

Response of *Sonneratia apetala* to Salinity in the Frame Work of Indian Sundarbans

Ankita Mitra¹, Prosenjit Pramanick², Sufia Zaman², Pardis Fazli³, Nabonita Pal² and Abhijit Mitra⁴

¹Department of Ecology and Environmental Science, School of Life Science, Pondicherry Central University, Puducherry, Kalapet, India

²Department of Oceanography, Techno India University, Salt Lake campus, Kolkata, India

³Department of Biological and Agricultural Engineering, University Putra, Selangor, Malaysia

⁴Department of Marine Science, University of Calcutta, 35, BC Road, Kolkata, India

Abstract: *Estuarine salinification has been suggested a serious threat to the survival and growth of mangroves. However, there are few fine-scale temporal and spatial data set of Above Ground Biomass (AGB) of mangrove species in relation to aquatic salinity which can provide a base line definition of extant conditions. Here we provide observational data from 24 different sites in the estuarine regions of Indian Sundarbans that is a luxuriant habitat for mangroves. Three distinct sectors within this habitat differ by salinity and to some extent by the nature of substratum. The influence of salinity is highly species-specific. Hence, we have focussed on the AGB of *Sonneratia apetala* in these three sectors of Indian Sundarbans namely western, central and eastern sectors. In the western sector, the average AGB of the species was 36.85 t ha⁻¹ in 1996, while in 2005 and 2015 the mean AGB were 43.17 t ha⁻¹ and 49.04 t ha⁻¹ respectively. In the central sector, the mean AGB of the species varied as per the order 7.83 t ha⁻¹ (in 2015) > 2.74 t ha⁻¹ (2005) > 0.84 t ha⁻¹ (1996). The eastern sector of Indian Sundarbans adjacent to Bangladesh Sundarbans exhibited highest AGB in 2015 (mean value = 20.21 t ha⁻¹) followed by 2005 (mean value = 14.72 t ha⁻¹) and 1996 (mean value = 9.16 t ha⁻¹). In selected sectors the significant variation in AGB may be related to pronounced spatio-temporal variations of salinity. It is noted that *S. apetala* grows well in hyposaline environment compared to hypersaline central Indian Sundarbans. The study thus concludes with the lesson that salinity profile must be taken into account while developing the master plan for afforestation programme in this deltaic ecosystem at the apex of Bay of Bengal.*

Keywords: Above Ground Biomass (AGB), Indian Sundarbans, *Sonneratia apetala*, salinity

1. INTRODUCTION

Mangrove ecosystems are among the most productive ecosystem on Earth with a mean production of 2.5 g C m⁻² day⁻¹ (Jennerjahn and Ittekkot, 2002). The global storage of carbon in mangrove biomass is estimated to be 4.03 Pg; 70 percent of which occurs in coastal margins from 0° to 10° latitude (Twilley *et al.*, 1992). This unique halophytic vegetation under the domain of blue carbon contributes ~ 11% of global total export to the ocean. However very little information is available on the regulatory role of salinity on blue carbon community although salinity governs the distribution and biomass of halophytes.

Mangrove forest of Indian Sundarbans is an ideal experimental bed to study the impact of salinity on the distribution and biomass of the floral species. Earlier works by researchers on this vertical reflect the inhibitory role of aquatic salinity on the AGB of mangroves (Mitra *et al.*, 2011; Banerjee *et al.*, 2013; Mitra, 2013; Raha *et al.*, 2014; Mitra and Zaman *et al.*, 2014; Mitra and Zaman, 2015). In this paper we attempt to combine information at different spatio-temporal scales which will aid in quantifying the regulatory role of salinity on the AGB of a common mangrove species, *S. apetala* inhabiting the 9630 sq.km. of Sundarban Biosphere Reserve (Indian part).

2. MATERIALS AND METHODS

2.1. The Test Bed: Indian Sundarbans

The study site is located at the apex of Bay of Bengal and encompasses about 102 islands (Mitra, 2000). 24 sampling sites were selected each in the western, central and eastern sectors of Indian Sundarbans (Figure 1). We demarcated these three sectors of Indian Sundarbans on the basis of

secondary data sources on salinity (Mitra *et al.*, 2009; Banerjee *et al.*, 2013; Mitra, 2013; Mitra and Zaman, 2015). The three sectors are significantly different due to anthropological and geo-physical factors. The western sector is hyposaline due to contribution of fresh water through Farakka barrage. The reduction in fresh water flow in the central Indian Sundarbans is attributed to Bidhyadhari siltation since the late 15th century (Chaudhuri and Choudhury, 1994). The eastern Indian Sundarbans, adjacent to Bangladesh receives fresh water from Ichaamati/Raimangal and also from upstream region.

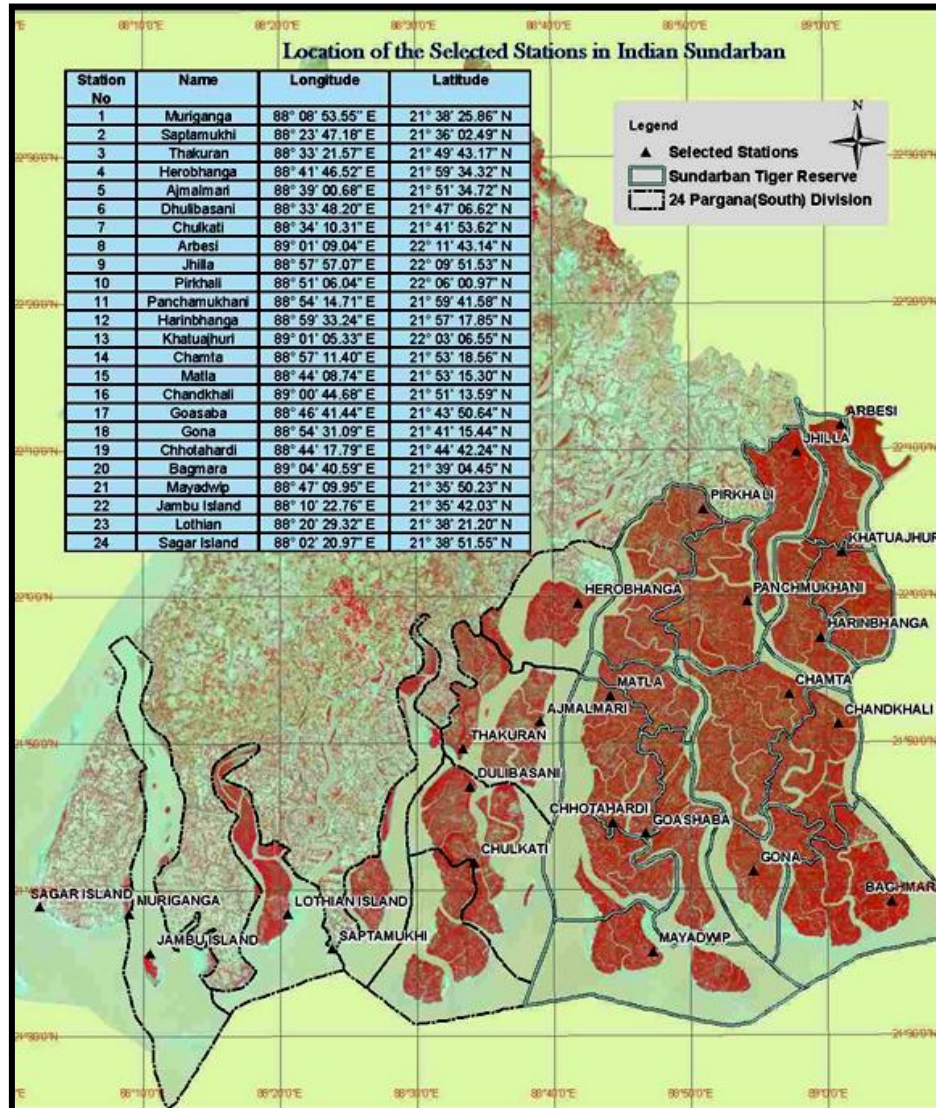


Figure1. Indian Sundarbans with 24 stations distributed in western, Central and eastern sectors; Sagar Island, Muriganga, Jambu Island and Lothian Island are within the western sector; Herobhanga, Matla, Ajmalhari, Thakuran, Dulibasani, Chotahardi, Chulkati and Saptamukhi are within the central sector and Arbesi, Jhilla, Pirkhali, Katuajhuri, Panchmukhani, Harinbhanga, Chamta, Chandkhali, Goashaba, Gona, Bagnara and Mayadwip are within the eastern sector of Indian Sundarbans

2.2. Data Description

We used several data sets from archives of Marine Science Department University of Calcutta, as well as published documents by Springer (Mitra, 2013; Mitra and Zaman, 2015) and TERI (Mitra and Zaman, 2015).

2.3. Statistical Analysis

To assess whether salinity and AGB varied significantly between sectors (western, central and eastern Indian Sundarbans) and years ANOVA was performed considering the secondary data. It is to be noted that every data point of salinity for each sector/station is the mean of 3 seasons (Premonsoon, monsoon and postmonsoon). Possibilities less than 0.05 ($p < 0.05$) were considered statistically significant.

3. RESULTS

Figure2. Represents Station-Wise Average AGB of *S.apetala*

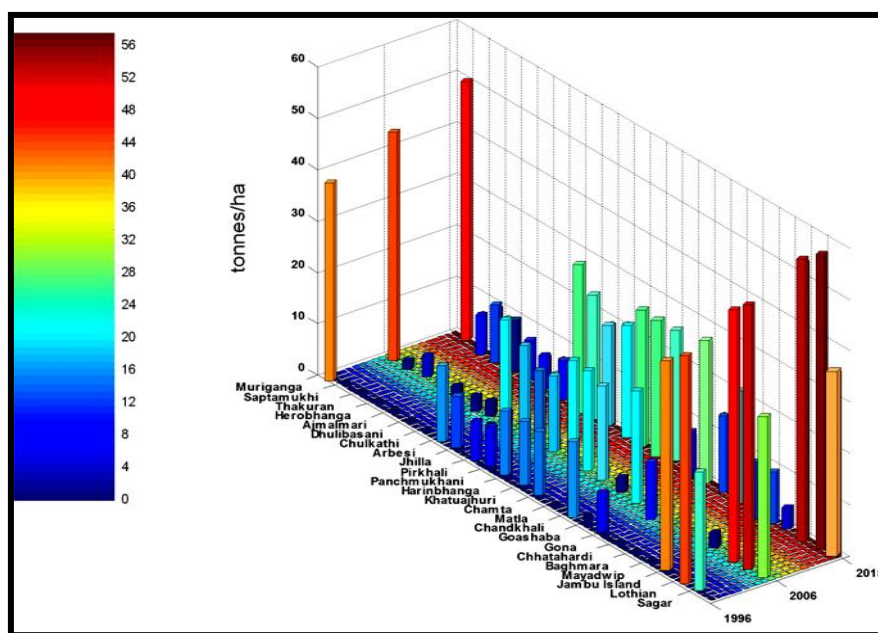


Figure2. Spatio-temporal variation of AGB of *S. apetala* in Indian Sundarbans

The average AGB of *S.apetala* in the western sector are 36.85 t ha⁻¹, 43.17 t ha⁻¹ and 49.04 t ha⁻¹ in 1996, 2005, 2015 respectively. In the central sector, the AGB values are 0.84 t ha⁻¹, 2.74 t ha⁻¹ and 7.83 t ha⁻¹ in the same years. The eastern sector of Indian Sundarbans adjacent to Bangladesh Sundarbans exhibit an intermediate average AGB of 9.16 t ha⁻¹, 14.72 t ha⁻¹ and 20.21 t ha⁻¹ in the same years. The salinity data collected from secondary data bank reflects the central sector hypersaline compared to the western and eastern sectors. The data of AGB were amenable to analysis by two-way ANOVA and significant variations between years and stations were observed (Table 1A and 1B).

Table1A. Seasonal and Spatial Variations of Salinity in Indian Sundarbans

Source of Variation	SS	df	MS	F _{cal}	P-value	F _{crit}
Stations	300.0044	23	13.04367	240003.5	2.5 × 10 ⁻⁹	1.77
Years	20.35583	2	10.17792	187273.7	1.13 × 10 ⁻⁹	3.19
Error	0.0025	46	5.43E-05	Comment: There are significant variations in salinity between years and stations (p < 0.01)		
Total	320.3628	71				

Table1B. Seasonal and Spatial Variations of AGB of *S. apetala* from Indian Sundarbans

Source of Variation	SS	df	MS	F _{cal}	P-value	F _{crit}
Stations	14498.98	23	630.3904	247.16	9.65 × 10 ⁻⁴¹	1.77
Years	1177.005	2	588.5027	230.7364	1.04 × 10 ⁻²⁴	3.19
Error	117.3249	46	2.550541	Comment: There are significant variations in AGB of <i>S. apetala</i> between years and stations (p < 0.01)		
Total	15793.31	71				

4. DISCUSSION

The Indian Sundarbans in the lower Gangetic delta region at the apex of Bay of Bengal is a complex region with numerous water masses. ANOVA results exhibit distinctly different salinity profile between the western, central and eastern sectors of Indian Sundarbans (Table 1A). This variation in salinity is primarily due to the coastal influence (intrusion of salinity water from Bay of Bengal during high tide), addition of fresh water through Farakka Barrage and complete blockage of fresh water supply due to siltation of the Bidhyadhari River. These primary factors regulating the salinity profile in the present geographical locale have been addressed by several researchers (Chaudhuri and Choudhury, 1994; Mitra *et al.*, 2011; Banerjee *et al.*, 2013; Mitra, 2013; Mitra and Zaman, 2015; Mitra and Zaman, 2016). Because of this variation in salinity, the AGB of *S. apetala* has been pronouncedly affected (Table 1B), and it is of the order western sector > eastern sector > central sector.

The present study has immense relevance in context to afforestation programme or eco-restoration programme as land-use changes in the Indian Sundarbans since last few decades has led to degradation of this fragile ecosystem and a loss of the goods and services they provide. Restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed and is critical for habitats where natural recovery is hindered. Random plantation of mangrove species often hikes up the restoration cost. The present study pinpoints clearly that *S. apetala* can be used to eco-restore the hyposaline zones of Indian Sundarbans and will be a mismatching species for hypersaline central sector.

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AUTHORS' BIOGRAPHY



Ms. Ankita Mitra, is a postgraduate student in the Department of Ecology and Environmental Science, School of Life Science, Pondicherry Central University, Puducherry, Kalapet, India. She has to her credit 8 publications on biodiversity and climate change. Ms. Mitra received the **Young Scientist Award** for the year 2014 from Centre for Ocean and Environmental Studies (COES), New Delhi. She participated in several national and international seminars both within India and abroad.



Mr. Prosenjit Pramanick, Research Scholar (presently) in the Dept. of Oceanography, Techno India University, Kolkata, India. He had completed his master degree in Biochemistry. He has to his credit about **53** scientific publications in various National and International journals on biodiversity, climate change, alternative livelihood etc. Mr. Pramanick received **Young Scientist Award** for the year 2014 from Centre for Ocean and Environmental Studies (COES), New Delhi.



Dr. Sufia Zaman, presently serving as Adjunct Assistant Professor in the Department of Oceanography in Techno India University (Kolkata) started her career in the field of Marine Science since 2001. She worked in the rigorous region of Indian Sundarbans and has wide range of experience in exploring the floral and faunal diversity of Sundarbans. She has published 3 books on carbon sequestration, 86 scientific papers and contributed chapters in several books on biodiversity, environmental science, aquaculture and livelihood development.



Dr. Pardis Fazli, holds a PhD degree in Agricultural Waste Engineering from Department of Agricultural and Biological Engineering, University Putra Malaysia. Currently, in addition to cooperation with her department, she is honoured of collaboration with Professor Dr. Mitra's research group in India. She has published more than 25 scientific papers and has expertise in ecological modelling and graphics.



Ms. Nabonita Pal, Research Scholar in the Department of Oceanography, Techno India University is a post graduate in Biotechnology. Ms. Pal is credited to have 10 publications in National and International journals of repute. Ms. Pal has experience in working in the mangrove ecosystem of Indian Sundarbans. On behalf of Techno India University, she attended several National and International seminars. Ms Pal was honoured with **Young Scientist Award** in 2014 by the Centre for Ocean and Environmental Studies (COES), New Delhi.



Dr. Abhijit Mitra, Associate Professor and former Head, Dept. of Marine Science, University of Calcutta (INDIA) has been active in the sphere of Oceanography since 1985. He is a Gold Medalist in Marine Science (M.Sc.) and obtained his Ph. D as NET qualified scholar in 1994. Dr. Mitra is credited to have about 350 scientific publications in various National and International journals, and 28 books of postgraduate standards. Dr. Mitra also successfully guided 24 Ph.D students. Presently his research areas include environmental science, mangrove ecology, sustainable aquaculture, alternative livelihood, climate change and carbon sequestration.