Stability of Organo-mineral Complexes in Soils with Andic Properties as Influenced by Land Use Intensification

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RITHA KOV

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ABSTRACT

Soils with andic properties are characterised by having abundant reactive Al in the form of short-range-order Al constituents and organo-Al complexes, which facilitate the accumulation of soil organic matter (SOM) through the formation of the so-called organo-mineral complexes. Recent studies on New Zealand pastoral systems, however, have reported the loss of C from soils with andic properties. This has been attributed to management practices such as liming and urine deposition and associated hydrolysis reactions that un-stabilise the associations of SOM with reactive Al. but mechanistic studies to prove this have not been carried out. The objective of this study has been to compare soils under different land uses and management intensification regimes so that the influence of these on the organic and inorganic chemistry and the stability of organo-mineral complexes of soils with andic properties can be inferred. For this, soil samples under a pine stand (Forest) and two paddocks differing in the degree of intensification (Paddock 1 < Paddock 2) were taken. Major soil chemical properties were determined, including pH, total C and N content, reactive inorganic and organic Al fractions, and SOM molecular fingerprinting. Soil pH in Forest (pH-H_2O, 5.3) was significantly lower ($P<0.05$) than that in Paddock 1 (pH-H_2O, 5.7), which was itself significantly lower ($P<0.05$) than pH in Paddock 2 (pH-H_2O, 6.1). Soil C and N concentrations were significantly higher in the soils under pasture than under pine (63.8 g C kg^{-1}), and C in Paddock 2 (96.0 g C kg^{-1}) was significantly lower ($P < 0.05$) than that in Paddock 1 (101.7 g C kg^{-1}). While allophane content was shown to increase (from 5.1 to 7.9 to 10.5 %) with intensification (i.e. Paddock 2 compared with Paddock 1 and Forest), organo-Al complexes, as estimated with sodium pyrophosphate (Al_p), were shown to decrease (Forest, 6.6 g kg^{-1}; Paddock 1, 6.8 g kg^{-1}; Paddock 2, 5.7 g kg^{-1}). At the molecular level, SOM under pine had a higher relative contribution of microbially processed organic matter than that under pasture, whereas the latter had a larger contribution of N-containing and aliphatic compounds. We proposed that the increase in pH on intensification weakened the ability of organic ligands to compete with OH^- for reactive Al and thus the potential of inorganic short-range-order constituents to chemically protect SOM through the formation of organo-mineral complexes. The study thus provided evidence of how different land uses and management intensification influence soil chemistry and SOM stocks in soils with andic properties as well as SOM molecular composition.

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