Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(2), 1392-1397 | ISSN: 2251-6719

Assessment of Soil Organic Carbon Dynamics in a Freshwater Lake Ecosystem: A Model-Based Study

B. Madhavi[1], S. Subha[2], M. V. Raju[3]

[1]Assistant Professor, Department of Environmental Studies, Dr. Lankapalli Bullayya College, Visakhapatnam, Andhra Pradesh, India.
[2]HOD and Assistant Professor, Department of Microbiology, Dr. Lankapalli Bullayya College, Visakhapatnam, Andhra Pradesh, India.
[3]Assistant Professor, Department of CEPC, Vignan's Foundation for Science, Technology and Research, Deemed to be University, Guntur, Andhra Pradesh, India.

(Received: 26 February 2025 Revised: 30 March 2025 Accepted: 22 April 2025)

KEYWORDS
Soil Organic Carbon (SOC), Wetland, Lake, Freshwater, Public Health and Environment

ABSTRACT:
Wet lands are estimated to cover between 2-6% of the earth's surface and contain about 35% of global terrestrial carbon since they are highly productive. Wetlands are incredible important systems for water, nutrient and carbon cycling, water purification, flood prevention and in supporting biodiversity. Wetlands are depositional areas capable of storing carbon rich organic sediments. Biologically wetlands are with high photosynthesis rates, leads to greater carbon capture and have potential to remove large quantities of carbon from the atmosphere, which will help to mitigate global warming. Changes in the hydrological conditions of these wetlands, however, could lead to the release of a huge amount of stored carbon back into atmosphere. As wetlands are centers of high productivity in the landscape, they have a high capacity to sequester and store carbon. Clearing or drainage of wetlands can lead to large losses of stored organic carbon to atmospheric carbon dioxide. In view of the above background and importance of wetlands, this study has been conducted on the role of wetland communities and soil organic carbon (SOC) content in the soils at four habitat zones of Kondakarla Fresh water lake, Visakhapatnam district, Andhra Pradesh, India.

1. Introduction

Soil Organic Carbon (SOC) plays a critical role in the global carbon cycle, acting as both a source and sink of atmospheric carbon dioxide. In aquatic ecosystems such as freshwater lakes, sediments serve as major reservoirs of organic carbon, contributing significantly to long-term carbon storage and biogeochemical cycling. Understanding the dynamics of SOC in these environments is essential for evaluating their role in climate regulation, ecosystem functioning, and nutrient cycling. Freshwater lakes receive organic carbon inputs from a variety of sources, including terrestrial runoff, aquatic vegetation, and planktonic productivity. Once deposited in the sediment, SOC undergoes complex interactions influenced by physical, chemical, and biological processes. These processes govern the stabilization, decomposition, and eventual sequestration or release of carbon within the sediment layers.

The dynamics of SOC in lake ecosystems are shaped by a range of factors such as sedimentation rates, hydrological conditions, temperature, microbial activity, and land-use practices in the surrounding catchment area. As anthropogenic pressures and climate change continue to alter these systems, the balance and behavior of SOC are increasingly subject to change, making it imperative to study and model these dynamics in detail. This study aims to explore the spatial and temporal variations of SOC within the sediments of a freshwater lake, using modeling tools to understand the mechanisms of carbon accumulation and transformation. By establishing a model framework, the research provides insights into the lake's potential for carbon sequestration and offers a scientific basis for managing freshwater ecosystems in the context of climate change.

2. Objectives:

- ✓ To quantify the concentration and distribution of Soil Organic Carbon (SOC) in the sediments of a freshwater lake

3. Study Area:

Kondakarla Ava, commonly known as Kondakarla Freshwater Lake, is located in the Anakapalli district of Andhra Pradesh, India. Geographically positioned at approximately 17.6°N latitude and 83.1°E longitude,

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(2), 1392-1397 | ISSN: 2251-6719

the lake lies at the foothills of the Eastern Ghats and is part of a unique wetland ecosystem. Recognized as an important biodiversity hotspot, Kondakarla Lake is a designated Eco-Tourism Destination and is known for its rich variety of flora and fauna, especially migratory birds and aquatic vegetation.

The lake plays a crucial ecological and socio-economic role, supporting local agriculture, fisheries, and providing water for nearby villages. Surrounded by agricultural lands and human settlements, the lake is subject to seasonal runoff, nutrient input, and anthropogenic pressures, all of which influence the sediment composition and carbon dynamics within the lake system.

Given its ecological sensitivity and strategic location, Kondakarla Lake offers a representative site for studying Soil Organic Carbon (SOC) dynamics in a tropical freshwater ecosystem. The interaction of organic matter input from surrounding vegetation, aquatic biomass, and land-use changes makes it an ideal natural laboratory for understanding the processes of carbon accumulation, storage, and decomposition in lake sediments. This study focuses on examining the concentration and distribution of SOC in the lake's sediment profile, aiming to provide insights into its carbon sequestration potential, biogeochemical functioning, and implications for lake ecosystem management under changing environmental conditions.

The study area of Kondakarla lake is divided into four habitat zones: Wet meadows of lake fringes (Zone – I), Marshy swamps of transitional areas (Zone-II), Shallow open areas of littoral waters (Zone- III), and Lake bed interior limnetic waters (Zone-IV). The description of Lake habitat zones has been shown in Figure 1.

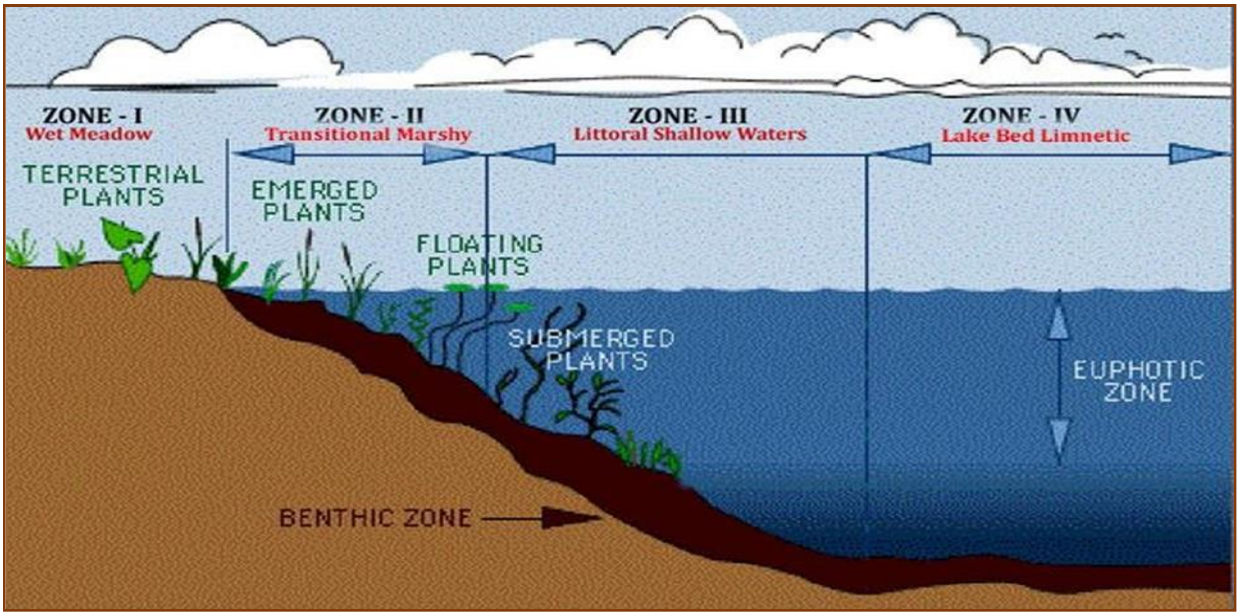


Figure 1. Demarcation of habitat zones and contour areas of study water lake

4. Results & Discussions:

It was estimated in the laboratory using the Walkley and Black method, which was widely adopted in many laboratories due to its rapidity and cost-effectiveness.

The Percentage of Organic Content (OC) in the soil is calculated as:

SOM (%) = % of Soil Organic Carbon × 1.724.

Table 1. Soil Organic Matter (SOM) at four wetland vegetation zones in Study Lake

Sample No.	Wet meadows (%)	Marshy swamps (%)	Shallow Waters (%)	Interior lake bed (%)
1	2.605±0.017	1.788±0.068	4.123±0.367	6.09±0.529
2	2.383±0.469	3.558±0.129	3.223±0.502	5.553±0.356

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(2), 1392-1397 | ISSN: 2251-6719

3	1.835±0.110	1.665±0.029	2.988±0.760	4.023±0.765
4	2.718±0.083	1.978±0.073	4.078±0.605	5.868±0.405
5	1.908±0.030	2.893±0.043	5.450±0.220	6.463±0.183
6	1.098±0.015	1.903±0.088	2.665±0.863	3.748±0.414
7	1.773±0.057	2.448±0.062	2.555±0.132	2.645±0.537
8	2.155±0.049	2.728±0.046	3.588±0.147	5.895±0.234
9	1.935±0.037	2.703±0.207	5.743±0.862	4.933±0.871
10	2.908±0.0274	1.705±0.090	3.780±0.139	5.663±0.015
Mean	2.131±0.146	2.3365±0.052	3.819±0.300	5.088±0.260

Table 2. Soil Organic Carbon (SOC) at four Wetland zones of Study Lake

Sample No	Wet Meadows ($g^{C}Kg^{-1}$)	Marshy Swamps ($g^{C}Kg^{-1}$)	Shallow waters ($g^{C}Kg^{-1}$)	Interior lake bed ($g^{C}Kg^{-1}$)
1	15.10±0.12	10.35±0.41	23.90±2.14	35.33±3.06
2	13.83±2.72	20.63±0.75	18.69±2.92	32.20±2.07
3	10.65±0.65	9.65±0.17	17.33±4.40	23.35±4.42
4	15.78±0.48	11.45±0.41	23.65±3.52	34.05±2.35
5	11.05±0.17	16.78±0.26	31.60±1.27	37.48±1.06
6	6.35±0.10	11.03±0.53	15.45±5.02	21.73±2.39
7	10.28±0.33	14.20±0.36	14.83±0.78	15.33±3.12
8	12.48±0.29	15.83±0.25	20.80±0.84	34.20±1.36
9	11.23±0.22	15.68±1.20	33.30±5.00	28.60±5.06
10	16.85±1.58	9.90±0.52	21.93±0.80	32.85±0.10
Mean	12.36±0.84	13.55±0.30	22.15±1.75	29.51±1.50

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(2), 1392-1397 | ISSN: 2251-6719

Figure 2. Graphical representing mean values of soil organic carbon (SOC) content in four habitat zones of study lake

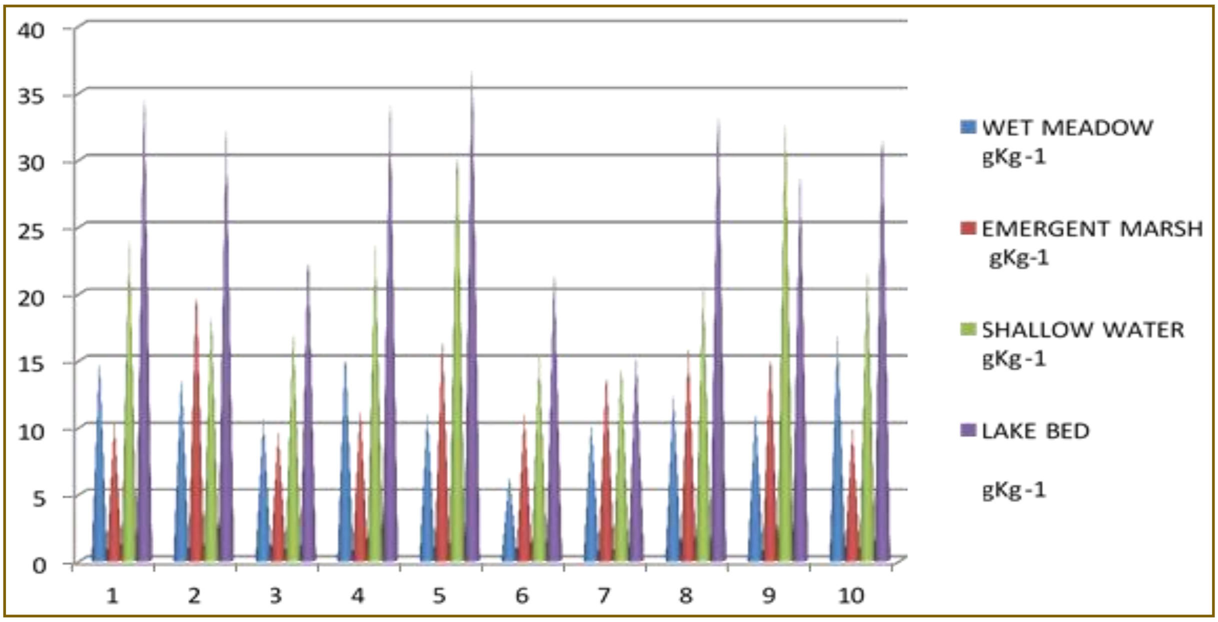
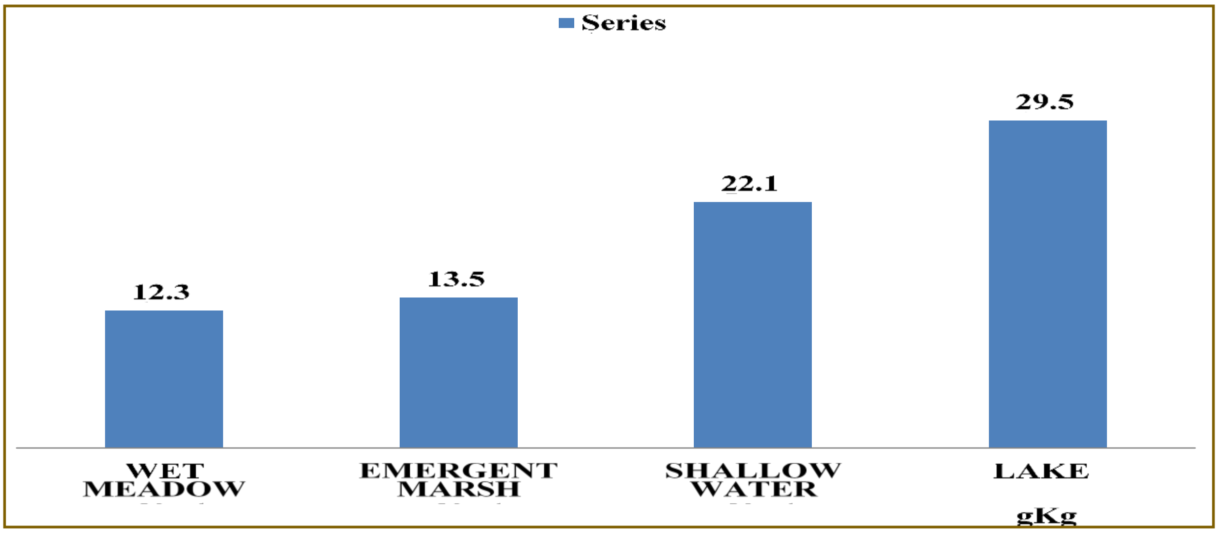


Figure 3. Graphical representing average mean values of the soil organic carbon (SOC) content in four habitat zones of study lake



Soil organic matter:

The percentage of organic matter content of four habitat zones, indicated highest percentage was recorded at lake bed of interior areas (5.08±0.26%); followed by shallow waters (3.81±0.30%); wet meadow towards landward gradients (2.13±0.14%) and transitional areas of marshy swamps (2.33±0.05%).

Soil organic carbon:

Highest concentration of soil organic carbon (SOC) was recorded at lake bed interior areas ranges from 15.33±3.12 to 37.48±1.06 $g^{C}Kg^{-1}$ with a mean value of 29.51±1.50 followed by littoral shallow water soils (14.83±0.78 to 33.30±5.00 $g^{C}Kg^{-1}$) mean of 22.15±1.75.

Lowest concentration of organic carbon was found at wet meadow swamp (6.35± 0.10 to 16.85±1.58 $g^{C}Kg^{-1}$) mean 12.36±0.84 and emergent marsh (9.65±0.17 to 20.63±0.75 $g^{C}Kg^{-1}$) mean 13.55±4.12 respectively.

The soil organic carbon was increased from land ward to lake interior areas: wet meadows: wet meadows< marshy swamps <shallow littoral waters < limnetic lake deep waters.

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(2), 1392-1397 | ISSN: 2251-6719

The soil organic carbon of wetland communities shows significant variation in total amount of organic carbon between wet meadow swamp and emergent marshy zones, rather shallow waters and lake bed interior areas. Fig 2 has been shown the Graphical representing mean values of soil organic carbon (SOC) content in four habitat zones of study lake and the Fig 3 has been shown the Graphical representing average mean values of the soil organic carbon (SOC) content in four habitat zones of study lake.

5. Conclusions:

In the context of understanding and managing the concentration and distribution of Soil Organic Carbon (SOC) in the sediments of freshwater lakes, the application of the wise-use principle provides a strategic framework for policy development and environmental stewardship. The following conclusions are drawn:

Legislative and Policy Alignment:

Effective management of SOC in freshwater lake sediments necessitates the review and harmonization of existing legislation and government policies. This alignment ensures that wetland conservation and sustainable use are adequately supported at all administrative levels.

Promotion of Knowledge and Awareness:

Raising awareness about the ecological importance of wetlands and the role of SOC in supporting ecosystem functions is essential. Regular reviews of the ecological status of wetlands and the identification of priority areas are critical steps toward informed policy and management decisions.

Targeted Site-Based Approaches:

Specific challenges at individual wetland sites must be addressed through targeted interventions. Rapid dissemination of available scientific and traditional knowledge on soil characteristics, vegetation, hydrology, and aquatic communities—through media, public dialogue, and stakeholder engagement—can significantly enhance public understanding and contribute to the formulation of effective management plans.

Utilization of Geo-Referenced Data:

Geo-referenced, location-specific data on factors such as topography, landform, soil type, climate conditions, water availability and usage, water quality, land cover, agricultural suitability, population dynamics, infrastructure, and land tenure play a vital role in planning for the sustainable use and monitoring of wetlands, including the assessment of SOC distribution.

Integration of Geospatial Technologies:

The use of remote sensing and Geographic Information Systems (GIS) offers valuable tools for monitoring changes in wetland land use, mapping environmental conditions, and characterizing spatial patterns of SOC in lake sediments. These technologies support evidence-based decision-making and long-term ecological monitoring.

References

1. APHA, AWWA, WPCF, Standard methods for the examination of water and wastewater. (20th edition). American public health association, Washington DC, New York. 1998.
2. Alongi, D. M. 2011. "Carbon Payments for Mangrove Conservation: Ecosystem Constraints and Uncertainties of Sequestration Potential." Environmental Science &Policy 14(4): 462-470.
3. Asha, A., Keerthi, Muthukrishnaraj, A., & Balasubramanian, N. (2014). Improvement of biodegradability index through electrocoagulation and advanced oxidation process. International Journal of Industrial Chemistry, 5, 1-6.
4. Aselmann, I. And Crutzen, P. J. 1989.global distribution of natural freshwater wetlands and rice paddies, Their net primary productivity, seasonality and possible methane emissions. J. Atmos. Chem. 8, 307–358.
5. Bernal B, Mitsch W.J. 2012. Comparing carbon sequestration in temperate freshwater wetland communities. Glob change biol. 18:1636–1647.
6. Bernal.B. 2012 carbon sequestration in natural and created wetlands. Dissertation Ohio State University, USA.
7. Babuponnusami, A., Sinha, S., Ashokan, H., Paul, M. V., Hariharan, S. P., Arun, J., (2023). Advanced oxidation process (AOP) combined biological process for wastewater treatment: A review on advancements, feasibility and practicability of combined techniques. Environmental research, 116944.
8. Coletti, J. Z., C. Hinz, et al. 2013. "Hydrological controls on carbon metabolism in wetlands." *Ecological Modelling* 249(0): 3-18.
9. Costanza, R., R. D'Arge, et al. 1997."The value of the world's ecosystem services and natural capital."*Nature* 387(6630): 253-260.
10. Dahl, T. 2000.Status and trends of wetlands in the conterminous United States 1986 to 1997., U.S. Department of the Interior; Fish and Wildlife Service.*Washington*, D.C: 82.
11. https://www.cpcb.nic.in/generalstandards.pdf
12. Figueiredo CC, Resck DVS, Carneiro MAC2010. Labile and stable fractions of soil

organic matter under management systems and native cerrado. R Bras Ci Solo.;34:907-16.

13. Gopal B.1995.Handbook of Wetland Management WWI. India. – 306.
14. Kayranli, B., M. Scholz, 2010. "Carbon Storage and Fluxes within Freshwater Wetlands: a Critical Review." Wetlands 30(1): 111-124.
15. Krogh, L., Noergaard, A., Hermansen, M., Greve, M.H., Balstroem, T., Breuning- Madsen, H., 2003. Preliminary estimates of contemporary soil organic carbon stocks in Denmark using multiple datasets and four scaling-up methods. Agric. Ecosyst. Environ. 96,19–28.
16. Kusler, J. 2005. “Common questions: Wetland, climate change, and carbon sequestering.”Retrieved from http://www.aswm.org/pdf_lib/11_carbon_6_26_06.pdf
17. Mitra S, Wassmann R, Vlek PLG 2005 An appraisal of global wetland area and its organic carbon stock. CurrSci 88:25–35
18. Mitra, S., Wassmann, R., Vlek, P.L.G., 2005.An appraisal of global wetland area and its organic carbon stock.Curr. Sci. 88, 25–35. Mitsch, W.J., Gosselink, J.G., 2007. Wetlands, fourth ed. John Wiley & Sons, New York.
19. Mitsch, W. J. and J. G. Gosselink2000. "The value of wetlands: importance of scale and landscape setting." Ecological Economics 35(1): 25-33.
20. Tiwari, J.N. (1988), Water Quality Index for Indian rivers, in ecology and pollution of Indian rivers. Ed R.K. Trivedi. Ashign Publishing House New Delhi. pp 271-286.
21. Thom, B. G.1967: Mangrove ecology and deltaic geomorphology: Tabasco, Mexico, J. Ecol., 55: 301–343.