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Potential substitution of mineral P fertilizer by manure: EPIC development and implementation

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Sources of mineral phosphorus (P) fertilizers are non-renewable. Although the longevity of P mines and the risk of future P depletion are highly debated P scarcity may be detrimental to agriculture in various ways. Some of these impacts include increasing food insecurity and nitrogen (N) and P imbalances, serious fluctuations in the global fertilizer and crop market prices, and contribution in geopolitical conflicts. P-rich waste produced from livestock production activities (i.e. manure) are an alternative to mineral P fertilizer. The substitution of mineral fertilizer with manure (1) delays the depletion of phosphate rock stocks, (2) reduces the vulnerability of P fertilizer importing countries to sudden changes in the fertilizer market, (3) reduces the chances of geopolitical conflicts arising from P exploitation pressures, (4) avoids the need for environmental protection policies in livestock systems, (5) is an opportunity for the boosting of crop yields in low nutrient input agricultural systems, and (6) contributes to the inflow of not only P but also other essential nutrients to agricultural soils.

The Environmental Policy Integrated Climate model (EPIC) is a widely used process-based, crop model integrating various environmental flows relevant to crop production as well as environmental quality assessments. We simulate crop yields using a powerful computer cluster infra-structure (known as EPIC-IIASA) in combination with spatially-explicit EPIC input data on climate, management, soils, and landscape. EPIC-IIASA contains over 131,000 simulation units and it has 5 arc-min resolution. In this work, we implement two process-based models of manure biogeochemistry into EPIC-IIASA, i.e. SurPhos (for P) and Manure DNDC (for N and carbon) and a fate model model describing nutrient outflows from fertilizer via runoff.

For EGU, we will use EPIC-IIASA to quantify the potential of mineral P fertilizer substitution with manure. Specifically, we will estimate the relative increase (or decrease) in crop yields under mineral P depletion scenarios and the intensification of manure use as an alternative P input for the major crops (i.e. wheat, barley, rye, rice, maize, and potatoes). This work will take into account existing estimates of livestock population densities, existing manure recycling technologies, and transportation costs.