Stored Carbon in the Phytoplankton Community of a Freshwater Pond: A Case Study from Sirakol, South 24 Parganas, West Bengal

Jagadish Mondal[1], Sufia Zaman[2], Subhra Bikash Bhattacharyya[3], and Abhijit Mitra[4]

[1]Research Scholar, Department of Oceanography, Techno India University, West Bengal, EM 4 Salt Lake, Sector V, Kolkata 700091, India.

[2]Associate Professor, Department of Oceanography, Techno India University, West Bengal, EM 4 Salt Lake, Sector V, Kolkata 700091, India.

[3]Adjunct Professor, Department of Oceanography, Techno India University, West Bengal, EM 4 Salt Lake, Sector V, Kolkata 700091, India.

[4]Director (Research),Techno India University, West Bengal, EM 4 Salt Lake, Sector V, Kolkata 700091, India.

Abstract

Phytoplankton in freshwater ponds play a significant yet often underappreciated role in the global carbon cycle, particularly in the context of carbon sequestration and the reduction of atmosphericCO_2 levels. These microscopic organisms, primarily algae, perform photosynthesis, a process in which they absorb CO_2 from the atmosphere and convert it into organic matter. This function is crucial, as it forms the foundation of the aquatic food web and contributes to the storage of carbon in various forms within the pond ecosystem.This study investigates the carbon content of phytoplankton in a pond located at Sirakol, South 24 Parganas, West Bengal. Samples were collected and analyzed to determine the standing stock, cell volume, and carbon content of various phytoplankton species. The results reveal significant variations in carbon content across species, with *Fragilaria* sp. contributing the highest total carbon content per liter due to its substantial cell volume.

Keywords: Phytoplankton, Freshwater Pond, Sirakol, Stored carbon

1. Introduction

In freshwater ponds, phytoplankton are the primary producers, meaning they are at the base of the food chain. Through photosynthesis, they capture solar energy and use it to fix carbon dioxide, producing organic carbon compounds that serve as food for higher trophic levels, including zooplankton, fish, and other aquatic organisms. The carbon fixed by phytoplankton can follow several pathways: it can be respired back into the atmosphere, consumed by other organisms, or settle into the sediments at the bottom of the pond. When carbon settles into the sediments, it becomes part of the long-term carbon storage system, effectively sequestering it from the atmosphere for extended periods.

The efficiency of carbon storage in freshwater ponds is influenced by various environmental factors, including nutrient availability, light penetration, temperature, and the overall health and diversity of the phytoplankton community. Ponds that are rich in nutrients, particularly nitrogen and phosphorus, tend to have higher rates of primary production, leading to greater carbon fixation by phytoplankton. However, excessive nutrient loading, often from agricultural runoff, can lead to eutrophication, causing algal blooms that can disrupt the balance of the ecosystem and potentially reduce the efficiency of carbon sequestration.

One of the critical aspects of carbon storage in ponds is the role of sedimentation. When phytoplankton die, their organic matter can sink to the bottom of the pond, where it may be buried in sediments. In the absence of oxygen, the decomposition of this organic matter is slowed, leading to long-term storage of carbon in the sediment layers. This process is similar to what occurs in larger bodies of water, such as lakes and oceans, but on a smaller scale. Despite their size, ponds can be surprisingly effective carbon sinks due to their often high rates of primary productivity and sediment accumulation.Moreover, the carbon storage capacity of freshwater ponds contributes to the regional carbon budget, acting as a small but crucial counterbalance to the anthropogenic emissions of CO_2. The preservation and restoration of these ecosystems are essential for enhancing their role in carbon sequestration. Protecting freshwater ponds from pollution, managing nutrient inputs, and maintaining healthy phytoplankton communities are all critical strategies for maximizing their potential as carbon sinks.

In the context of climate change and increasing atmospheric CO_2 levels, the role of phytoplankton in carbon sequestration has gained renewed attention. Phytoplankton's ability to fix carbon and its subsequent storage in aquatic systems can help mitigate the impacts of climate change by reducing the amount of CO_2 in the atmosphere. Therefore, quantifying the carbon content of phytoplankton and understanding the factors that influence it is of great importance for both ecological research and environmental management.

This study utilizes data collected from the pond at Sirakol to analyze the standing stock, cell volume, and carbon content of various phytoplankton species. The findings will contribute to a broader understanding of phytoplankton's role in carbon cycling within inland water bodies, with potential implications for regional carbon management strategies.

2. Methodology

The study was conducted in a freshwater pond located at Sirakol, South 24 Parganas, West Bengal, India. The pond (labelled as Pond A in the drone view) is situated near to the western sector of Indian Sundarbans, a region known for its rich biodiversity and complex aquatic ecosystems (Fig. 1). Basically this pond is meant for carp culture that has been identified as one of the sampling site for carrying out the Ph.D programme of Mr.Abhirup Mitra, a research scholar of Techno India University, West Bengal.

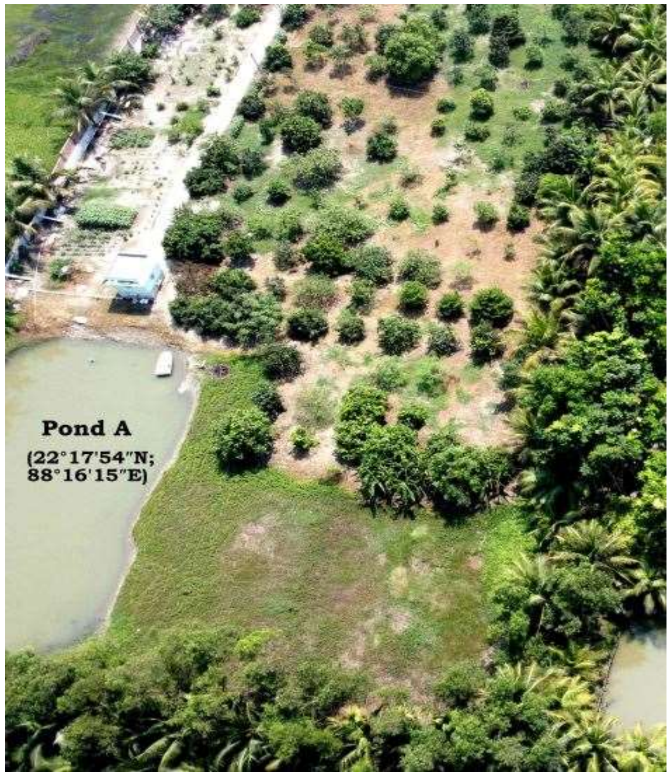


Fig. 1. Study stite (freshwater pond labelled as pond A) at Sirakol in 24 Parganas (South) in West Bengal

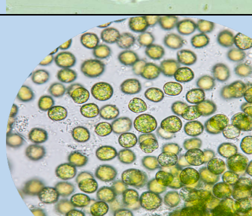
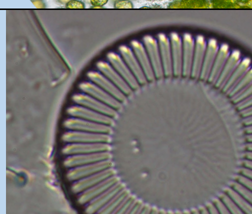
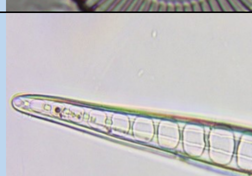
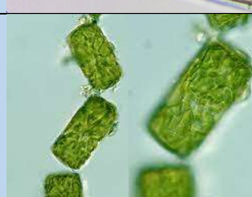
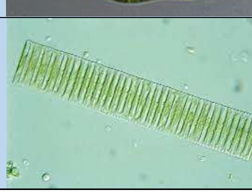
Water samples were collected from the pond during the study period on 22ndto 26thApril, 2024. Phytoplankton species were identified and quantified using standard microscopic techniques. Linear dimensions of the phytoplankton species were measured by obtaining taxonomic information and searching the shape code as provided by Sun and Liu (2003). For each species the best fitting geometric shape and corresponding equation was used to calculate the cell volume. The carbon content per cell was estimated based on the cell volume, using established conversion factors. The total carbon content per litre of water was calculated by multiplying the carbon content per cell by the standing stock of each species.

3. Results

A total of 15 species were identified, with *Fragilaria*sp. exhibiting the highest cell volume and total carbon content per litre (Table 1).

The total carbon content across all species varied, with *Fragilaria* sp. contributing the most significant amount, followed by *Climocosphenia* sp. and *Nitzschia* sp. The overall carbon content per litre of water was found to be significant, indicating that the pond serves as a notable sink for carbon storage.

Table 1 List of phytoplankton species with numbers, cell volume, carbon content per cell and per litre

Sl. No.	Microscopic view	Scientific Name	Standing Stock (No. × 10^5/L)	Cell Volume (μm^3) of phytoplankton	Carbon content per cell (pg)	Total Carbon content (pg/lt)
1.		*Coscinodiscus* sp.	21.10	10637.39	461.76	9743.14
2.		*Chlorella* sp.	16.45	12132.22	455.26	7489.03
3.		*Cyclotella* sp.	13.65	4196.70	150.67	2056.65
4.		*Climocosphenia* sp.	18.65	44451.19	1295.75	24165.74
5.		*Biddulphia* sp.	7.05	4266.90	247.94	1747.98
6.		*Euglena* sp.	6.65	3839.30	210.79	1401.76
7.		*Fragilaria* sp.	9.10	26499.76	6154.72	56007.96

8.		*Nitzschia*sp.	9.40	25031.36	953.69	8964.69
9.		*Nostoc* sp.	10.15	770.75	55.12	559.47
10.		*Navicula*sp.	3.65	357.90	86.66	316.31
11.		*Peridinium* sp.	3.25	1503.43	93.85	305.01
12.		*Pleurosigma* sp.	5.50	19855.18	858.81	4723.46
13.		*Rhizosolenia*sp.	3.20	3764.91	228.73	731.94
14.		*Synedra* sp.	2.45	4341.69	248.55	608.95
15.		*Thallassiosira* sp.	3.95	3726.28	228.73	903.49

4. Discussion

Phytoplankton play a fundamental role in the carbon cycle of aquatic ecosystemslike other members of producer communities including the halophytes (Mitra, 2013; Mitra and Zaman, 2015; Mitra and Zaman, 2016; Mitra, 2018; Mitra and Zaman, 2021; Paul et al., 2021, Mitra et al., 2022; Mitra et al., 2023). These microscopic free floating floral entities are noted for their carbon sequestration potential (Mitra et al., 2016; Pal et al., 2016, 2018, 2018a, 2019, 2020, 2020a, 2021, 2022). Understanding how phytoplankton species adapt to these variations and their capacity for carbon storage is crucial for assessing the role of estuarine ecosystems in mitigating climate change.

The carbon storage potential of phytoplankton is influenced by their cell volume, which can vary significantly across different species and environmental conditions. Even in the estuarine regions like the Sundarbans, where salinity gradients are pronounced, the relationship between salinity and phytoplankton cell volume can provide insights into the adaptability and carbon sequestration efficiency of these organisms. Despite the well-documented diversity of phytoplankton in the Sundarbans (Mitra, 2013; Mitra and Zaman, 2015; Mitra and Zaman, 2016; Mitra, 2018; Mitra and Zaman, 2021), there has been limited research on how cell volume regulates the carbon storage in the phytoplankton community.Based on the data provided in the document, *Fragilaria* sp. emerges as the most effective species for carbon storage in freshwater ponds. Its ability to fix higher amounts of carbon per unit of water, coupled with its adaptability to different environmental conditions, makes it the best candidate for maximizing carbon sequestration in these ecosystems. The implications of this finding are significant for managing freshwater bodies to enhance their role as carbon sinks. By promoting the growth of *Fragilaria*sp. in ponds, especially in controlled environments where nutrient inputs can be managed, it is possible to increase the carbon storage potential of these ecosystems.

5. Conclusion

The present study focuses on a pond located at Sirakol in the South 24 Parganas district of West Bengal, India. This region is characterized by its proximity to the Sundarbans and its unique ecological conditions. The objective of this study is to assess the carbon content of phytoplankton species in this pond, considering the implications for carbon storage. Understanding the carbon dynamics of phytoplankton in such smaller water bodies is essential for several reasons. Firstly, ponds and other small aquatic systems can collectively contribute significantly to local, regional and global carbon budgets. Secondly, the species composition and biomass of phytoplankton in these systems can vary considerably from those in larger water bodies, potentially leading to differences in carbon storage efficiency. Lastly, the study of carbon content in phytoplankton provides insights into the ecological health of the water body, serving as an indicator of productivity and nutrient cycling.

References

1. Mitra, A. (2013). Sensitivity of mangrove ecosystem to changing climate. Springer, New Delhi, Heidelberg, New York, Dordrecht, London. ISBN-10: 8132215087; ISBN-13: 2013 978-8132215080. ISBN 978-81-322-1509-7 (eBook), XIX: pp. 323. DOI: https://doi.org/10.1007/978-81-322-1509-7.

2. Mitra, A. (2018). Can Species serve as Proxy to Climate change induced Salinity alteration? Journal of Marine Biology and Aquascape, 1-3.

3. Mitra, A., Pal, N., Chakraborty, A., Mitra, A., Trivedi, S. and Zaman, S. (2016). Estimation of stored carbon in *Sonneratia apetal*a seedlings collected from Indian Sundarbans. Indian Journal of Marine Science, Vol. 45(11), pp. 1598-1602.

4. Mitra, A., Zaman, S. (2015). Blue carbon reservoir of the blue planet published by Springer, ISBN 978-81-322-2106-7, XII, pp. 299. DOI 10.1007/978-81-322-2107-4.

5. Mitra, A., Zaman, S. (2016). Basics of marine and estuarine ecology. Published by Springer New Delhi, eBook ISBN 978-81-322-2707-6, Hardcover ISBN 978-81-322-2705-2, XII, pp. 483. DOI: https://doi.org/10.1007/978-81-322-2707-6.

6. Mitra, A., Zaman, S. (2021). Estuarine Acidification: Exploring the Situation of Mangrove Dominated Indian Sundarban Estuaries. Springer eBook ISBN 978-3-030-84792-0, XII: pp. 402. DOI: https://doi.org/10.1007/978-3-030-84792-0.

7. Mitra, A., Zaman, S., Pramanick, P. (2022). Blue Economy in Indian Sundarbans: Exploring Livelihood Opportunities. Springer ISBN 978-3-031-07908-5 (e-Book), XIV: pp. 403. DOI: https://doi.org/10.1007/978-3-031-07908-5.

8. Mitra, A., Zaman, S., Pramanick, P. (2023). Climate Resilient Innovative Livelihoods in Indian Sundarban Delta. Springer, Hardcover ISBN 978-3-031-42632-2, eBook ISBN 978-3-031-42633-9, XII, pp. 297. DOI: https://doi.org/10.1007/978-3-031-42633-9.

9. Pal, N., Agarwal, S., Sinha, M., Zaman, S. and Mitra, A. (2022). Chlorophyll *a* level in the Coastal Water of Digha Coast: A Situation Analysis. Journal of Mechanics of Continua and Mathematical Sciences, Vol. 17 (10), 17-24. https://doi.org/10.26782/jmcms.2020.10.00003.
10. Pal, N., Amin, G., Zaman, S., Biswas, P., Mitra, A., (2016). Spatial Variation of Stored Carbon in Avicennia alba Seedlings of Indian Sundarbans. Int. J. Trend Res. Dev.; Vol. 3(4), pp. 100-103.

11. Pal, N., Barman, P., Das, S., Zaman, S., and Mitra, A. (2020). Status of brackish water phytoplankton during COVID-19 lockdown phase. NUJS Journal of Regulatory Studies, 2020 (Special Edition), ISSN: 2456-4605, pp. 75-78.

12. Pal, N., Fazli, P., Pramanick, P., Zaman S. and Mitra, A. (2018a). Can Near Surface Air Temperature act as Proxy to Anthropogenic influence in the mangrove dominated Indian Sundarbans? Parana Journal of Science and Education (PJSE), Vol. 4(2), pp. 61-68.

13. Pal, N., Mitra, A., Gobato, R., Zaman, S., Mitra, A. (2019). Natural Oxygen Counters in Indian Sundarbans, the Mangrove Dominated World Heritage Site. Parana Journal of Science and Education, Vol. 5(2), pp. 6-12.

14. Pal, N., Saha, A., Zaman, S., Mitra, A., (2018). Soil Organic Carbon (SOC) level of the inter-tidal mudflats in Indian Sundarbans. Techno International Journal of Health, Engineering, Management & Science, Vol. 2(3), pp. 64-68.

15. Pal, N., Zaman, S. and Mitra, A. (2020a). Carbon Scrubbing Property of *Rhizophora apiculata* inhabiting Indian Sundarbans. In: Natural Resources and Their Ecosystem Services. Edited by Abhijit Mitra, Monruskin M. Calma and Shambhu Prasad Chakrabarty, published by HSRA Publication, ISBN 978-81- 947216-7-3, pp. 50-54.

16. Pal, N., Zaman, S. and Mitra, A. (2021). Response of *Avicennia marina* seedlings to salinity fluctuation. Chapter 9, In: Natural Resources and Their Ecosystem Services, Vol. II, Edited by Abhijit Mitra, Monruskin M. Calma and Shambhu Prasad Chakrabarty, published by HSRA Publication, ISBN 978-93-5506-064-8, pp. 153-160.

17. Paul, D.K., Pramanick, P., Zaman, S., Mitra, A. (2021). Respondent analysis in context to Impact of Climate Change on the regulating services of mangrove vegetation. Journal of Mechanics of Continua and Mathematical Sciences, 16(11), 26-33. Doi: https://doi.org/10.26782/jmcms.2021.11.00003.

18. Sun J & Liu DY (2003), Geometric models for calculating cell biovolume and surface area for phytoplankton, J. Plankton Res., 25: 1331-1346.