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

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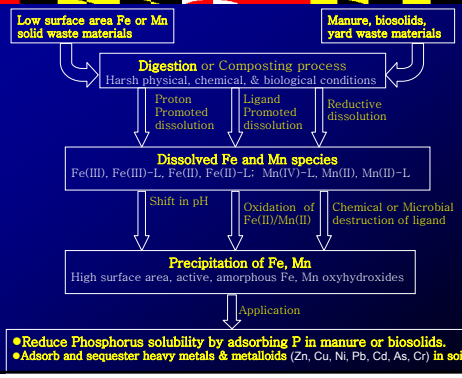
Introduction
(Limitation of manure/biosolids field application)

- 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

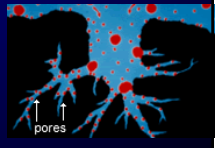


Objective

- 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.

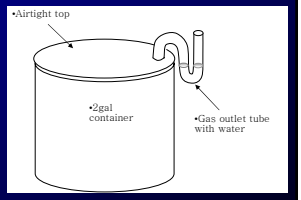


Methodology

- 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.)

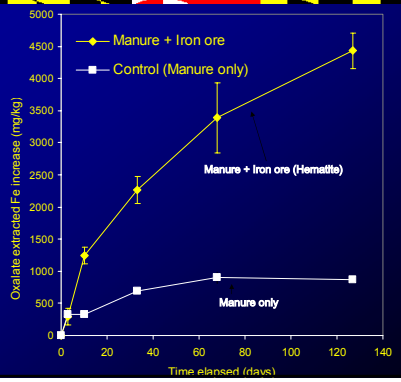
- The top of the containers was sealed and the gas outlet tube was filled with water to maintain anaerobic conditions in the container during the digestion process.
- Two containers for each mixture(iron ore + manure, steel slag + manure, and Mn tailings + manure) and one control container were sacrificed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

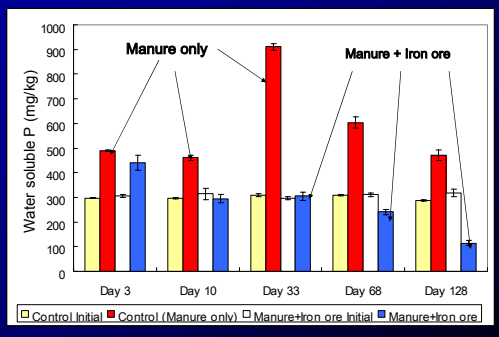
Results (Manure + Iron ore); oxalate extracted Fe increase



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.

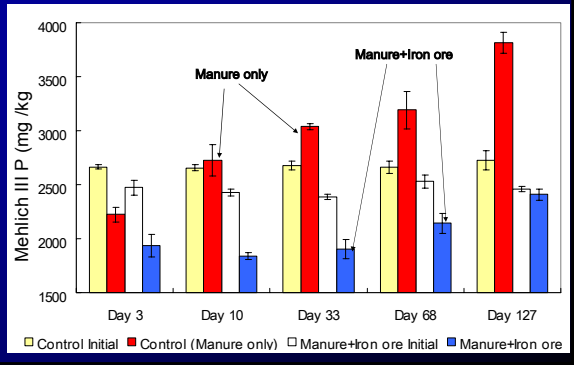
Results (Water soluble P)



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.

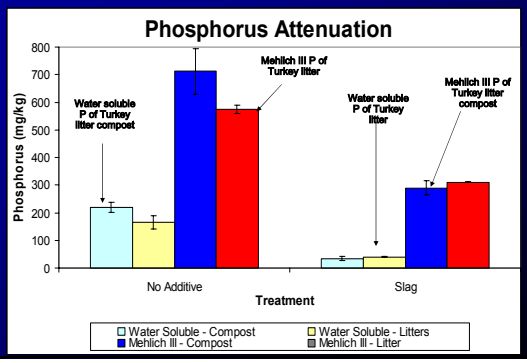
Mehlich III P



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 bioavailibility 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 a 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 ?