

Use of Inorganic By-product to Reduce Phosphorus Solubility in Manure/Biosolids and to Sequester and Reduce Heavy metal Bioavailability in Soils

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Introduction

(Limitation of manure/biosolids field application)

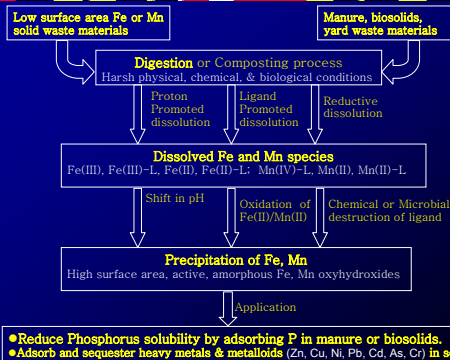
- Environmental concern from highly soluble phosphorus species
 - Eutrophication of freshwater by agricultural runoff and infiltration.
- Major concern as a nonpoint nutrient source in the Chesapeake Bay watershed
 - Phosphorus movement through runoff from poultry-litter amended soils
- Excess manure P application to croplands
 - Manure application to meet crop N needs frequently leads to over-application of P



Need to minimize runoff losses of P from manure field application

- Need to reduce phosphorus solubility by converting readily-soluble P to less-soluble or less-available forms of P in manure while maintaining fertility of manure/ biosolids applied to field.
- Chemical amendments that contain Fe or Al have been used to reduce phosphorus solubility in manure
 - In order to lower soluble P via chemical fixation (precipitation with metals and/or adsorption onto metal oxides or hydroxides).
- Little study has been focused on increasing Fe and/or Mn content in biosolids as additives to decrease phosphorus solubility.

Proposed Mechanisms and Processes involved in the formation of Organic/Inorganic Additive



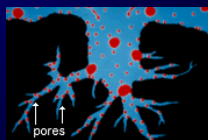
Objective

- To investigate waste Fe and Mn materials from associated metal industries and to examine low cost biological processes (digestion) for processing manure/waste inorganic materials into inexpensive, chemically active materials with high surface area.

- Manure/biosolids amendments with low P solubility

- Metal sequestering soil additive

which could reduce costs and provide assurance of remediation of heavy metals in soil.

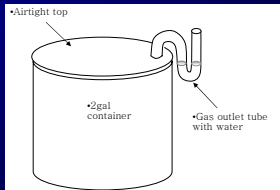


Methodology

- Three different low cost Fe/Mn materials, **Iron ore (Hematite), Steel slag and Mn tailings (from local steel plant)** were evaluated in the experiment.
- **Fresh dairy manure** was mixed with Fe/Mn material to have 5% Fe or 1% Mn in dry weight and total mass (wet) of 6 kg, and transferred to 2 gal airtight containers with a gas outlet.
- Total 35 identical containers were setup including ten containers for each mixture (**Iron ore + manure, Steel slag + manure, and Mn tailings + manure**) and five containers for control (**manure only**).

Methodology (cont.)

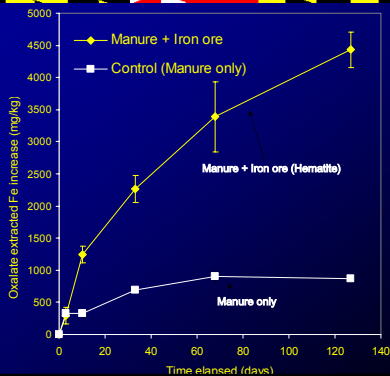
- The top of the containers was sealed and the gas outlet tube was filled with water to maintain anaerobic conditions in the container during the digestion process.
- Two containers for each mixture (iron ore + manure, steel slag + manure, and Mn tailings + manure) and one control container were sacrificed at day 3, 10, 33, 68 and 127.



Methodology (cont.)

- The pH, Eh, temperature and water content of the manure/inorganic mixture were measured initially and directly as soon as the container was sacrificed.
- Transformation of low cost Fe/Mn material to a chemically active amorphous form were monitored by acid ammonium oxalate extraction in darkness (Soil Science Society of America and American Society of Agronomy, 1996).
- Two different extractions for phosphorus, water soluble P (extraction with DI water) and Mehlich III extraction were performed to evaluate the relationship between phosphorus concentration and chemically active amorphous form of Fe/Mn oxides.

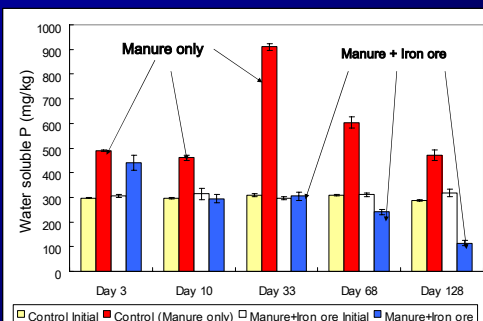
Results (Manure + Iron ore); oxalate extracted Fe increase



Summary (oxalate extracted Fe increase)

- Oxalate extracted Fe increases (considered as amorphous Fe oxides) as digestion proceeds for Iron+manure
- Oxalate extracted Fe concentration increases by ~ 5000 mg/kg throughout ~ 3 month digestion process.

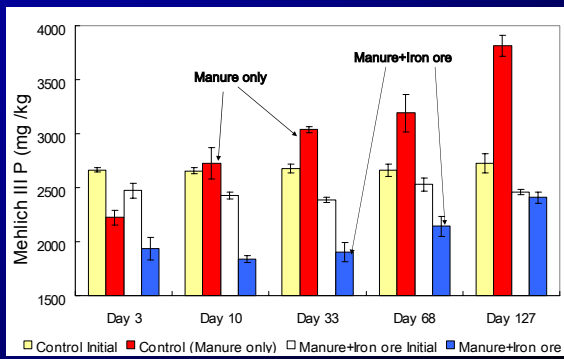
Results (Water soluble P)



Summary (Water soluble P)

- Maximum % reduction of water soluble P of digested manure with Fe ore was observed in 123 days of digestion, showing about 60 % and 75 % reduction compared to fresh manure and digested control manure, respectively.
- Maximum decrease of water soluble P was observed in 33 days of digestion, showing ~600 mg/kg decrease compare to digested control manure.

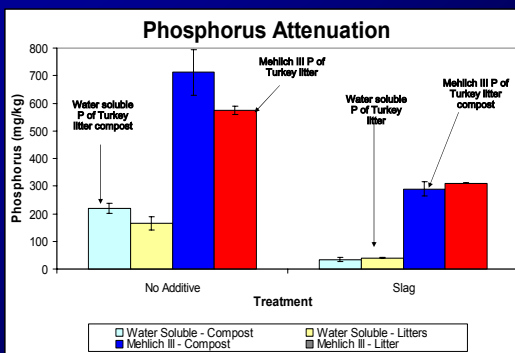
Mehlich III P



Summary (Mehlich III P)

- Mehlich III Phosphorus for digested manure with iron ore decreased most about 29% and 37 % compared to fresh manure and digested control manure, respectively in 33 days of digestion
- Maximum decrease of Mehlich P was observed in 127 days of digestion, showing ~1400 mg P/kg decrease compare to digested control manure.

Results (steel slag manure, Mn tailings + manure)



Summary and Conclusion

- Simple digestion process can increase oxalate extracted Fe content (considered as amorphous Fe oxides) by adding iron ore (Hematite) in manure.
- The results showed that water soluble-P and Mehlich III P in manure can be substantially reduced by **use of Inorganic By-product (Iron ore, Hematite)** through **simple digestion process**.
- Some by-products (steel slag) contain amorphous Fe and, therefore, digestion might not be required to reduce P solubility of manure and biosolids.

Other application of manure+inorganic by-product

- Manure+inorganic mixture can be used as **metal sequestering soil additive** which could reduce costs and provide assurance of remediation of heavy metals in soil.
 - Adsorption onto metal oxides
 - Precipitation with phosphorus species

Heavy metal contamination in soils

- Heavy metal contamination in soil from various sources
 - Risks associated with the terrestrial food chains and phytotoxicity which are related to bioavailability of toxic elements.
- The long-term deposition of heavy-metal bearing particulate **emissions from metal refinery industries**.
- Deposits of mine tailings** rich in pyrite from mining industries and smelter slag from metal smelting industries.
- Lead contamination of urban soil** which has been mainly resulted from **older painted housing**; Pb risk to urban children.
- Agricultural land application of sewage sludge** as well as manure.

Heavy metal contamination in soil (Palmerton, PA)



Heavy metal contamination in soil

- Limestone, which is an effective ameliorant for many metals has been widely used to increase soil pH and thereby improve soil fertility
- However, relatively large amounts of limestone (typically 50 to 100 ton/ha) should be applied.
- Therefore, a low cost material to sequester and reduce heavy metal bioavailability in soil would be very beneficial.
- Specifically, despite the importance of Fe and Mn content in biosolids, little study has been focused on increasing Fe and/or Mn content in biosolids as additives to decrease phytotoxicity and bioavailability of heavy metals in soil.

Conclusion

- Using selected organic/inorganic material(s) and developed process (digestion) through the research
- A promising and cost-effective “tailor made” mixture with high amorphous Fe and/or Mn content as soil amendment
 - To decrease the environmental concern of high phosphorus release from manure and biosolids and improve the fertility of Atlantic Coastal Plain soils
 - To sequester and reduce phytotoxicity and bioavailability of heavy metal in soil.

Thanks to

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Any Question ?

