Substantial research has been conducted to develop best management practices for land application of the 700,000 tons of poultry litter and 28,000 tons of biosolids annually generated on the Delmarva Peninsula. The research has helped crop growers and environmental managers develop agronomic applications of waste materials as organic fertilizers to meet plant nutrient requirements, sustain soil fertility, and reduce non-point source pollutant load to Chesapeake Bay and Delaware Bay.

Soil-based Recycling of Organic Waste for Crop Productivity and Environmental Health

Who cares and why?

Delmarva Peninsula has concentrated broil production. Each year more than 700,000 dry tons of poultry litter are generated in the region. The chicken waste is being disposed of predominantly by applying to cropland as an organic fertilizer. Poultry litter contains relatively high contents of plant nutrients including N, P, K, Ca, Mg, and S and serves as a best soil amendment for crop production. Repeated and excess application of poultry litter to the limited local cropland acreage, however, has resulted in accumulation of P in soil and severe nutrient dissipation via runoff and leaching, causing eutrophication and quality degradation of local water bodies including Chesapeake Bay and Delaware Bay. It was estimated that 26.3 million kg of N and 2.0 million kg of P were annually lost from land-applied animal manures via surface runoff to the Chesapeake Bay. Another non-point nutrient source to water pollution is land-applied biosolids at 28,000 tons/yr in the region. Farmers and environmental managers need scientific guidelines to develop best manure land disposal programs in terms of application rate, timing, frequency, and mode that promote crop productivity and minimize nutrient water losses.

What has the project done so far?

Years of laboratory, greenhouse, and field studies with financial support from Delaware Department of Agriculture, USDA/Capacity Building Grants (CBG), and NSF/Experimental Program to Stimulate Competitive Research (EPSCoR) have measured total and labile nutrient contents of Delmarva poultry litter, biosolids, and their derived products (e.g., biochar, pellets, lime-fortified granules), examined their nutrient release kinetics and plant availability, predicted their nutrient supply capacity, and recommended agronomic application rates for the organic fertilizers. To protect water quality, Delmarva poultry litter should be incorporated into cropland soil at 6.6 ton ha^{-1} instead of commonly practiced 9-20 ton ha^{-1} shortly before planting with supplemental 72.3 kg N ha^{-1} chemical fertilization. In repeated annual applications using poultry litter as the sole P source, the application rate should be further reduced to 5.2 ton ha^{-1}. For lime-stabilized biosolids, a N-based application rate is recommended at 10.4 ton ha^{-1}, providing 165 kg N ha^{-1} to plants without P runoff and leaching risks. The fertilizer value of lime-stabilized biosolids was estimated at \$155 ton^{-1} at the current market prices. In addition, value-added reuse of organic residues was explored. Poultry litter was converted to activated carbon for removing heavy metals and

organic contaminants from waste water. The optimal activation conditions for producing best quality activated carbon from poultry litter were determined. Sorption isotherms, kinetics, and capability of poultry litter activated carbon for metal ions and hydrocarbons were investigated.

Poultry litter, crop residues, and forest debris were further used as source materials to produce biochar, bio-oil, and syngas through pyrolysis. A farm-based, pollution-free prototype pyrolysis system was developed. Mass yield and quality of the bio-products from different feedstocks under varied pyrolysis conditions were characterized. The biochars have been tested in long-term field plot trials as a soil amendment for enhancing soil fertility and promoting crop production. Upgrading procedures were developed to transform pyrolysis bio-oil into a quality liquid fuel. It has shown that at 300°C pyrolysis temperature biochar had the highest mass yield and retained all P and most N in poultry litter, but the biochar C was not maximized in stability. Poultry litter P was immobilized in biochar as Ca/Mg precipitates through pyrolysis, remarkable decreasing its water solubility and runoff loss potential upon soil application. Soil amendment with biochar instead of raw poultry litter at 2 mass% demonstrated improved crop growth and significantly reduced nutrient water losses. Biochar soil amendment also increased soil porosity, organic carbon sequestration, water and nutrient retention, and microbial activity, reduced soil compaction, and improved soil tilth.

Impact Statement

Land application of Delmarva poultry litter at 6.6 ton/ha instead of commonly practiced 9-20 ton/ha would meet crop P requirement and minimize nutrient runoff and leaching losses.

The fertilizer value of lime-stabilized biosolids was $155/ton at current market prices. Agronomic application of lime-stabilized biosolids should be N-based at 10.4 ton/ha.

Poultry litter can be used to produce activated carbon for removing heavy metals and organic contaminants in wastewater treatment.

Organic waste materials were converted to biochar as a soil amendment and bio-oil as a renewable liquid fuel through low temperature slow pyrolysis. Soil amendment with poultry litter biochar at 2 mass% improved crop productivity and soil quality over a long term.

What research is needed?

Further research is needed to develop simple and cost-effective pyrolysis units for farm-based production of biochar and bio-oil from agricultural residues. Best land application practices of biochar products from different sources should be identified and disseminated to crop growers.

Want to know more?

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Strategic Priority: Natural Resources and the Environment

Additional Links:
http://www.umes.edu/ard/Default.aspx?id=46285

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