Synthesis of Short- and Long-term Studies Reporting Soil Quality Metrics under Agricultural and Municipal Biosolid Applications

2016 Manure and Soil Health Working Group Data Brief

Background

The principal focus of soil health management is to preserve and improve soil physical, chemical, and biological properties such that conditions for supporting plant growth and ecological function are optimized. Practices such as planting cover crops and minimizing or eliminating tillage, are promoted for improving soil health. However, utilizing livestock manure and municipal biosolids as soil amendments on agricultural cropland has received comparatively less attention as a practice for improving soil qualities. Recycling locally available nutrients, such as livestock manure, prior to importing commercial fertilizer should be promoted as a component of the overall strategy to address nutrient imbalance and net increases of nutrients to regions. However, few studies have investigated the impact of manure and biosolid application on all three components of soil health metrics – physical, chemical, and biological.

Purpose

In order to understand and advance the state of science related to manure management and soil health, funding from the North Central Region Water Network and the Soil Health Institute was utilized to synthesize research focused on this area. A review of literature was conducted with two objectives: (1) summarize results of short- and long-term studies reporting chemical, physical, and biological soil properties from application of livestock manure and animal by-products (i.e. compost) and municipal biosolids to soil, and (2) describe research needs related to manure and soil health based upon identified gaps in knowledge resulting from the literature review.

AUTHORS

Linda R. Schott
Extention Graduate Research Assistant,
Biological Systems Engineering,
University of Nebraska-Lincoln

Amy Millmier Schmidt
Assistant Professor,
Biological Systems Engineering
& Animal Science,
University of Nebraska-Lincoln

AUTHOR CONTACT

Amy Millmier Schmidt
Biological Systems Engineering
Assistant Professor
213 L.W. Chase Hall
Lincoln, NE 68583
(402) 472-0877
aschmidt@unl.edu

NETWORK CONTACT

Rebecca Power
rlpower@wisc.edu

SUBMISSION

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Current State of the Science and Understanding

The effect of manure and municipal biosolids on soil physical and chemical properties has been well documented in previous literature reviews. In general, the effect of manure and municipal biosolids on soil chemical properties is heavily dependent upon the chemical properties of the applied amendment. When applied at appropriate rates, these organic amendments increase soil organic carbon and cation exchange capacity, in addition to providing beneficial micronutrients for crops. The application of manure or biosolids decreases bulk density which, subsequently, increases soil porosity. However, manure and biosolid application does not increase water holding capacity of the soil. Studies also indicate that manured soil is more resistant to compaction, especially when wet; aggregate stability is increased due to an increase in soil organic carbon (SOC) and microbial activity, and infiltration rate is also increased. Both of these effects lead to reduced risk for runoff and erosion.

However, the effect of manure and municipal biosolids on soil biological properties has not been well researched. This is likely due to cost and time constraints related to these measurements. Overall, manure and biosolid application increases abundance of soil fauna, such as bacteria, fungi, and earthworms, but does not seem to increase faunal diversity when compared to inorganic fertilizer. Manure and biosolid application also increases microbial respiration and mineralization, which are indicators of nutrient cycling. However, the application of manure does not affect the abundance of soil microarthropods, like Collembolla or Acari. Microbial biomass carbon (MBC) is the most commonly utilized metric for assessing soil biological properties. This measurement only indicates the abundance of soil microbes and does not reflect microbial activity or diversity.

Challenges and Research Needs

Most of the research published about the impact of manure or biosolid application on soil properties, crop production, and water quality is based on studies where manure is applied annually. When manure and biosolids are applied annually at rates that exceed the nutrient requirements of crops, the risk for leaching, runoff, and accumulation of nutrients, such as N, P, K, salts and heavy metals, is increased. This is especially true in studies that apply manure annually at the crop N rate because P and K are often over applied. Only a few studies have investigated the residual effects of manure or biosolids once application has ceased.

Future research endeavors should: (1) incorporate quantification of soil biological metrics since soil biology provides ecosystem services, like nutrient cycling, (2) investigate the short- and long-term effects of a single application of manure or biosolids to support an effort to identify the optimal frequency of application for improving soil health, (3) be designed such that nutrient application among treatments is balanced on an annual or multi-year basis, and (4) provide discussion that clearly relates research findings to management decisions relevant to agricultural crop producers.