kolkata), down to Sagar south (estuarine mouth) in a time series reveals a positive significant increasing trend as evident from the following table:



DISCUSSION

The salinity level of river Hoogly became abruptly lower during post Farakka barrage period as below:

Hoogly River Salinity (ppt) (After Nath and De, 1996)[12]

Place of Measurement	Pre Farakka (1960-61)	Post Farakka (1985)
Kakdwip	32.80	15.10

It becomes apparent from the above data that the level of salinity in the river Hoogly there after is steadily rising. The data collected from the estuarine mouth at Sagar south and upstream upto Barrackpore shows significant rise of average river salinity during

Location	R^2 value	Av. rate of salinity rise / y
Sagar south (estuarine mouth)	0.7984	0.63 ppt
Uluberia (half way tidal excursion)	0.9005	0.0066 ppt
Barrackpore (3/4 th tidal excursion)	0.7708	0.0018 ppt

The city of Kolkata lies in between Uluberia and Barrackpore. From the Table-1 it is also clear that the rate of salinity rise during last decade had been rather faster. As a result the boundary of true mangrove trees which were limited upto

Diamond harbour municipality during last 200 years along the river Hoogly has extended upstream even upto Kolkata. The 7 year old *Sonneratia caseolaris* tree between Babughat and Princep ghat along with the 5-6 year old same trees below Judges ghat is a nature's signature of the rising salinity.

Conclusion

The invasion of mangrove in the Kolkata stretch of the river Hoogly is only a sure indicator of increase in river salinity. The fear is the risk of salt water incursion in ground water in near future in the thickly populated metropolis of Kolkata. Some advance actions like massive recharging of ground water though rain water harvesting may delay the process.

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