Geophysical Research Abstracts
Vol. 19, EGU2017-17405, 2017
EGU General Assembly 2017

Processes controlling soil P amounts and availability along a weathering gradient

Julian Helfenstein (1), Federica Tamburini (1), Christian von Sperber (2), Michael Massey (3), Chiara Pistocchi (1), Oliver Chadwick (4), Peter Vitousek (5), and Emmanuel Frossard (1)

(1) ETH Zurich, Group of Plant Nutrition, Lindau, Switzerland (julian.helfenstein@usys.ethz.ch), (2) Institute of Crop Science and Resource Conservation, University of Bonn, 53115 Bonn, Germany, (3) Department of Earth and Environmental Sciences, California State University, East Bay, CA 94542, USA, (4) Department of Environmental Studies, University of California, Santa Barbara, CA 93106, USA, (5) Department of Biology, Stanford University, Stanford, CA 94305, USA

In 1976 Walker and Syers presented a model describing the development of P pools with increasing weathering status of a soil (Walker and Syers 1976). This model has been repeatedly confirmed along gradients of different soil ages as well as gradients of different climatic conditions (Crews et al. 1995, Tamburini et al. 2012, Roberts et al. 2015, Feng et al. 2016). However, limited information is available on the processes controlling P amounts and availability along a weathering gradient. We used isotopic (^{33}P, ^{18}O), spectroscopic (P K-edge XANES), and other (enzymatic activity, chemical P speciation) methods to reveal drivers of P dynamics along the 150'000-year-old Kohala lava flow on Hawai'i, which stretches from 250 mm to over 3000 of mean annual precipitation. Chemical extractions and X-ray absorption spectroscopy show the gradual disappearance of apatite in favor of Fe- and Al-sorbed P species as well as organic P.

We then distinguish two different types of processes: 1) processes determining the total amount of P in the topsoil, and 2) processes determining P availability. While weathering of apatite and eolian erosion control P amounts on less weathered and arid soils, leaching and biological uplift become increasingly important with increasing soil weathering status. On very weathered sites, leaching becomes the dominant process controlling P amounts, though it is partially counteracted by biological uptake and atmospheric dust deposition. In terms of P availability, dissolution of mineral P adds to the available P pool up to the intermediate range. Activity of acid phosphatase suggests that mineralization becomes increasingly important with higher weathering of soils. Despite this, P availability decreases drastically, as a result of continued loss of highly-mobile P through immobilization by biomass, increased P-sorption capacity by soils, and leaching.

Crews, T. E., K. Kitayama, J. H. Fownes, R. H. Riley, A. Darrell, D. Mueller-dombois, and P. M. Vitousek. 1995. Changes in Soil Phosphorus Fractions and Ecosystem Dynamics across a Long Chronosequence in Hawaii. Ecology 76:1407-1424.

Feng, J., B. L. Turner, X. Lü, Z. Chen, K. Wei, J. Tian, C. Wang, W. Luo, and L. Chen. 2016. Phosphorus transformations along a large-scale climosequence in arid and semiarid grasslands of northern China. Global Biogeochemical Cycles 30.

Roberts, K., D. Defforey, B. L. Turner, L. M. Condron, S. Peek, S. Silva, C. Kendall, and A. Paytan. 2015. Oxygen isotopes of phosphate and soil phosphorus cycling across a 6500 year chronosequence under lowland temperate rainforest. Geoderma 257-258:14-21.

Tamburini, F., V. Pfahler, E. K. Bünemann, K. Guelland, S. M. Bernasconi, and E. Frossard. 2012. Oxygen isotopes unravel the role of microorganisms in phosphate cycling in soils. Environmental Science and Technology 46:5956-5962.

Walker, T. W., and J. K. Syers. 1976. The fate of phosphorus during pedogenesis. Geoderma 15:1-19.