

ABSTRACT

Wetlands are the aquatic ecosystems that exist in various eco-climatic zones at a wide range of latitudes and altitudes worldwide. Among the aquatic ecosystems, freshwater wetlands located at higher elevations and tropical regions play a crucial role in conserving the species diversity as well as providing various bioresources to the people inhabiting nearby for their subsistence. Several environmental factors, including biotic and abiotic ones, along with anthropogenic activities, determine the surface water quality of wetlands and their overall general structural and functional attributes. Wetlands provide a number of ecosystem functions and services, including water purification, water storage, processing of carbon and other nutrients, stabilization of shorelines, and support of flora and fauna. In relation to climate change, plants play a significant role in carbon sequestration by converting carbon dioxide into organic matter through photosynthesis and storing and regulating water. Wetlands can store more carbon than other landforms because of their vegetation, waterlogged nature, and organic matter deposition from rivers, streams, and other inlets. Wetlands store about one-third of the global soil organic carbon pool and cover approximately 4-6% (7 to 9 million km²) of the earth's land area. Researchers have estimated the carbon sequestering potential of wetlands using different approaches. However, there is still a significant need for comprehensive research that employs accurate methods and calculations in the majority of wetland areas. There are a limited number of studies on wetlands across the globe, with very few investigations on the effects of wetlands on carbon storage potential. Hence, this study was conducted in Loktak Lake, the largest freshwater lake in northeast India and a wetland of international significance (designated as a Ramsar Site). The study aims to minimize the current research gap and provide valuable knowledge and information regarding the role of wetlands in carbon sequestration for climate change mitigation. The study looked at different factors like water quality, sediment buildup, carbon storage, heavy metal pollution, macrophyte diversity, and land use and land cover (LULC) changes to gather information.

The present thesis consists of seven chapters that contain the overall presentation of the work done, including a general introduction, a review of literature, methodology findings, and discussions of the investigation. We provide a summary of the chapters below.

Chapter 1 focuses on the general introduction, emphasizing the crucial role of wetlands. The chapter highlights the ecological importance of wetlands in reducing atmospheric carbon dioxide and mitigating climate change through carbon sequestration. The study was conducted in Loktak Lake, the largest freshwater lake in northeast India, in Manipur. The lake is recognized as a wetland of international significance under Ramsar Sites. The objectives of the study are mentioned in this chapter.

Chapter 2 provides a comprehensive literature review on numerous global studies related to the objectives of the current research. Wetlands's water quality parameters and vegetation were studied extensively through published papers and articles. This review also highlights the necessity for precise estimation of the carbon sequestration potential of various wetland types using accurate methods and calculations, particularly the tropical wetlands like the Loktak Lake.

Chapter 3 presents the seasonal water quality status of Loktak Lake through the investigation of water quality parameters including electrical conductivity (EC), pH, salinity, total dissolved solids (TDS), dissolved oxygen (DO), temperature, turbidity, total alkalinity (TA), calcium (Ca), chloride (Cl), total hardness (TH), sulphate, potassium (K), and magnesium (Mg). A total of 38 sampling sites were selected, and samples were collected from these sites and analyzed for their physicochemical parameters using different methods on site as well as in the laboratory. Significant seasonal variations in physicochemical parameters of water were observed for all the parameters except for sulphate (significance level of 0.05). Mean turbidity in monsoon, post-monsoon, and pre-monsoon was above the acceptable range of 1 NTU, indicating its unsuitability for drinking purposes. The mean TDS value was found within the acceptable limit except in some locations. Mean concentrations of nine metrics, namely TA, Ca, Cl, EC, pH, sulphate, temperature, TH, and TDS, were discovered to be within the acceptable range. In certain sampling sites, the values of TA, DO, EC, TH, pH, TDS, turbidity, K, and Mg were found beyond the desirable limits, indicating poor water quality status. The overall condition of the Loktak Lake water exhibited a mild level of pollution, necessitating appropriate treatment to render it suitable for domestic use for drinking. This study highlights the need for monitoring the quality of the lake's water through seasonal observations for long periods of time and evaluating contaminants and their origins.

Water quality index (WQI) values showed that water quality was deteriorated during monsoon and post-monsoon seasons, but it recovered during winter and pre-monsoon seasons, indicating seasonal recovery. Principal component analysis—absolute principal component score-multivariate linear regression (PCA-APCS-MLR) model revealed the source apportionment of pollutants affecting the water quality of the Loktak Lake.

Chapter 4 investigates in detail the technique of marking sampling sites for measurement of accretion rate using a handmade sediment corer. Parameters including bulk density, nutrient content, carbon sequestration potential, and heavy metal concentration of the collected sediments were analyzed systematically. The The 2nd IB post (KLNP) recorded the highest accretion rate at 7.9 cm/season, while Naranshena recorded the lowest at 2.3 cm/season. It was observed that bulk density ranged from 0.30 g/cm³ at Ngakra Kom to 0.93 g/cm³ at Thinungei. Correlation analysis revealed that carbon, nitrogen, and sulphur were significantly positively correlated, cementing the finding that sulphur prevents the deterioration of organic matter. Analysis of variance (ANOVA) revealed that accretion and carbon sequestration rates varied significantly across different seasons. The average carbon sequestration rate in Loktak Lake is between 338.31 and 345.56 mgC.cm⁻².year⁻¹, or between 3383.1 and 3455.6 gC.m⁻².year⁻¹, which is much higher than what has been seen in some other wetlands.s. The total carbon stock of Loktak Lake was found to be 17822574 MgC. This suggests tropical intermontane freshwater lakes like Loktak Lake have a higher potential for carbon sequestration than other wetland forms. Analyzing the Mean-ERM-quotient (M-ERM-Q) of heavy metals indicated the toxicity potential of Loktak Lake exhibited a medium-high level, which is a matter of great concern.

Chapter 5 discusses the seasonal composition and distribution of macrophytes in Loktak Lake. Quantitative characteristics including frequency, density, abundance, abundance by frequency (A/F) ratios, and importance value index (IVI) were determined. Species diversity indices such as Margalef's species richness index, Shannon-Wiener index of diversity, Simpson's index of dominance, Pielou's evenness index, and Whitford index were calculated. A total of 47 macrophyte species, belonging to 40 genera and 19 families, were documented. Monsoon recorded the highest number of species with 47, followed by post-monsoon, winter, and pre-monsoon with 42, 29, and 27 species, respectively.

Species with a high importance value index (IVI) represent dominant species in the community. *Alternanthera philoxeroides*, *Azolla filliculoides*, *Brachiaria mutica*, *Cyperus difformis*, *Cyperus esculanthus*, *Enydra fluctuans*, *Hydrilla verticillata*, *Leersia hexandra*, *Limnophila aquatica*, *Pistia stratoites*, *Pontederia crassipes*, *Rotala rotundifolia*, *Salvinia minima* and *Zizania latifolia* were dominant. *Alternanthera philoxeroides*, *Brachiaria mutica*, *Hydrilla verticillata*, *Leersia hexandra*, *Limnophila aquatica* and *Rotala rotundifolia* were the dominant species throughout the year. The monsoon recorded the highest macrophyte density (863461 ha), while the winter recorded the lowest (315769 ha). The post-monsoon recorded a species density of 621153 ha, while the pre-monsoon recorded 585384 ha. Margalef's species richness index ranged from 5.96 (monsoon) to 3.55 (pre-monsoon), Simpson index from 0.05 to 0.06, Shannon index from 3.44 to 2.96, and Pielou's evenness index from 0.89 to 0.90. The Sørensen similarity index was highest between monsoon and pre-monsoon seasons (94.38%) and lowest between monsoon and post-monsoon seasons (72.97%). Luxuriant growth of certain species like *Hydrilla verticillata*, *Pontederia crassipes*, and *Limnophila aquatica* indicates eutrophic nature. The presence of invasive plant species such as *Ageratum conyzoides*, *Alternanthera philoxeroides*, *Pontederia crassipes*, *Mikania micrantha*, *Pistia stratoites*, and *Hydrilla verticillata* is also threatening the growth and development of native plant species. Further, the unavailability of certain economically important species like *Trapa natans* in its natural habitat revealed the disturbed ecological structure of Loktak Lake.

Chapter 6 discusses the Land Use and Land Cover (LULC) changes of Loktak Lake. We prepared the decadal LULC changes from 1995 to 2024 using QGIS 3.24.1 "Tisl".er.' Landsat TM and ETM+ images of Landsat 4, 5, 7, and 8 satellites from 1995 to 2024, comprising 7 to 11 multispectral bands with no cloud cover in the region, were obtained from the United States Geological Survey (USGS). A supervised classification technique was employed for the preparation of the LULC map. Five land use classes, such as waterbody, phumdi, built-up, agriculture, and vegetation, were classified. The result showed a decrease in waterbody area of 23.35 km² from the 1995 to 2024 period. Phumdi and built-up areas were increased by 66.68 km² and 1.55 km², respectively, during the period. Agriculture and vegetation cover of the lake reduced by 17.79 km² and 27.08 km², respectively. The overall outcome demonstrated a continuous decrease in land cover and an increase in land use, indicating the degrading state of Loktak Lake. Despite

changes observed in LULC proportions over time (through paired t-tests), there was no significant change in the absolute LULC areas between the years.

Chapter 7 provides a comprehensive synthesis of the study, integrating modeling outcomes with findings from the previous chapters to draw key conclusions. It highlights the major results and emphasizes the importance of conserving this vital freshwater wetland ecosystem. Overall, the chapter underscores the significance of the research and outlines potential directions for future investigation.

This page is intentionally left blank