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A novel isotope pool dilution approach to quantify gross rates of organic phosphorus mineralization, microbial phosphate uptake and abiotic phosphate sorption-desorption processes in soils

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Efforts to understand and model the current and future behavior of the global P cycle and its coupling to the global carbon (C) and N cycles have been intensified, but are strongly limited by the scarcity of global data on gross rates of soil P sorption/desorption and organic P mineralization, as well as its environmental controls. In order to facilitate measurement of these processes, we developed a novel isotope pool dilution approach, based on 33P labelling of live and sterile soils and the measurement of inorganic P (Pi) concentration and its specific activity over time. Extraction was performed with 0.5 M sodium bicarbonate, and bio-available Pi and its 33Pi activity separated from organic P (Po) and quantified by isobutanol fractionation followed by phosphomolybdate blue reaction and liquid scintillation counting. Direct acidification of bicarbonate extracts followed by Pi measurement by the more sensitive malachite green assay and quantification of total dissolved 33P by liquid scintillation counting yielded similar results as isobutanol fractionation, showing the lack of organic 33P release during the incubations. This greatly simplified the measurements of isotope pool dilution and made this method highly suitable for strongly weathered and P impoverished soils. Linearity of isotope pool dilution processes was observed between 4 and 24 hours. Abiotic processes were studied in double-autoclaved soils which exhibited negligible microbial and extracellular phosphatase activities. Abiotic desorption processes rapidly slowed down but continued over the entire observation period of 48 hours, making it necessary to measure them over the same time period as for live soils (i.e. over 4 and 24 hours). Gross process rates were calculated based on published isotope pool dilution equations allowing for analytical solutions of the tracer kinetics. This novel method allows to obtain high quality data on gross fluxes of soil inorganic Pi sorption and desorption, as well as of gross fluxes of organic P mineralization and microbial Pi uptake. At the same time, net immobilization of 33Pi by soil microbes and abiotic sorption can be easily derived and partitioned. Finally, major controls of gross and net P cycle processes will be presented across three P-poor tropical forest and three P-rich temperate grassland soils.