Carbon stock in a mangrove ecosistem in northern Mexico: environmental changes for 35 years

Abstract

The carbon stock in mangroves that border the estuarine system of San Blas-Laguna Grande de Mexcaltitn, Nayarit, Mexico, during the period 1980-2015, defined 3 environmental zones considering different anthropic pressures and the amount of storage carbon in the arboreal biomass and in the soil. These zones show differences in the width and interstitial water residence time period. Biomass and carbon stock (aereal and underground), as well as the soil carbon storage at 20 cm depth, increased from the south to the northern zone. These parameters indicated low values compared to results from a number of authors in primary type mangroves. This was caused by the loss of structure and ecosystem functions, and it is considered now as a secondary mangrove forest, with displacement of Rhizophora mangle by Avicennia germinans and Laguncularia racemosa. This is the reason why is key to produce information that allow to confirm the ecosystem conservation status, considering the carbon capture and storage capacity, as well as its economic value and loss. This research obtained an arboreal carbon storage value of US$4,431,826.7; with losses for the period 1980-2015, of US$132,414.3.

Introduction

Mangroves are coastal ecosystems of immense ecological importance that function as major carbon reservoirs, thus contributing to the moderation of global climate change. In Mexico, these ecosystems cover approximately 775,555 hectares, representing 5% of mangroves globally. The estuarine system of San Blas-Big Lagoon of Mexcaltitán in Nayarit constitutes an area of particular interest due to the anthropogenic pressure it has experienced in the past time.

This study evaluated changes in carbon stocks during a period of 35 years (1980-2015), providing crucial data to comprehend the carbon dynamics in mangroves subject to different levels of human disturbance. The mangroves capture and store carbon in significantly larger quantities than other terrestrial ecosystems, storing up to five times more carbon per area than tropical rainforests.

Methodology

Three study zones were established along the estuarine system.

1. **Northern Zone**: Area with less human influence, characterized by more stable hydrological flow and greater presence of *Rhizophora mangle*.
2. **Central Zone**: Area with moderate anthropic pressure, mainly from local fishing and tourism activities.
3. **Southern Zone**: Area with high anthropic pressure, close to human settlements and intensive agricultural activities.

In each zone, 10 x 10 m plots were established where forest parameters such as diameter at breast height (DBH), total height, tree density, and species composition were measured. Soil samples were taken at a depth of 20 cm to determine the organic carbon content. The aerial

and underground biomass was estimated using specific allometric equations for each of the mangrove species.

For economic valuation of stored carbon, the international carbon bond average price was utilized during the study period, adjusted according to the corresponding inflation rate.

Results

The results show a clear north-south gradient in terms of carbon storage, both in biomass and in soil. The northern zone presented the highest values of tree biomass (156.3 ± 23.5 t/ha) and organic carbon in soil (89.7 ± 12.4 t/ha). In contrast, the southern zone showed the lowest values (98.4 ± 18.7 t/ha in biomass and 67.2 ± 9.8 t/ha in soil), evidence of the adverse impact of human activities on the ecosystem's capacity to accumulate carbon.

The floristic composition also showed significant transformations. A gradual displacement of *Rhizophora mangle*, a species typical of primary mangroves, was observed. This species was replaced by *Avicennia germinans* and *Laguncularia racemosa*, species that are more resistant to disturbances and typical of secondary mangroves. This change in species composition is a clear indication of the degradation of the ecosystem during the studied period.

Keywords Carbon sequestration; Tree biomass; Economic valuation; Mangroves and anthropic pressure; Climate change; Coastal ecosystems; *Rhizophora mangle*; *Avicennia germinans*

Reference

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