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Influence of urbanisation on cation exchange capacity and nutrient availability in arable soils of Kumasi (Ghana)

Stephen Boahen Asabere (1), Thorsten Zeppenfeld (1), Kwabena Abrefa Nketia (1,2), Volker Haering (3), and Daniela Sauer (1)

(1) Georg-August Universität Goettingen, Institute of Geography , Physical Geography , Germany (stephen-boahen.asabere@geo.uni-goettingen.de), (2) Centre for Scientific and Industrial Research, Soil Research Institute, Ghana, (3) Geschäftsstelle Biosphärengebiet Schwäbische Alb, Germany

Rapid urbanisation is known to proceed at the expense of agricultural fields in African cities. Yet, staple and vegetable fields are still common in many core and peripheral urban landscapes of Western Africa. Empirical data on the influence of urbanisation on the soils of these fields are rare. In this study, we investigated the spatial variability of soil fertility parameters of arable soils of the Kumasi area from the inner city to its periphery, also representing an urbanisation chronosequence. We used a systematic grid-based sampling design to extract topsoil samples (0–10 cm) from 210 maize fields on Acrisols belonging to the same local soil series. Thus, the factors land-use and soil series were kept constant. The sampling took place in 2016. Based on historical satellite images, we included in the sampling scheme (1) the inner Kumasi area, which was urban already in 1986 (thus for $>$ 30 years = long-term urban soils), and (2) the periphery of Kumasi that became urban afterwards (thus being urban for $<$ 30 years at the time of sampling = short-term urban soils). Three replicates were sampled on each maize mono-crop and/or mixed-crop field, using steel cylinders with a length of 10 cm and a volume of 255 cm^3. The samples were analysed for pH (soil:water = 1:5), effective cation exchange capacity (CEC_{eff}), exchangeable Ca, Mg, K, and Na, total C (TC) and N (TN) (by dry combustion) and soil organic matter (SOM) by loss on ignition. All element contents were transformed to element stocks per m^2. Generally, pH was acid to moderately alkaline with significantly ($p < 0.001$) higher values in long-term compared to short-term urban soils. Both contents and stocks of SOM were significantly higher in long-term (contents = 51 g kg^{-1}, stocks = 5.7 kg m^{-2}) than short-term (contents = 43 gkg^{-1}, stocks = 5.3 kg m^{-2}) urban soils. $CEC_{eff}$was influenced by SOM content and pH (r^2= 0.63). Hence, CEC_{eff} was higher in long-term (16 cmol kg^{-1}) than in short-term (12 cmol kg^{-1}) urban soils. Stocks of exchangeable Ca, K, and Na were correspondingly higher in long-term urban soils, while exchangeable Mg and base saturation were similar in both groups of soils. TN stocks, however, were significantly lower in long-term (0.16 kg m^{-2}) than short-term urban soils (0.18 kg m^{-2}), indicating long continuous use of urban soils without N replacement. Among other reasons, it was concluded that disposal of household waste including organic materials, which is generally practised in urban Ghana due to inadequate waste management has contributed to increased SOM contents and pH in long-term urban soils. We suggest community level composting, offering dumping sites for organic household waste, and application of N fertilisers or use of leguminous plants to improve the N supply of cultivated sites. This study has shown that in cities like Kumasi, arable soils that have been influenced by urbanisation for a long time, still have the potential to further improve food security of the local population if included into well-coordinated urban planning.