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The Real Dirt on Biosolids as Soil Amendments

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The U.S. Environmental Protection Agency (EPA) estimates that more than 60 percent of dry biosolids—treated wastewater solids that can be recycled or stored—are applied to land, composted, or used to cover landfills. The biosolids have been processed to kill pathogens, and EPA strictly regulates biosolid use to ensure the materials don't harm the environment, human health, or animal health.

Farmers who follow pre- and postapplication management regulations can obtain permits to use biosolids for amending fields where food and feed crops are grown. Now, research by an Agricultural Research Service scientist is helping to clarify the long-term effects that biosolid amendments can have on some soil types—and how the amendments could affect crop production.

"Processed biosolids contain nitrogen and phosphorus that can be used for fertilizer," says agronomist Eton Codling, who works at the ARS Environmental Management and Byproduct Utilization Laboratory in Beltsville, Maryland. "They also contain copper, manganese, and zinc, which are plant micronutrients. But biosolids also have lead and cadmium, which can contaminate the soil."

Tracking a Timeline

Codling decided to investigate how long plant-available phosphorus and other minerals remain in soils amended with biosolids and how much phosphorus, copper, cadmium, lead, manganese, and zinc was taken up by wheat grown on those soils. He measured mineral levels in three different soils that had previously received a single amendment of a biosolid processed via one of the following methods: high heat, additions of lime, anaerobic digestion, or air drying.

The amendments had taken place 16 to 24 years earlier during a series of studies on biosolid amendments, and they had been applied to the soils at several different rates. As part of the earlier work, the fields had been cropped after the biosolids had been added, so the biosolid nutrients in the experimental fields had been available for crop uptake for at least 16 years before Codling began his research.

Still, the scientist observed that phosphorus levels were generally higher in the biosolid-amended soils than in control soils, which strongly indicated that soluble phosphorus levels in biosolid-amended soils could exceed typical plant requirements for years after the addition of the soil amendments. This meant that the excess phosphorus could wash out of the biosolid-amended soils into adjacent water channels and contribute to the development of oxygen-deficient "dead zones."

Codling also noted that phosphorus solubility varied with the biosolid type and application level. For instance, a soil amended with heat-treated biosolids contained higher levels of water-extractable phosphorus than the same soil type amended with lime-treated biosolids. This occurred even though the soil with the lime-treated biosolids had received amendments at levels that were three times that of the heat-treated biosolid amendment. The lime-treated biosolids had most likely sequestered phosphorus in low-solubility

Safe Food, Safe Water

Since there are health risks associated with cadmium ingestion, the EPA has established maximum contaminant levels for cadmium in drinking water. The U.S. Food and Drug Administration has established limits for cadmium in bottled water and for several food products. The agency monitors the metal in the food and feed supply and would take appropriate regulatory action if the cadmium levels were found to be injurious to health.

STEPHEN AUSMUS (D2710-1)

Agronomist Eton Codling inspects wheat plants grown in biosolid-amended soils. Yields from some biosolid amendments were higher, but yields from lime-treated biosolids were severely reduced. The unhealthy plant on the left is growing in soil amended with lime-treated biosolids.

calcium phosphate compounds. Most of the biosolid-amended soils also had higher levels of plant-available cadmium, copper, and zinc than the nonamended soils, and soil mineral levels generally increased as amendment levels increased.

Crop Response

Codling then conducted a study in which wheat was planted in pots filled with each type of amended soil. The researcher observed that yields from wheat grown in three of the five biosolid-amended soils were higher than from wheat grown in control soils. The highest yields were recorded for wheat grown in soils amended with biosolids created via anaerobic digestion, and yields in these experimental soils increased as amendment levels increased. But yields from wheat grown in lime-treated biosolids were severely reduced, probably as a result of manganese deficiency.

Codling also measured mineral levels that had accumulated in the above-ground biomass of the experimental crops. He observed that wheat grown in any of the biosolid-amended soils had higher phosphorus concentrations than wheat grown in the control soils. This coincided with the soil's elevated levels of plant-available phosphorus and provided additional indications that phosphorus was readily available for crop uptake 16 years after test soils were amended with biosolids.

Overall wheat tissue levels of lead were low, because most plants typically do not bioaccumulate lead to any significant degree. But tissue cadmium levels ranged from 1.2 parts per million (ppm) to more than 20 ppm in wheat cropped in the biosolid-amended soils. (Cadmium levels in the control soils averaged around 1.4 ppm.)

In addition, all the soil mineral levels were reduced after one cropping of wheat. Since Codling had collected leachate from each pot after watering and returned it to the pots, he surmised that the lower levels of extractable metals and phosphorus in the soils most likely resulted from plant uptake.

Taken together, these results, which are scheduled for publication in the *Journal of Plant Nutrition,* confirmed to Codling that minerals in biosolids can linger in soils long after the soils are amended. In addition, the way biosolids are processed before they are applied to soils may affect soil mineral levels to some degree.

"Even though I was evaluating mineral levels in vegetative tissue, not grain, the results still show that food and feed crops can take up minerals left over from biosolids years after the soils have been amended," Codling says. "Since sewage treatment facilities have different processes for treating biosolids, this information could help us manage biosolid amendments more effectively."—By **Ann Perry,** ARS.

This research is part of Food Safety, an ARS national program (#108) described at www.nps.ars.usda.gov.

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With Hot Air Treatment, Bacteria Fly the Coop

ANNA BATES (K9516-1)

While being transported in hauling coops on trucks, poultry that have been colonized with bacteria such as *Campylobacter* can contaminate, through fecal shedding, pathogen-free poultry. Those pathogens can also be passed on to the next group of birds during the next trip, and so forth, unless the cycle is broken.

That's where Agricultural Research Service microbiologists Mark Berrang and Richard Meinersmann and colleague Charles Hofacre at the University of Georgia in Athens come in. The team has reported a treatment that reduces poultry cross-contamination from transport-cage flooring.

Campylobacter are foodborne pathogens that can be present in raw or undercooked poultry. Since the bacteria are commonly found in the digestive tracts of poultry, they're readily deposited, through fecal shedding, onto coops and trucks when contaminated animals are transported to processing plants.

Berrang and Meinersmann are in ARS's Bacterial Epidemiology and Antimicrobial Resistance Research Unit in Athens.

Earlier work has shown that drying soiled or washed cages for 24 to 48 hours could lower or eliminate detectable *Campylobacter* on cage flooring. But extended drying times are impractical, so the researchers tested the use of hot flowing air to speed the process.

To determine whether the effect was due to heat alone or flowing air alone, hot flowing air was compared with unheated flowing air and static hot air as well as with a control. The numbers of *Campylobacter, Escherichia coli,* and coliforms on small squares of washed or unwashed fecally soiled transport cage flooring were measured after drying treatments.

When applied after a water-spray wash treatment, flowing hot air for 15 minutes lowered the numbers of *Campylobacter* to an undetectable level. The authors reported that the treatment could provide significant savings in drying time if used by industry, suggesting a potential commercial application. Static heat at similar temperatures was not nearly as effective, and unheated flowing air was moderately effective, but less so than hot flowing air.

The authors concluded that processors may be able to use a forced-hot-air treatment to dry cages between transporting flocks, lessening the number of *Campylobacter* on cage flooring, thereby decreasing the potential for cross-contamination during live haul.

More findings are reported in the *Journal of Applied Poultry Research,* December 2011.—By **Rosalie Marion Bliss,** ARS.

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