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STUDIES IN ENVIRONMENTAL SOIL CHEMISTRY: USE OF POULTRY MANURE FOR MINE SOIL RECLAMATION
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SUMMARY

Studies in Environmental Soil Chemistry: Use of Poultry Manure for Mine Soil Reclamation

Coal accounts for 24 percent of total energy consumed globally, making it the second largest source of primary energy. Although coal is an important source of energy, its mining activities disturb both soils and the terrestrial ecosystem.

In Pennsylvania alone, there are over 250,000 acres of unreclaimed surface mine lands. The soil at many of these abandoned mine sites supports poor vegetative cover due to acidity, limited water holding capacity, degraded soil physical properties, and low levels of organic matter and nutrients, especially N and P. In addition, Pennsylvania is home to numerous intensive animal production facilities, which produce large quantities of manure. Poultry manure in particular is a problem, as this enterprise is often concentrated on small parcels of land and lacks a land base for the manure it produces. These operations have enriched soil N and P levels, creating the potential for these nutrients to reach waterways.

Because these two environmental problems exist in the same region, making the use of poultry manure for mine reclamation a logical solution to both issues. Furthermore, abandoned mine lands could be used to grow switchgrass (*Panicum virgatum L.*), a biofuel crop, to return these lands to productivity. To achieve high production rates, however, significant and sustained nutrient levels are necessary.

The risk in using poultry manure in mine reclamation, however, is that low C:N ratio of manure (7:1), coupled with the lack of organic C in mine soils, necessitates large applications of manure to meet organic C requirements of the soil, which would inevitably lead to large nutrient leaching, which could further degrade nearby water bodies.

The goal of this research is to identify how poultry manure could be used on abandoned mine lands to ameliorate soil phytotoxicity, minimize nutrient losses, sequester nutrients and produce high switchgrass yields. To achieve this goal, greenhouse and field studies were designed to test two different methods of using poultry manure, composting and C:N ratio adjustment.

1. Greenhouse Experiment

In a greenhouse experiment, columns of mine soil were amended with:

1. Lime and inorganic fertilizer,
2. Fresh manure,
3. Manure mixed with three rates of paper mill sludge (to achieve C:N ratios of 20:1, 30:1, and 40:1)
4. Three rates of composted manure.

Each column was planted with 40 switchgrass seeds (*Panicum virgatum* L.) and leached every month for a total of 6 times during the course of the experiment to assess leaching loss of macronutrients and switchgrass growth. The results of greenhouse experiments showed that:

1. Fresh manure exhibited the highest leaching of NO_3–N (192 mg $column^{-1}$).
2. Increasing the C:N ratio to 30:1 resulted in a five-fold decrease in the amount of NO_3^- leached.
3. All compost treatments leached less than 6% of added N despite large application rates.
4. Less than 2% of added P was leached from all treatments, indicating no significant risk of P leaching loss.
5. There was a linear increase in switchgrass growth with increasing compost addition and with increasing paper mill sludge addition.
6. These results confirmed the idea that N losses by poultry manure could be minimized by composting and C:N adjustment and produce more switchgrass than lime and fertilizer amended soils.

2. Field Experiment

A field reclamation study was established on a surface coal mine in Pennsylvania. Five reclamation treatments were each replicated four times in a randomized complete block design. The treatments included:

1. A standard reclamation practice of ground limestone and inorganic fertilizer (ammonium nitrate, triple super phosphate and KCl) amendment,
2. Two rates of composted poultry layer manure (78 and 156 Mg ha^{-1} dry weight),
3. Two blends of fresh poultry layer manure (50 Mg ha^{-1} dry weight) mixed with paper mill sludge (103 and 184 Mg ha^{-1}) to achieve C:N ratios of 20:1 and 30:1.

These rates were chosen based on results obtained in the preliminary greenhouse study. All plots were planted with switchgrass. The results of field experiment showed that:

1. Both composting and C:N adjustment methods work equally well to revegetate the mine soil and eliminate phytotoxic conditions.
2. Leaching losses from composts were <1% of added N, while manure and paper mill sludge lost 8% and 16% of added N with a 20:1 and 30:1 C:N ratio, respectively.
3. Organic treatments sequestered greater C and N in soil compared to lime plus fertilizer.
4. Although revegetation was successful for all treatments, organic treatments produced superior switchgrass yields after three years.

The conclusion of greenhouse and field experiments:

1. All treatments examined in this research, including lime plus fertilizer, fresh poultry manure, composted poultry manure, and fresh manure mixed with paper mill sludge, were equally effective at ameliorating soil phytotoxicity of mine soils and producing vegetative cover.
2. Fresh manure alone leached significantly more nutrients than any treatment.
3. Whereas leaching losses were considerably smaller for treatments containing both fresh manure and paper mill sludge. These results confirm that C:N ratio adjustment of poultry manure with paper mill sludge is an effective way to minimize nutrient losses.
4. In both greenhouse and field experiments, the application of composted poultry manure to mine soil proved to be an extremely effective method for minimizing nutrient loss and sequestering more nutrients in the soil, confirming that this method of mine reclamation poses minimal environmental risks.
5. Switchgrass yields were significantly higher for all organic treatments compared to the lime plus fertilizer treatment three years after amendment application, demonstrating that a lime plus fertilizer treatment would be insufficient to produce high switchgrass yields necessary for economical biofuel production on mine soils.
6. Furthermore, it appears that manure and paper mill sludge application rates could be further reduced to more effectively minimize nutrient losses while maintaining high switchgrass yields.
7. These results have implications for the long-term enhancement of soil quality and sustainable biomass production.

8. The economics of mine reclamation necessitate an inexpensive method for widespread adaptation and successful implementation. On-site application of manure and paper mill sludge would fulfill this stipulation more so than compost, which incurs additional expenses during the production and transport of material.
9. Finally, the production of switchgrass or participation in a C or N sequestration program could help pay for the reclamation costs incurred with these methods.