Impacts of agricultural activities on soil phosphorus biogeochemical transformations

CHUNHAO GU,[1*] CHONGYANG LI,[1] YONGFENG HU,[2] ANDREW J. MARGENOT[1]

[1] University of Illinois at Urbana-Champaign, IL, USA (*Correspondence: chunhao@illinois.edu, margenot@illinois.edu; cyfli@ucdavis.edu)

[2] Canadian Light Source, University of Saskatchewan, Saskatoon, Canada (Yongfeng.Hu@lightsource.ca)

Agriculture is thought to be the driving force of profound anthropogenic alteration of global phosphorus (P) cycle. A comprehensive understanding of how agriculture changes P biogeochemical transformation would entail better environmental and agricultural management of the finite reserve of P. This study evaluated long-term (centennial) impacts of agricultural activities on P biogeochemical transformations using soils from the Morrow Plots at the University of Illinois, the second oldest long-term agricultural plots in the word established in 1865 and situated in a region of intensive agriculture, the US Corn Belt. Sampled in 2020, these plots provide a 155 year factorial experiment of 2 crop rotations of Continuous Corn (CC) versus Corn-Oats-Alfalfa (COA) × 3 fertilization regimes of manure, NPK, and no fertilization. Two restored (>30 y) native land uses of grassland and forest sites were sampled for comparison to approximate non-agricultural land use, on the same soil type (loess-derived Aqiuc Argiudoll). Soils were analysed by P K edge X-ray absorption near-edge structure (XANES) spectroscopy.

Phosphorus speciation in agricultural soils was dominated by Fe-bound and/or Al-bound forms ((Fe+Al)-P, 55.0 – 83.8%) with varying proportions of organic P (P_o) and Ca-bound P (Ca-P) that reflected interactions of crop rotation and fertilization regimes. For both COA and CC, manured soils had up to 50% greater Mechlich-3 P than without fertilization. Regardless of crop rotation, both NPK fertilized and unfertilized agricultural soils had similar P_o and Ca-P proportions but had less P_o and greater Ca-P than manured soils. Greater differences occurred between agriculturally managed soils (Morrow Plots) than the reference (restored) native land uses. Overall, soil Ca-P decreased in the order of Forest (36.2%), Prairie (24.9%), and agricultural (2.7 – 19.5%) soils. Results suggest that, on the centennial-scale, agriculture led to depletion of Ca-P regardless of diverse crop rotations and inputs of P and other elements. By virtue of its longevity and the complementarity of P characterization approaches used, this study affords unique insights to long-term impacts of agricultural management on soil P cycling in one of the most intensified agricultural regions of the world.