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Soil organic phosphorus saturation and balance as soil function and ecosystem service

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Soil quality is a measure of how soil can accomplish ecosystem functions such as P filtering, buffering, and supply to crops. The soil P cycle comprises geochemical and biological pools. Components of the geochemical P pool, made of inorganic P (Pi) forms, can be biologically converted into organic P (Po) forms. Organic P forms are not currently diagnosed due to methodological limitations while labile soil Pi forms are routinely estimated in laboratories. Soil P buffer has been defined so far by inorganic soil P saturation indices hence neglecting the role of P turnover through the soil biological pool as ecosystem service. Our objective was to expand the notion of soil P buffer to organic P saturation and balance between inorganic and organic P pools as ecosystem service provided by the soil P cycle. We collected 41 sandy soils, 56 acid to neutral loamy to clayey soils, and 41 acid organic soils in Québec, Canada. We sequentially extracted soil P as resin-P, $NaHCO_3$-P, and NaOH-P fractions, total C and N, as well as Mehlich-3- and oxalate-extractable forms of P, Al, and Fe. Soil components were arranged into balances between biological and geochemical pools and their buffering mechanisms, and numerically classified for the risk of P leaching using a receiver operating characteristic procedure. Soil P biological pools incorporated Pi into Po until soil saturation with Pi exceeded a critical degree of soil Pi sorption capacity similar to published thresholds. As a result, soil's capacity to transform Pi into Po gets saturated in high P risk soils and ecosystem service to biologically incorporates Pi into Po is being lost. The soil Pi saturation index proved to be a useful single soil quality indicator not only as proxy for Pi buffering but also for soil's capacity to convert Pi into Po.