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Microbial mobilization of various P species depends on weathering history of soils

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Phosphorous (P) is a key element for life on earth. Since microbes take up P largely as orthophosphate, the speciation of P, especially its solubility in soil is more important than its absolute amount. P adsorbed to soil particles shows differing availability depending on particle size distribution, carbon (C) content and structure and amount of poorly crystalline Fe- and Al-oxyhydroxides. We conducted a laboratory incubation study with soils from four study sites on similar granitic parent material along the Coastal Cordillera of Chile, comprising a gradient from arid to humid temperate climate. In a short-term batch experiment, we determined adsorption kinetics by isotopic dilution (33P) for the four different soils in each A and B horizons. Sterile (γ-irradiated) soil was used for adsorption to exclude any biotic uptake and immobilization of inorganic P (Pi), i.e. to solely target the mobilization from adsorbed and precipitated P species. Natural soil was mixed with a proportion of the labelled soil and incubated for 25 days at constant temperature and water content. A subset of the mesocosms was treated with 13C enriched glucose to test for the effect of an easily available C source providing resources for P mobilization. We hypothesized that (I) total microbial P incorporation will be greatest in the most southern ecosystem where microbial activity is highest but (II) microbial driven Pi mobilization will show a unimodal distribution considering the gradient from dry to humid climate regimes as sorption of P is expected to be strongest at the climatic extremes and (III) the response to addition of glucose will be most expressed in soils from the arid regions, which are adapted to efficient utilization of pulse events in C availability.

Sorption of P was strongest under arid and humid temperate climate and within these soils highest in the A horizon with up to >90% of the added tracer adsorbed to the soil matrix. Exchangeable Pi was lowest in the A horizon of the Mediterranean and in the humid temperate site with a high C content and high amounts of poorly crystalline Al- and Fe-oxyhydroxides. Uptake of P was strongly enhanced by the addition of glucose, increase in Pi mobilization capacity of microbes was stronger in A than B horizons for all soils. Microbial driven mobilization of Pi was strongest in the semi-arid and Mediterranean site and can partly be attributed to less strongly adsorbed P in these sites. Increase of microbial C by the addition of glucose was strongest in the arid and semi-arid site. This might be explained by a microbial community adapted to rare events in which C suddenly gets available and nutrients rapidly need to get utilized.

This study reveals that P uptake is mediated by sorption kinetics more than by total amount of P. Adaptation of microorganisms to environmental conditions plays a major role in their response to an added energy source and determines their ability to mobilize Pi. This contrasting microbial P mobilization dynamics along the climatic gradient has critical feedback on ecosystem P nutrition.