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Shallow groundwater in sustainable agriculture and water management: Insights from Ghana's cocoa farming landscape

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Abstract

Shallow groundwater plays a pivotal role in both domestic water supply and the ongoing transformation of cocoa farms in Ghana, aimed at mitigating the impacts of climate change. Managing shallow groundwater requires understanding its interaction with surface water and role in transporting key nutrients like phosphorus (P) and nitrogen (N). This study was conducted in the sub-humid agroforestry-dominated Mankran micro-watershed, situated close to the city of Kumasi, in the upper Offin basins located in Ghana. Mankran, characterised by its relatively gentle slopes and an expected annual rainfall of about 1300 mm, predominantly comprises forested areas interspersed with cocoa plantations (70 %), cultivated lands (24 %), and minor built-up areas including mining and pre-urban zones (5 %). Since June 2023, the study has involved the monitoring of seven shallow groundwater well levels, two stream flows, chloride concentrations in rainfall, streamflow, and groundwater, as well as dissolved N and P concentrations in both wells and streams. Analysis reveals that groundwater recharge can account for approximately 17 % of seasonal rainfall (700mm) from June to December 2023 using chloride mass balance. The water table fluctuation (WTF) method leads to 75 % of the seasonal rainfall within the watershed. The high variation mirrors the application of different methods each tied to its own uncertainties such as specific yield in the WTF approach. Streamflow represents only a fraction (about 9–14 %) of the seasonal rainfall. Notably, mining activities significantly influence flow dynamics within the landscape. Nitrate concentrations in Mankran rivers peaked in June, whereas agricultural wells consistently displayed elevated concentrations throughout the rainy season, suggesting substantial leaching via subsurface flow. Similarly, phosphate concentrations in streams increased as the rainy period progressed, closely mirroring concentrations observed in wells and further indicating the dominance of subsurface flow. This study underscores the predominance of subsurface flow within the landscape and its pivotal role as a potential mechanism for affecting the WTF approach and transporting pollutants. Consequently, crops with deep root systems or a high tolerance to waterlogging may be advantageous in areas characterised by significant subsurface flow, particularly in the context of agro-food system transformation efforts.

Keywords: Agriculture, cocoa, groundwater, management, recharge

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