

Chapter 4

Spatial Heterogeneity of Soil Carbon Sequestration Potential and Its Estimation Using GIS Technologies and Remote Sensing Data

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ABSTRACT

The chapter considers soil carbon sequestration potential as a characteristic associated with the genesis of soils and the degree of their degradation. Various options for estimating the soil carbon sequestration potential based on comparing potentially achievable and actual levels of organic carbon content in soils are considered. Possible scenarios of carbon losses and carbon sequestration by the soils of Ukraine for the period up to 2050 are discussed. A method of spatial quantitative assessment of soil sequestration potential is proposed, considering the heterogeneity

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of relief and the degree of erosion degradation of soils. The implementation of the method is presented in the case of an experimental site located in the forest-steppe of Ukraine (Kharkiv region). It was shown that underestimation of the features of soil spatial heterogeneity can lead to errors in the estimation of the soil organic carbon sequestration potential up to 50% of the average value.

BACKGROUND

Despite all the efforts of the world's community, the Greenhouse Gases (GHG) emissions still haven't decreased enough, and global temperature rise continues. It makes issues of atmospheric carbon capture and removal critically important, along with emission reduction and decarbonization of economics, which focused on COP28 in December 2023 (COP 28, 2023).

One of the ways of reducing the amount of carbon dioxide in the atmosphere is a carbon sequestration (CS). Carbon sequestration it is the capturing and long-term storage of atmospheric carbon in plants, soils, geologic formations, and the ocean. Carbon sequestration occurs both naturally and as a result of anthropogenic activities (Selin N. E., 2023). The U.S. Geological Survey USGS divides two major types of CS: geologic and biologic. Geologic CS is the process of storing carbon dioxide (CO₂) in underground geologic formations. The CO₂ is usually pressurized until it becomes a liquid, and then it is injected into porous rock formations in geologic basins (USGS, 2017). Essentially, geologic CS is the final stage of the most anthropogenic carbon capture and storage processes. Biologic carbon sequestration is the storage of atmospheric carbon in vegetation, soils, woody products, and aquatic environments (USGS, 2017).

Climate experts claim that approximately 9 – 11 Gt of CO₂ must be removed from the atmosphere annually to maintain a long-term average global temperature rise of no more than 1.5°C (Baugh L. S., 2023). According to the Global Carbon Project report (GCP, 23) total global CO₂ emissions (fossil + land use change) was 40.9 Gt in 2023. About half of all CO₂ emitted continues to be absorbed by land and ocean “sinks” globally, with the rest remaining in the atmosphere, where it causes climate change. As shown by Zhu et al., (2010), in the 2000s, annual carbon sequestration by terrestrial ecosystems in the United States accounted for an even smaller part of the carbon budget —approximately only 25% of all carbon emissions.

Meanwhile, according to Global CCS Institute report (2023), there are only 41 large-scale carbon capture projects in operation around the world, capturing roughly 49 Mt of CO₂ annually. That's a tiny amount (less than 0.25%) compared to the biological sequestration of carbon. Although biological carbon sequestration is insufficient to offset anthropogenic GHG emissions, it is still the most effective way

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