Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

MIS006-07 Room: Exibition hall 7 subroom 3 Time: May 26 15:30-15:45

Quantitative analysis of soil acidification in forested ecosystems in Japan

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Soil acidification is also a natural process caused by dissociation of carbonic and organic acids, nitrification, cation excess uptake by vegetation, although soil acidification has been widely recognized as soil degradation caused by acidic deposition. To evaluate the main reason and extent of soil acidification, the contribution of different proton sources to soil acidification needs to be analyzed including ecosystem-internal acid load. In the present study, the impact of acid load on soils was evaluated by quantifying the rates of net proton generation and consumption and soil acidification.
The experiments were carried out in ando soil under cold temperate forest (NG), podzolic soil under cold temperate forest (TG) and brown forest soil under warm temperate forest (KT). Soil acidification rate and net proton generation were quantified based on the theory of proton budget for the respective soil horizon compartments (mainly the O, A and B horizons) by measuring fluxes of solutes entering and leaving the soil horizon compartment and vegetation uptake. The acid neutralizing capacities (ANCs) in soils were measured and calculated from the sum of cationic components in soils.
Protons were produced by the dissociation of organic acids, nitrification and vegetation uptake in the O horizon at all plots. In NG and KT, intensity of acid load in each of soil horizons was low due to even distribution of fine root biomass. In TG, the intensive acidification in the O horizon was derived from net proton generation by the dissociation of organic acids and nitrification as well as cation excess uptake by vegetation due to concentrated fine root biomass in the O horizon. In deeper soil horizons, protons were consumed by adsorption and mineralization of organic acids and nitrate uptake by vegetation at all plots. Cation excess uptake by vegetation was highest among proton sources in the whole soil compartment at all plots. Soil acidification is considered to include cation leaching from surface soil horizons due to proton generation by the dissociation of organic acids and nitrification and subsequent cation excess accumulation in wood in the growth stage of forests. Our study shows that the temporal and spatial heterogeneity of proton generation and consumption in the soil profile, which was related to soil organic matter dynamics as well as parent materials and climate, resulted in different patterns of soil acidification. In our study, the contribution of ecosystem-internal acid load to soil acidification was larger compared to acidic deposition. It is necessary to evaluate soil acidification including natural processes.
As compared to the acidification rates and ANCs of soils reported in Europe and North America, soil acidification in Japan could be characterized by minor contribution of acid rain to soil acidification and the higher ANC values. In Europe and North America, since the soils have intrinsically low ANCs and are subjected to higher acid load by acidic deposition, acidic deposition is considered to have a strong impact on soil acidification. On the other hand, in Japan, the higher ANCs in volacanic and clayey soils masked the effects of acidic deposition on soil acidification. The dynamics of ecosystem-internal acid load and its contribution to soil acidification could be described quantitatively by our study.

Keywords: soil acidification, acid rain, organic acid, acid neutralizing capacity