PhD project: Jumpei Fukumasu

Effects of soil organic carbon fractions on soil structure and solute transport

Background

Soil is the largest carbon reservoir in the terrestrial environment and it has potentially a large capacity to sequestrate additional carbon. Therefore soil can mitigate global warming and climate change. In addition, soil organic carbon (SOC) plays a positive role in soil structure formation by enhancing soil aggregation; however, the effects of SOC on water flow and solute transport is not fully understood. In relation to environmental goals to enhance SOC sequestration, we need to know how an increase in SOC would influence soil physical processes. For both SOC sequestration and physical processes, it is important to quantify the fraction of stable SOC which is physico-chemically protected by clay and enhances soil aggregation at a submicron scale.

Aim

The aim of this PhD project is to clarify the effects of SOC on soil structure, water flow and solute transport. Based on previous literature, it has been hypothesized that the fraction of SOC that is physico-chemically associated with clay can increase meso- and micro- porosity and soil matrix water flow, potentially reducing the degree of preferential flow. This hypothesis needs to be tested using soils from a conventionally tilled agricultural field where chemicals such as fertilizer and pesticide are used and hence there is a risk of preferential transport of the chemicals to groundwater. By revealing the possibly beneficial role of physico-chemically protected SOC in the soil physical processes, I would like to show additional benefit of SOC sequestration for sustainable agriculture.

Methodology

For this purpose, we use intact soil samples taken from a conventionally tilled field that has large variations in SOC and clay contents. The soil samples are then used to quantify (1) soil pore structure using X-ray tomography and soil water retention curve, (2) the degree of preferential flow by conducting steady state solute transport experiment and (3) estimated unsaturated hydraulic conductivity using tension infiltrometers. After these experiments, soil samples are disturbed and used to measure soil texture, total SOC and SOC fractions that have various carbon stability by conducting SOC fractionation. Based on the results, I will link SOC-clay association, soil structure, water flow and solute transport.