

比重分画法と安定同位体トレーサー法を用いた土壌有機物安定化プロセスの定量的解析：火山灰土壌と熱帯強風化土壌の比較
Organic matter stabilization in Andisol and Ultisol revealed by isotopic tracer experiment and density fractionation

早川 智恵^{1*}; 和穎 朗太²; 稲垣 善之³; 浅野 真希²
HAYAKAWA, Chie^{1*}; WAGAI, Rota²; INAGAKI, Yoshiyuki³; ASANO, Maki²

¹ 東大院農, ² 農環研, ³ 森林総研
¹Univ. Tokyo, ²NIAES, ³FFPRI

For predicting C cycling in terrestrial ecosystem, dynamics of organic matter (OM) in soil can be a large component that increases uncertainty. Once OM is supplied into soil system mainly as plant detritus and root exudates, OM is decomposed by microorganisms and a proportion of OM is stabilized through association with soil mineral particles. The OM in soils has a wide range of size, density, and chemical reactivity. Organo-mineral particles of heavy-density fraction are highly resistant against microbial degradation compared to mineral-free OM (i.e., plant detritus and low-density fraction). The high C sequestration capacities of soils (e.g., Andisol) are hypothesized to be regulated by incorporation rates of microbial-processed OM into heavier fraction. To test this hypothesis, we conducted incubation experiment using tracer to quantify the pool sizes, influx and efflux rates, and mean residence times (MRTs) of different density classes.

Different types of soils were sampled from two agricultural lands; a volcanic-ash soil (Andisol) from Japan and a highly-weathered tropical soil (Ultisol) from Indonesia. The incubation experiments were carried out after addition of ¹³C-labelled glucose (99 ¹³C atom%, 0.1915 mmol ¹³C g⁻¹ soil as solution) or ¹³C, ¹⁵N-labelled glutamic acid to the soils (2-mm sieved, 5 g dry weight). The soils were incubated for 276 d at 30°C and 50% water holding capacity. After the incubation, soil was separated into three fractions according to its density using sodium polytungstate as heavy liquid: low (<1.8 g cm⁻³), middle (1.8-2.25 g cm⁻³ for Andisol, 1.8-2.5 g cm⁻³ for Ultisol), high (>2.25 g cm⁻³ for Andisol, >2.5 g cm⁻³ for Ultisol) density fractions. We measured the mass, isotopic ratios (¹³C/¹²C, ¹⁵N/¹⁴N) and total C and N concentrations of the density fractions as well as the amount of CO₂ respired during the incubation by alkali trap method. We also measured the specific surface areas (SSA) of soil minerals and the concentrations of Al, Fe oxides/hydroxides.

For both soils, ca. 70 to 80 % of added ¹³C were mineralized to CO₂ within 1 month after substrate addition. The density fractionation showed that ¹³C recovery in the low-density fraction was low (0.5 - 3.8%) throughout the incubation period. The ¹³C recovery within the mid- and high-density fractions was greater than 20%. This indicates that labile substrates were immediately incorporated into the mid- and high-density fractions through microbial processing in the both soils. The highest ¹³C recovery was observed in the mid-density fraction of Andisol and in the high-density fraction of Ultisol, respectively. MRTs of ¹³C in the density fractions positively correlated with SSAs for respective soil types. This can be explained by differences in mineralogy which contribute to OM stabilization through sorption; short-range-order minerals (e.g., allophane and imogolite) in Andisol and iron oxides in Ultisol, respectively. Our results support the hypothesis that newly-added OM is stabilized through association of microbial metabolites with mineral particles. However, dominant density class and turnover of stabilized OM could be variable depending on soil types and clay mineralogy with high specific surface areas.

Keywords: ¹³C-glucose, ¹³C, ¹⁵N-glutamic acid, Andisol, Ultisol, organo-mineral particle