The presence of antibiotic resistance in the environment is a growing human health concern. One antibiotic resistance pathway that is of critical importance to human and animal health is the usage of livestock manure in agricultural practices. The common practice of administering livestock with antibiotics has resulted in the presence of antibiotic-resistant bacteria (ARB) and antibiotic-resistance genes (ARGs) in manure. When manure is applied as fertilizer, the ARB may come in contact with crops or be washed into surface water, which spreads throughout the environment. To reduce the presence of bacteria and other pathogens in manure, it is recommended that livestock manure be composted prior to soil application. The composting process increases the temperature of the manure and can kill bacteria; however, composting cannot eliminate all pathogens from manure.

Researchers are interested in quantifying and tracking bacteria in manure, both non-resistant and resistant strains, to determine how best to reduce the risk posed to human and environmental health. A study published in the July–August 2019 issue of the *Journal of Environmental Quality* (https://doi.org/10.2134/jeq2018.12.0441) compared agricultural field plots amended with both raw and composted manure from antibiotic-treated and non-treated dairy cows. The study was conducted at the Virginia Tech Urban Horticulture Center in Blacksburg, VA, and fields were used to grow lettuce or radish with a barren field as a control.

To evaluate the presence and quantity of bacteria, surface runoff was collected from individual plots. The analysis was performed on samples from the “first flush” of surface runoff associated with rainfall events. Not all rainfall events were sampled, but those included in the data set produced at least 11 L of runoff per plot. Of the six sampling events included in the study, four occurred during the growing season (March–June 2016) and two post-harvest (July–August 2016). The researchers measured sediment concentrations and quantified a known marker of resistance (sul1) and an ARG associated with the drug class administered to the dairy cow (ermB) using known qPCR protocols.

The results were highly variable from one rainfall event to the next, as each natural storm event is inherently individual. Differences in duration and intensity of rainfall combined with variation in soil moisture and the amount of vegetation present during the growing season had a

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**Manure Composting May Not Reduce Pathogens in Agricultural Runoff**

by Tracy Hmielowski

Wind rows of compost on a dairy farm in California. Source: Jeff Vanuga (USDA-NRCS).

Inset: Amy Pruden, co-author of the study, inspects a Petri dish. Source: Virginia Tech.

- Bacteria, including antibiotic-resistant strains and antibiotic resistance genes (ARGs), can be present in manure applied as a source of fertilizer.
- Composting manure prior to application can reduce pathogens, but some bacteria may persist.
- A study monitoring runoff from manure-amended agricultural fields found no difference in fecal indicator bacteria or ARGs between composed and raw manure.

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It is common to use herbicide around planted seedlings to reduce competition and aid in the establishment of these trees. In this study, researchers tested differences in timing and number of applications of herbicide on pine survival and growth and how assays impacted soil N, recognizing that these chemical treatments can impact not only pine growth but also soil biogeochemistry.

The authors report that use of imazapyr did not have a negative impact on longleaf seedlings when applied in the second growing season after planting and that sulfometuron methyl and hexazinone were not suggested for use at wet sites, such as the study site. Imazapyr treatments had higher levels of ammonification and N mineralization compared with control samples. And there was little indication of an impact of any treatment on soil microbial and fungal biomass.

Overall, the study suggests that as private and public landowners are incentivized to restore longleaf pine habitat in the southern U.S., imazapyr applications in the second growing season were the most effective strategy for establishing planted longleaf seedlings.


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The analysis focused on two ARGs. While the data from individual storms varied, in general, the observed trends for the ARGs were similar for raw manure and compost treatments, and ARG presence was greater in early storms than those later in the season or post vegetable harvest from the field plots. It was notable that the ARG trends were different from those observed for the fecal indicator bacteria, a trend that has been observed in other studies of runoff, suggesting that fecal indicator bacteria monitoring cannot be used to predict the presence, quantity, or movement of ARGs. The observed complexity of interacting factors and the influence on pathogen movement suggest a need for detailed data collection of runoff to aid in improving management practices to reduce the potential of pathogens, ARB, and ARGs being carried away from agricultural fields as the environmental and human health impacts are still being determined.