Sustainable measures for sewage sludge treatment – evaluating the effects on P reaction in soils and plant P uptake

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RATIONALE

- Large P/N ratio in sewage sludge poses a limit to reusing this waste material as a soil amendment and nutrient source for plants.
- P buildup in soils may result in increased P loss to the environment, P increase in downstream surface water bodies, as well as adversely affect plant nutrition (Zn, Fe).
- P stabilization prior to application is proposed as a sustainable mean to allow beneficial use of this waste material.
- Methods to stabilize P in sewage sludge are available, but assessing P reactions in the sludge-treated soils, and its availability for plants is essential for validation of this approach.

OBJECTIVES

To assess P distribution among experimentally defined fractions and P availability for plants along time after incorporation of pre-treated sewage sludge materials into different soils.

EXPERIMENTAL

- Anaerobically digested sewage sludge was treated with either $FeSO_4$, $Al_2(SO_4)_2$, CaO, or stabilized through composting with yard-waste.
- Sandy, loamy, and clay soils were amended with the treated sludge materials or with reference P materials: glucose-1-P (G1P), inositol-hexaphosphate (IHP), and KH_2PO_4, all at a P-based rate of 50 mg P per kg soil.
- Amended and control (no additive) soils were incubated for 1, 7, 14, 35, and 112 days.
- Incubated soils were analyzed for P by a modified Hedley method [(1)] as well as Olsen-P and a plant-based rapid bioassay [(2)].

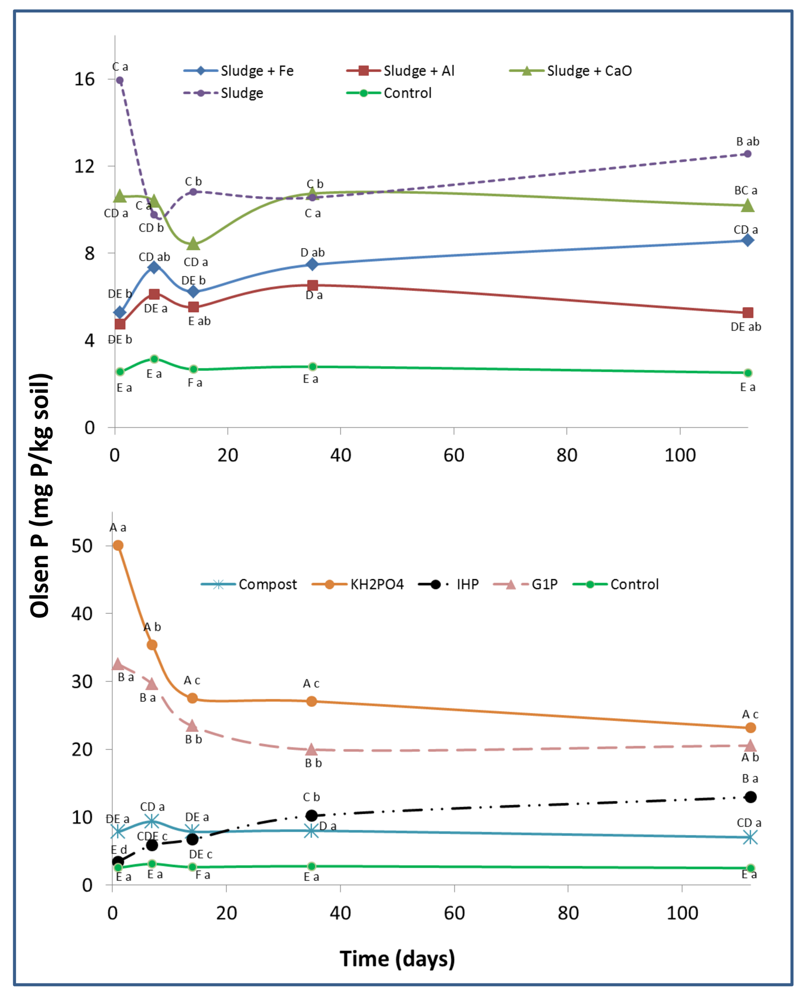
REFERENCES

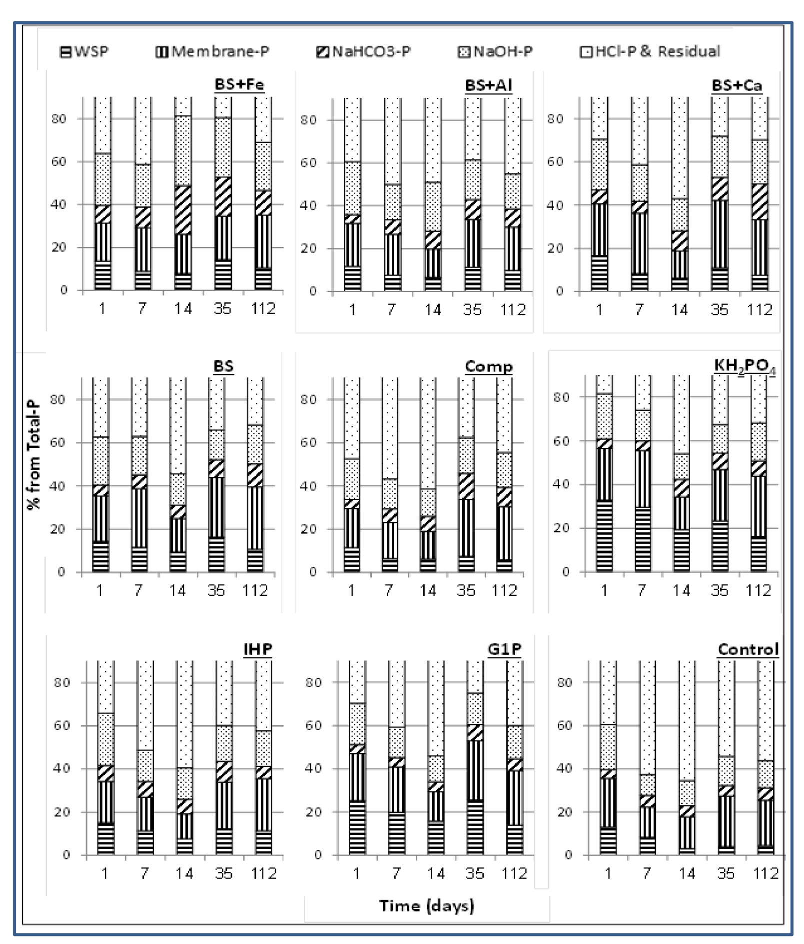
1. Huang, X., Y. Chen, and M. Shenker. 2008. Chemical fractionation of phosphorus in stabilized biosolids. Journal of Environmental Quality 37:1949-1958.

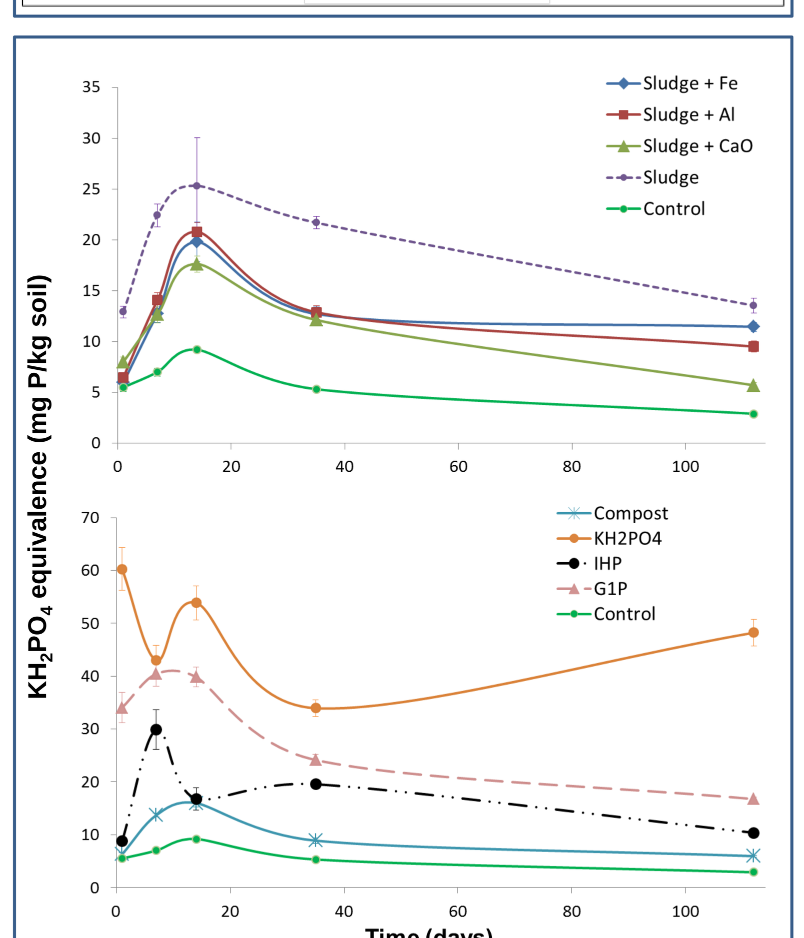
2. Huang, X., Y. Chen, and M. Shenker. 2005. Rapid whole-plant bioassay for phosphorus phytoavailability in soils. Plant and Soil, 271:365-376.

Red sandy soil

SSA - 23 $m^2\ g^{-1}$; 0% $CaCO_3$

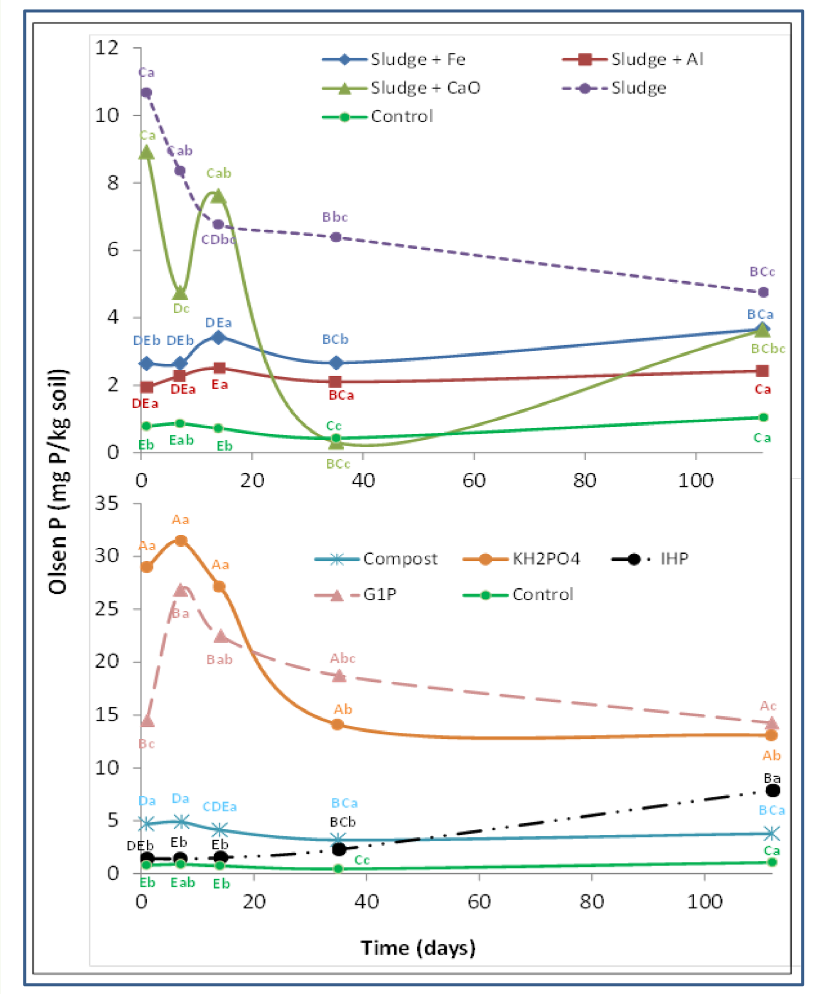


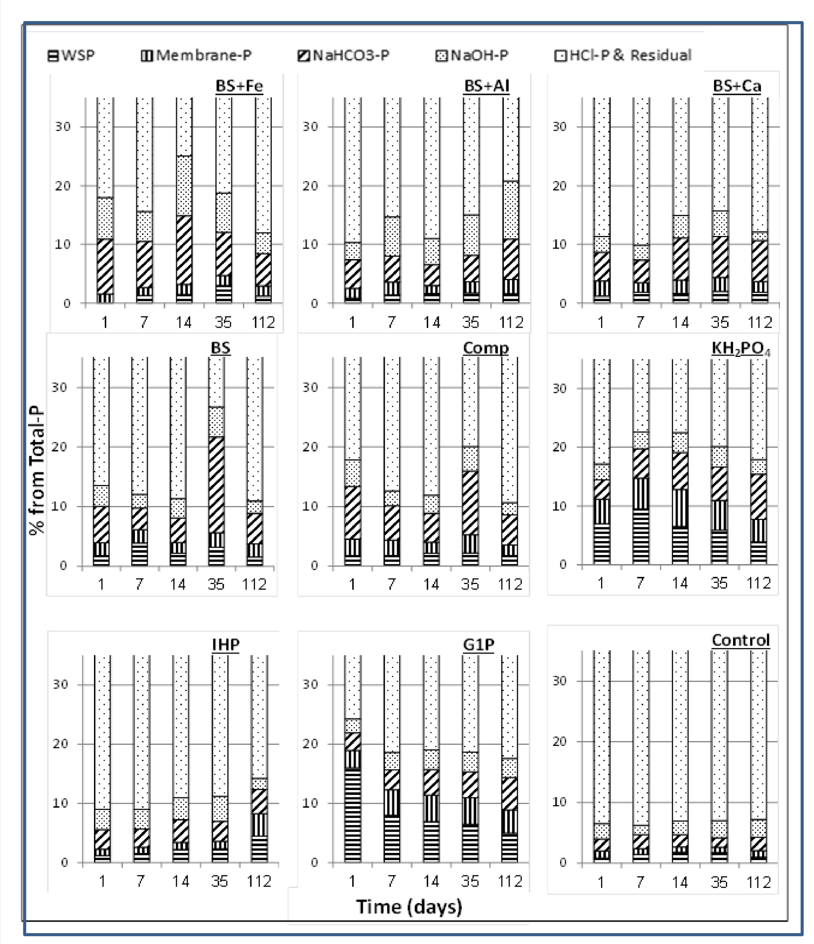


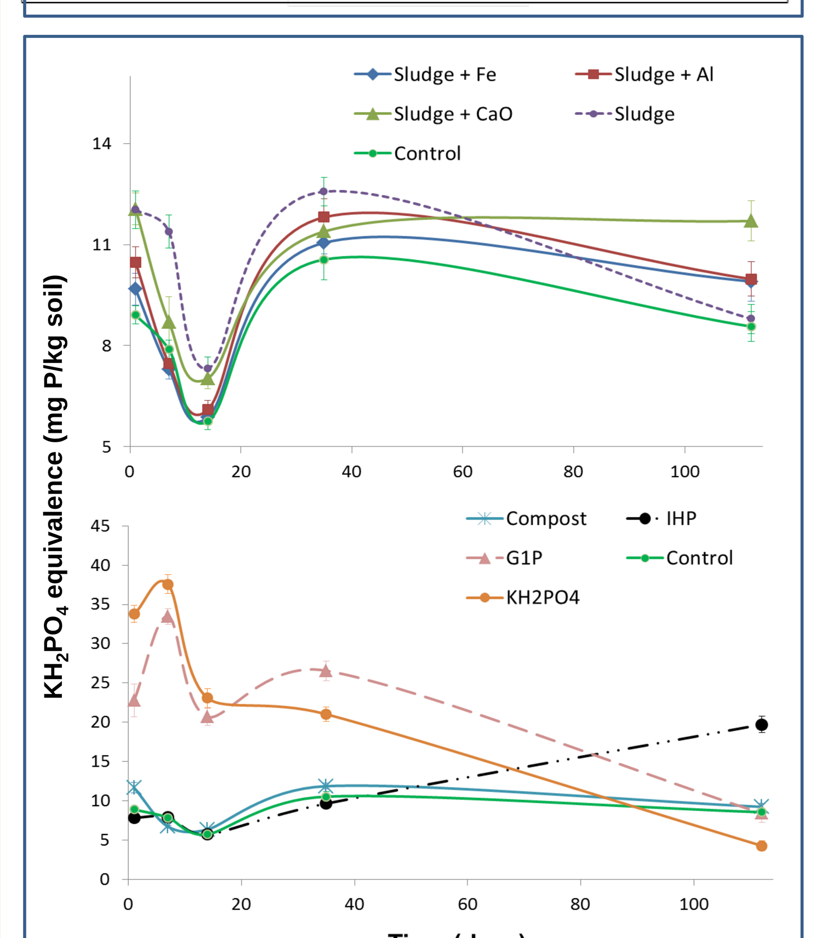


Loess soil

SSA - 75$m^2\ g^{-1}$; 11% $CaCO_3$

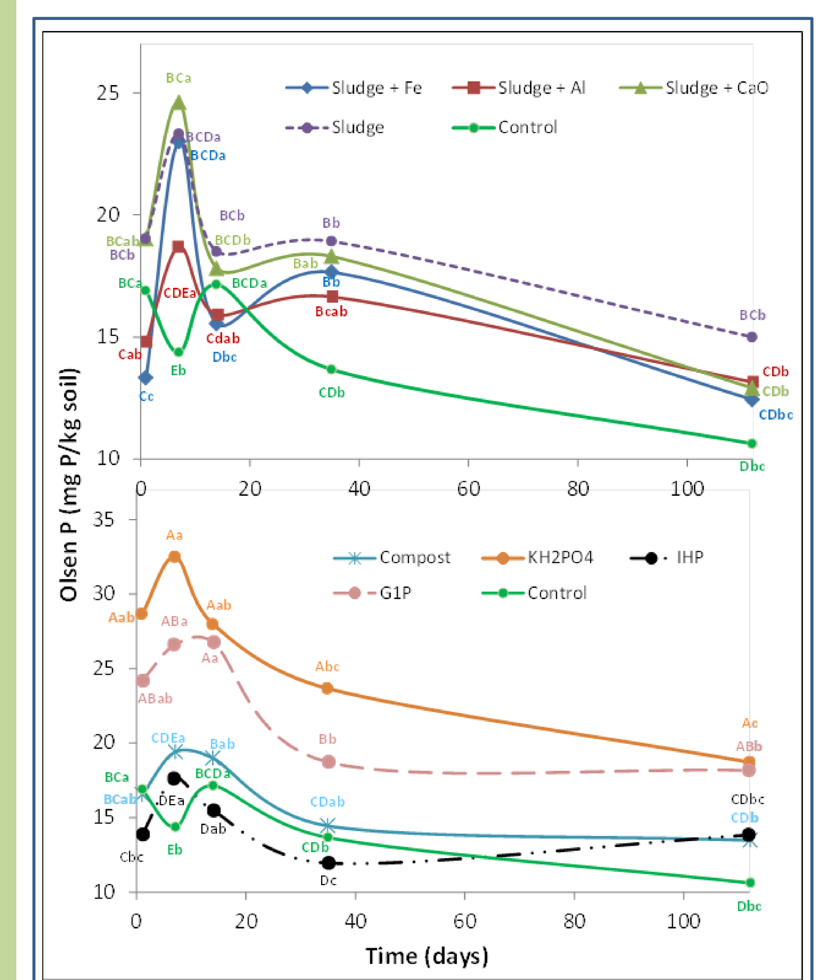


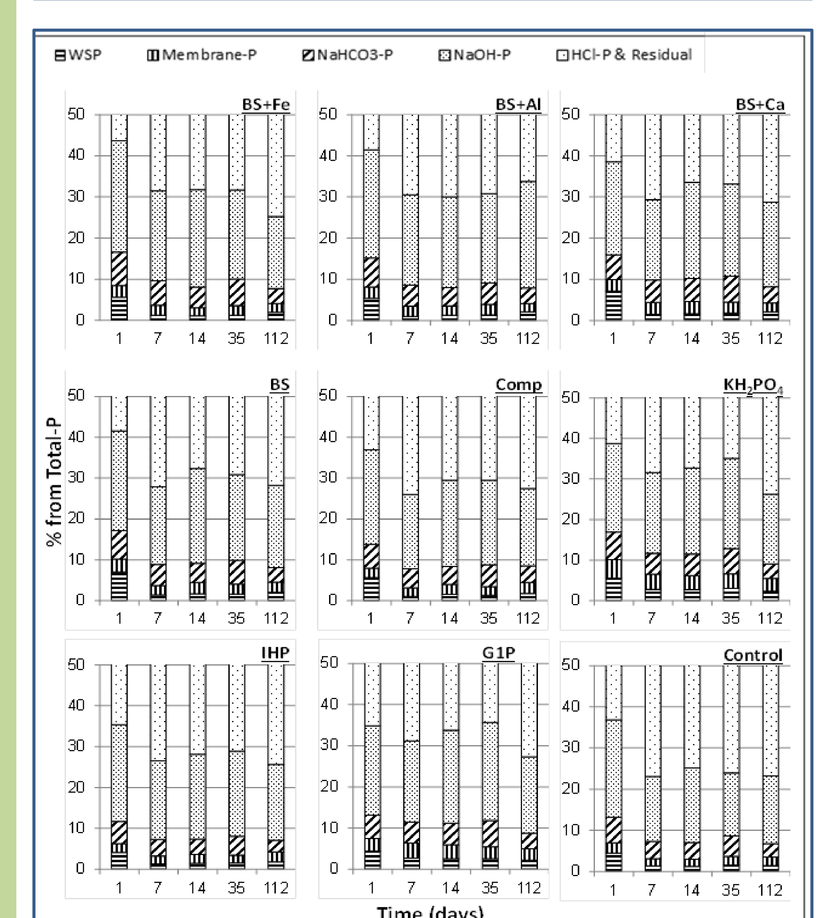


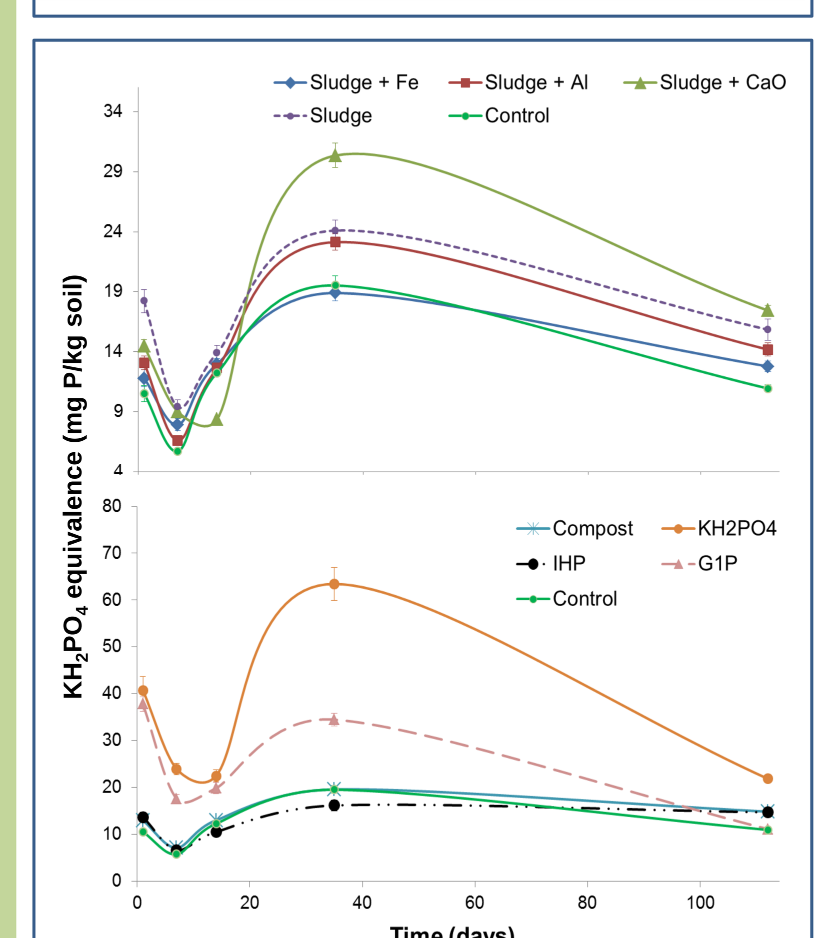


Terra Rossa

SSA - 361 $m^2\ g^{-1}$; 14% $CaCO_3$







RESULTS

- Sewage sludge P reactions in soils depends on both, the stabilization method and soil properties.
- The available three P fractions (i.e., water, membrane, and $NaHCO_3$ extracts) overpass the amount extracted by the Olsen method.
- The two most easily available P fractions (water and membrane P) were the major available fractions in the $CaCO_3$-free sandy soil and remained quite stable for months. In the presence of $CaCO_3$ (the other two soils) these fractions were converted to a more stable Ca-P phase.
- At an equal P addition to the soils P availability increased roughly by the order: KH_2PO_4 > GIP >> sludge ≥ compost ≥ Ca, Fe, Al sludge > control.
- IHP-P availability was negligible at the beginning and increased with time. The mineralization process was slow and was not complete 112 days after application.
- G1P-P was rapidly released and was as available as KH_2PO_4-P throughout the incubation period – both were fixed rapidly in all soils.
- All sludge materials had a net mineralization rate in-between that of the above reference organic-P sources.
- The bio-assay was highly correlated to the Olsen-P, as well as to the water extracted P and to the water extracted inorganic P, but not to the water extracted organic P.

CONCLUSIONS

- Phosphorus solubility and availability in soils amended with sludge can be effectively controlled.
- Using P-stabilized sludge materials will allow sustainable and beneficial use of sewage sludge.
- Stabilization with either Ca, Fe, or Al resulted in efficient long-term effect in the soils. The amount applied could maintain rather constant P availability.
- Thus – the stabilized phosphorus is stored in the treated soil and may provide P for the whole growing season, and probably to next growing cycles.
- As far as phosphorus is not commercially extracted from the sewage sludge, stabilization prior to application is proposed.