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"Reconcile land system changes
with planetary health"

Soil aggregate stability and organic carbon stock in Pandamantenga plains, Botswana: Towards a sustainable landuse

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Abstract

Soil aggregate stability and organic carbon (OC) storage are key biogeochemical indicators of soil health and its ability to function within an ecosystem including providing sustainable and just medium for the transformation of agri-food systems. Soil aggregation protects OC, and its disruption through natural or human activities can lead to OC loss. While land use impacts soil quality, its effect on aggregate stability and OC stocks in Botswana's agriculturally important Pandamantenga alluvial plains is not well understood. This study investigated how different land uses (arable land, grassland exclosures, natural exclosures, and pastures) influence these properties. Soil samples were collected at three depths (0–15, 15–30, and 30–45 cm) and sieved into six aggregate size classes (>4.75, 4.75–2.00,2.00–1.00,1.00–0.50, 0.50–0.25 and <0.25 cm). Routine laboratory methods were used to analyse soil properties, including particle size, bulk density, pH, electrical conductivity, exchangeable bases, OC content, and aggregate-associated carbon. Aggregate stability was assessed using wet sieving, calculating indices for water-stable aggregates (WSA), mean weight diameter (MWD), geometric mean diameter (GMD), and R0.25. The soils were classified as Vertisols. Results showed that land use significantly affected soil structure and carbon dynamics. Natural exclosures exhibited the highest MWD and GMD, followed by grassland exclosures, pastures, and arable land. WSA varied by land use and aggregate size, with arable land having more WSA in smaller fractions and less in larger ones. Pastures had more mid-sized aggregates, while natural exclosures were dominated by larger aggregates. R0.25 remained consistent across land uses due to high clay content. Larger aggregates (>0.25mm) contained more OC and showed a strong positive correlation between stability and OC, highlighting the importance of aggregate stability for carbon sequestration and soil health by minimising carbon loss and enhancing SOC storage. Natural exclosures had the highest OC stocks, particularly in larger aggregates, followed by arable land. Grassland exclosures and pastures had lower OC stocks. Our findings will help to design strategies to improve sustainable agricultural productivity, soil conservation, and carbon management in the face of climate change.

Keywords: Carbon sequestration, soil conservation, tillage, Vertisols, water stable aggregates

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