**Ecological, chemical, and physical nature of soil organic matter**

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Organic matter (OM) in soil plays a fundamental role in ecosystem functioning and has strong control on biogeochemical cycling of various elements. Perhaps the biggest challenge in soil OM research is to untangle the complexity in (a) soil-climate-rock-biota interactions and feedback processes among them at macro scales, and (b) the interactions between microbe, OM of different decay stages, and a suite of soil minerals at finer space-time scales. In this talk, I will go over my (not-always-successful) attempts to untangle some aspects of this complexity.

At a macro scale, I have been examining the interactive effect of climate and parent material on soil OM-mineral-microbe interaction. This was achieved by comparing the forest ecosystems on the environmental matrix consisting of two contrasting rocks along an altitude (climate) gradient. With my colleagues, I was able to show the changes in the stock and chemistry of soil OM pools of three density fractions [1], organic coverage on soil mineral surface area by N2 gas sorption approach[2], and microbial community composition by PLFA biomarker analysis[3]. Using soil OM concentration gradient induced by decadal soil management in Japan, I also examined the factors controlling the temperature sensitivity of soil OM decomposition by directly assessing soil C chemistry by solid-state NMR spectroscopy after distinguishing accessible low-density fraction and less-accessible organo-mineral fraction and by comparing microbial respiration with various soluble C pools and microbial biomass under different temperature treatments[4].

 Some aspects of OM-mineral interaction were also examined at finer scales. By focusing on Fe oxides, we developed a method to quantify the amount of OM sorptively stabilized by Fe oxides[5]. We also reviewed the density fractionation studies with a focus on the fraction with high uncertainty (occluded LF) and proposed a conceptual model linking the fractions[6]. While size-based fractionation is another common approach, the physical distinction between soil particle and aggregate remains unclear especially for OM-rich, strongly-aggregated Andisols. By characterizing the micron to submicron-sized particles liberated after different dispersion energy levels, we were able to refine the 1980’s concept of aggregate hierarchy and discussed its linkage to OM stabilization[7].

[1] Wagai et al. (2008) Geoderma 147: 23-33. [2] Wagai et al. (2009) Geoderma 149: 152-160. [3] Wagai et al. (2011) Ecological Research 26: 627-636. [4] Wagai et al. (2013) Global Change Biology 19: 1114-1125. [5] Wagai & Mayer (2007) Geochimica et Cosmochimica Acta 71(1): 25-35. [6] Wagai et al. (2009) Soil Science & Plant Nutrition 55(1): 13-25. [7] Asano & Wagai (2014) Geoderma 216: 62-74