Stock and stabilisation of organic carbon in tephra-buried volcanic soils: a case study in the northern Ecuadorian Andes

MATHILDE PAQUE, NOA LIGOT, LOÏC MORIZE, CHARLINE ONDERET, PIERRE DELMELLE

Environmental sciences, Earth and Life Institute, Université catholique de Louvain, Croix du Sud 2, B-1348 Louvain-la-Neuve, Belgium.
mathilde.paque@uclouvain.be

Soils contain at least two times more C than the atmosphere and soil organic carbon (SOC) is involved in rapid exchanges with atmospheric CO_2. However, major uncertainties in estimates of C trapped in soils and in the mechanisms that stabilise it may impede acurate climate predictions in the future. Notably, recent studies suggest that deep soil C represents a large and poorly constrained reservoir. In active volcanic regions, volcanic soils, which are reknown for their good capacity to retain organic C, are repeatedly buried underneath tephra deposits from explosive eruptions. The objective of this study is twofold: (i) to demonstrate that tephra-buried volcanic soils represent a significant but largely underestimated stock of organic C and (ii) to identify the main mechanism(s) responsible for organic C stabilisation in these soils. Our case study is a 4.8-m deep polygenetic volcanic soil profile located at 4080 m a.s.l. in the Province of Pichincha in Ecuador. It is comprised of one surface soil overlying five deep soils separated by 10 to 50 cm thick Holocene tephra layers. We measured soil bulk density, total C content and Al and Fe concentrations in pyrophosphate (Al_p and Fe_p) and oxalate extracts for each of the 11 soil horizons. X-ray powder diffraction analyses reveal that all soils are dominated by primary aluminosilicates. Poorly crystallised mineral contents varied in the range 5-13 wt.%. The total C stock in the five tephra-buried soils is ~70 kg m^{-2}, whereas the surface SOC stock is ~20 kg.m^{-2}, i.e. 3.5 times lower. Total C correlates strongly with Al_p and Fe_p (R^2>0.85), suggesting that organic C is predominantly stabilised in organo-metallic complexes both in the surface and tephra-buried soils. Volcanic soils are thought to account for 5% of the global SOC stock. This estimate is probably a minimum as our results hint to a large C stock associated with tephra-buried soils which has been overlooked. Further studies on the SOC stock and its future in active volcanic regions are advocated.