Soil carbon and nitrogen fractionation following biosolids applications

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Anaerobically digested and dewatered biosolids can be an effective source of nutrients in a cropping system, and application of biosolids from municipal solid waste facilities to farmland in WA has been practiced since the 1980s. In Douglas County, more than 50,000 acres of wheat-fallow agricultural land is part of the Boulder Park Project, where biosolids have been used as a crop nutrient source and to reduce soil erosion. Biosolids from wastewater treatment in WA's King County are trucked across the Cascade Mountains, spread on the soil, and incorporated within six hours of application. These biosolids supply a full complement of plant nutrients, which reduces the need for synthetic fertilizers that require fossil fuel inputs and generate greenhouse gas emissions, while also helping sequester carbon as soil organic matter.

IMPACT

The use of biosolids for plant nutrition benefits our agroecosystem by reducing emissions associated with synthetic fertilizer production and increasing soil carbon and nitrogen sequestration.

Intensive cropping practices in cereal production systems have led to degraded agricultural soils, largely characterized by a decrease in soil organic matter. Organic matter is a vital component of our soils; it lends itself to the better storage of nutrients and water in the soil and helps bind soil particles together so that they remain in place under conditions that could cause wind or water erosion. When organic matter in the soil declines, soils become more vulnerable to erosion. Long-term experiments have shown that the most effective way to rebuild soil organic matter while still harvesting a crop from the land is by applying organic soil amendments that are high in carbon.

Since 1994, researchers from Washington State University have been monitoring a cropping system in Douglas County where biosolids from a waste water plant in King County were applied for wheat production. The biosolids were applied every four years, in the fall following wheat harvest, at rates of 2.0, 3.0, or 4.5 dry tons per acre. These biosolid-amended systems were compared to one receiving no applications of biosolids and no nitrogen fertilizer, and to a system where no biosolids were applied but nitrogen was applied in the form of anhydrous ammonia (NH_3) every two years, in the spring of the fallow year.

Analysis of a time series of soil samples has shown that application of biosolids led to an increase in soil carbon and soil nitrogen. Different application rates yield different soil accumulation rates, as seen in the larger increase in soil carbon and nitrogen when 4.5 dry tons per acre were applied to a field, compared to the 2.0 dry tons per acre rate (Figure 1). What is most clear is that the application of biosolids at any of the three investigated rates led to an increase in soil carbon when compared to (1) a system that has had no nutrient additions and (2) one that has had only additions of conventional nitrogen fertilizer.

The increase in total soil carbon was more than 70% of what was applied as biosolids, while the increase in total soil nitrogen is about 35% of what was applied. One of the main reasons for this difference in accumulation rates is that grain, which is high in nitrogen, is harvested by the farmer and removed from the system, instead of contributing to the plant-soil nutrient balance.

Along with analyzing total carbon and nitrogen, we can separate different fractions to determine the form in which the nutrients are being stored. Acid hydrolysis is a procedure used to quantify the amount of carbon and nitrogen stored in a way that is resistant to digestion by a strong acid. To measure this, researchers reflux a 1-gram soil sample in hydrochloric acid at 240° F for 16 hours. After refluxing, the remaining soil is washed with pure water, and analyzed for total carbon and nitrogen content. The amount that remains allows us to calculate the acid-resistant

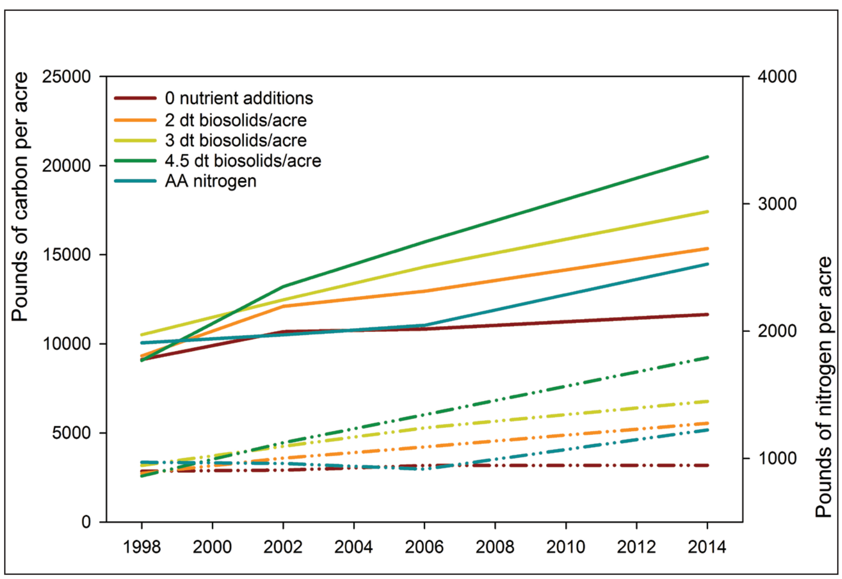


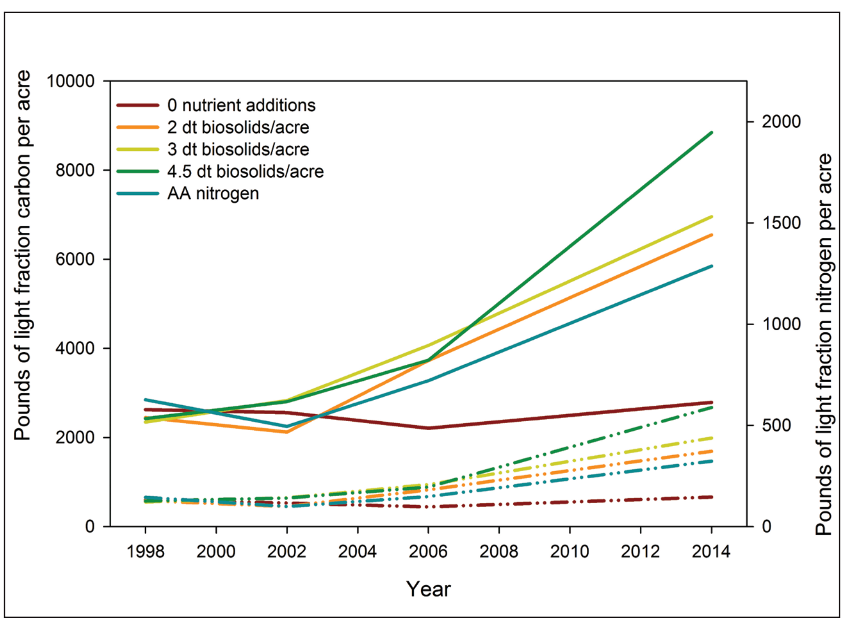
Figure 1. *Total carbon and total nitrogen measured in the soil. The dashed lines represent the nitrogen fraction, and the solid lines represent the carbon fraction.*

A winter wheat field, part of the Boulder Park biosolids project. Photo by Craig Cogger.

carbon and nitrogen fractions. The resistant fraction has been shown to be stable over time and does not change much with land management practices. The data from this site support that definition—the acid-resistant carbon fraction has increased over time, but very little, and the acid-resistant nitrogen fraction has not seen a significant change.

In contrast to the acid-resistant fraction, the light fraction is highly responsive to soil management. Light fraction carbon and nitrogen is measured by mixing a soil sample with sodium iodide (NaI), which has a density of 14 pounds per gallon. The light fraction floats on top of the NaI solution, while heavy soil particles sink to the bottom. The light fraction is then skimmed off of the NaI, treated to remove any remaining NaI, weighed, and analyzed for carbon and nitrogen content. The trends for light fraction carbon and nitrogen increases are very similar to what is seen in total carbon and nitrogen—the systems with additions of biosolids show major increases in the light fraction (Figure 2).

The light fraction exhibits the greatest increase in response to biosolid applications, and is the main contributor to the observed carbon and nitrogen sequestration. Biosolids are applied at a rate that provides optimum nutrition for growing wheat crops, and they have the added benefit of increasing soil organic matter to protect soil quality and sequester carbon and nitrogen. By reducing inputs of fossil fuel-intensive synthetic fertilizers, and acting as a carbon sink in our agroecosystem, biosolids applied to agricultural lands can help reduce carbon emissions associated with our farming systems.



Spreading biosolids on a wheat field in Douglas County, WA. Photo by Craig Cogger.

Figure 2. *Light fraction carbon and nitrogen as measured in the soil. The dashed lines represent the nitrogen fraction, and the solid lines represent the carbon fraction.*