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Seasonal dynamics of soil CO_2 efflux across land-use types: Implications for climate mitigation in Ghana

Famoussa Dembele[1], Stephen Adu-Bredu[2], Reginald Tang Guuroh[2], Roman Hinz[3], Samuel Kingsley Oppong[4], Rüdiger Schaldach[3], Amanuel Woldeselassie Gebremichael[5], Anja Linstädter[6], Atinuke Adebanji[7], Bismark Owusu[2], Dzigbordi Solomon Ayeh[8], Nat Owusu Prempeh[9], Padmore Boateng Ansah[2], Eunice Okyere Agyapong[2], Larissa Raatz[10]

[1] *Kwame Nkrumah University of Science and Technology (KNUST), Dept. of Civil Engineering (WASCAL), Ghana*

[2] *Council for Scientific and Industrial Research (CSIR), Forestry Research Institute of Ghana (FORIG), Ghana*

[3] *University of Kassel, Kassel Institute for Sustainability, Center for Environmental Systems Research (CESR), Germany*

[4] *Kwame Nkrumah University of Science and Technology (KNUST), Dept. of Wildlife & Range Management, Ghana*

[5] *GFZ German Research Center for Geosciences, Germany*

[6] *University of Potsdam, Inst. of Biochemistry and Biology, Biodiversity Research / Syst. Botany, Germany*

[7] *Kwame Nkrumah University of Science and Technology (KNUST), Dept. of Statistics and Actuarial Science, Ghana*

[8] *Kwame Nkrumah University of Science and Technology (KNUST), Dept. of Renewable Natural Resources, Ghana*

[9] *Kwame Nkrumah University of Science and Technology (KNUST), Dept. of Forest Resources, Ghana*

[10] *Leibniz-Institut für Agrartechnik und Bioökonomie e.V., Science Management Unit, Germany*

Abstract

Carbon dioxide (CO_2) is a major greenhouse gas driving climate change. In Ghana, the Agriculture, Forestry, and Other Land Use (AFOLU) sector contributes to national CO_2 emissions while also offering opportunities for carbon sequestration. Despite this dual role, there is limited empirical data on how land use and seasonal dynamics influence soil CO_2 fluxes in tropical forest landscapes. The study addresses this gap by assessing seasonal variations in soil respiration rates (SRR) across four land-use types, including forest, fallow, maize, and rice fields, in a semi-deciduous forest in Ghana. The aim was to provide baseline data and identify key soil factors influencing SRR to support mitigation strategies. Monthly measurements of soil respiration rates (SRR) were conducted over one year using a closed-chamber technique equipped with a CO_2 sensor. Simultaneously, soil physico-chemical properties, including organic matter (OM), pH, texture, and soil moisture (SM), were assessed to investigate their influence on CO_2 efflux. Stepwise multiple regression and correlation analyses were conducted to explore relationships between SRR and soil variables.

Results revealed significant seasonal and land-use-related differences in SRR, with higher emissions recorded during the wet season. Fallow and cropland areas (maize and rice fields)

Contact Address: Famoussa Dembele, Kwame Nkrumah University of Science and Technology (KNUST), Dept. of Civil Engineering (WASCAL), Kumasi, Ghana, e-mail: Famoussad93@gmail.com

exhibited the highest CO_2 efflux, while forested areas showed the lowest emissions, likely due to reduced disturbance and higher soil carbon stability. Among the tested variables, OM, pH, SM, and silt content emerged as significant predictors, with the final model explaining 58 % of the variation in SRR.

The findings highlight the importance of maintaining forest cover and adopting sustainable land use practices to mitigate CO_2 emissions in tropical regions. To further reduce emissions in the AFOLU sector, policies should also support reforestation, agroforestry, and reduced soil disturbance, which enhance soil carbon storage and promote sustainable land use.

Keywords: Bobiri forest reserve, climate change mitigation, land-use type, soil respiration rate