

Co-localization of iron and aluminum with organic matter across a range of soils: a density-based approach

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Recent studies suggest significant control on pedogenic iron (Fe) and aluminum (Al) on organic matter (OM) storage and stability across a wide range of soils around the world. This information would be useful to improve or replace existing SOM models. On the other hand, metal extraction studies have shown that only minor portions of soil OM are directly bound to pedogenic Fe and Al. How can these metals control OM storage and stability without direct binding with bulk of OM? To answer this, an important step is to understand the location of the metals and OM within bulk soils. Sequential density fractionation is useful to examine their localizations because pure OM (e.g., plant detritus) and pure mineral particles (e.g., quartz, clay, Fe oxide) are the two endmembers along particle density gradient. We tested if Fe and Al released by chemical weathering are mainly present in association with OM using 22 soil samples from 11 sites spanning 5 climate zones, 5 soil orders (Andisols, Spodosols, Inceptisols, Mollisols, Ultisols), and including several subsurface horizons and both natural and managed (upland and paddy) soils. Across all the studied soil samples, meso-density fractions (1.8-2.4 g cm⁻³) accounted for major portions of OM and the metals extractable by pyrophosphate, acid oxalate, and dithionite. We also found a strong stoichiometric relationship between the extractable metals and co-dissolved OM. We discuss the biogeochemical processes that may cause the co-localization of the metals and OM at the mesodensity across the soils from a wide range of pedogenic environments.

Keywords: Iron, Aluminum, organo-mineral interaction, soil carbon stability, density fractionation, aggregation