Antibiotic Residuals and Composting of Dairy Manure

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Introduction

Stockpiling and composting dairy manure are each manure management methods that some farms employ. Stockpiling is the simplest form of manure storage and is the heaping of solid manure, soiled bedding, or separated solids that degrade as they age. In arid climates, some dairies use stockpiling for manure storage year-round. More typically, stockpiling is used for short periods (weeks to months) to apply to cropland.

Composting can occur when dry matter is added to raw dairy manure with mixing/aerating to manage the moisture content. The composting process occurs at higher temperature than stockpiling and at aerobic conditions. Resources on composting of farm waste are available on the Cornell Waste Management Institute (CWMI) website.[1]

While stockpiling has been shown to reduce some antibiotic residues, more intensively managed composts at the right conditions are more effective.[2]

Impact of antibiotic residuals on composting process

Antibiotic residuals present in dairy manure can inhibit the microbial populations that develop in the composting process, leading to less consistent composting at lower in-mix temperatures. Studies have found that macrolides (i.e., tylosin) do not impact composting, but tetracyclines (i.e., chlortetracycline) do.[3] Some studies have found that interactions between different antibiotic residues can either slow or accelerate their degradation in manure composts, which may invite the opportunity to combine treated animal manure containing complementary antibiotics and separate that which slows degradation.[4]

Mitigation of antibiotic residuals in stockpiles

Antibiotic residues in stockpiled cow manure degrade over weeks, months, or longer, with varying amounts of residue remaining. A study of stockpiled Holstein cattle manure measured the half-concentration degradation rates (DT_{50}) and remaining residue content of three common antibiotics: chlortetracycline, sulfamethazine, and tylosin (Table 1).[5] While tylosin had a relatively short DT_{50} of 4.7 days, 13% of the residue remained after 140 days. The study also found that degradation of chlortetracycline slowed significantly when sulfamethazine residue was also present.

Table 1. Antibiotic residue degradation measured in stockpiled Holstein cattle manure.

Antibiotic residue	DT_{50}: time from initial to half concentration (days)	Percent remaining after defined period
Chlortetracycline	1.8	<1% after 17 days
Sulfamethazine	20.8	2% after 77 days
Tylosin	4.7	13% after 140 days
Chlortetracycline in the presence of sulfamethazine	6.0	<1% after 56 days

Mitigation of antibiotic residuals in compost

With proper composting methods, the DT_{50} has been reduced by up to one-half for several tetracyclines in dairy and beef manure. Similar results with the macrolide kitasamycin were found in a cow manure and sawdust compost.[4] Evidence of possible disruption of the antibiotic degradation process from mixing compost windrows as compared to stockpiling has also been observed.[3] Frequent mixing of windrows can cause drying and temporary cooling that are believed to disrupt the microbial community responsible for antibiotic residue degradation. Antibiotic degradation has been shown to increase under thermophilic (130°F) compost conditions as compared to mesophilic (100°F) conditions.[6]

Understanding the direct impact of composting conditions on antibiotic mitigation is complicated by the non-biological behaviors of antibiotics. Some antibiotic residues adsorb tightly to components in the compost that limits their detection. Additionally, false-negative detections can occur when some antibiotics transform in compost. Antibiotic molecular structures can be unstable and degrade from UV exposure and abiotic hydrolysis. The sorption dynamics and accurate methods for extracting and measuring antibiotics, degradation products, and conjugates in composted manures add complexity.

Mitigation of antibiotic residuals in in-vessel compost

In-vessel compost systems, such as a rotary drum style unit, have not been extensively studied for their possible impact on antibiotic degradation. These compost systems are believed to be effective at degrading antibiotic residues due to their sophisticated control of temperature and moisture content, and operation at thermophilic conditions.

An on-farm study[7] of a manure treatment system (Figure 1) consisting of solid-liquid separation (SLS) and rotary drum (RD) composting of separated solids (SS) found mass reduction of both oxytetracycline (OTC) and sulfadimethoxine (SDM) after the SLS, with only the OTC mass reduction statistically significant at 39%. Approximately 80% of the OTC residual and over 90% of the SDM residual partitioned with the separated liquid (SL) effluent after SLS. Of the OTC and SDM mass measured in the SS, a 50% reduction of OTC and a 20% reduction in SDM was measured after the RD composter.

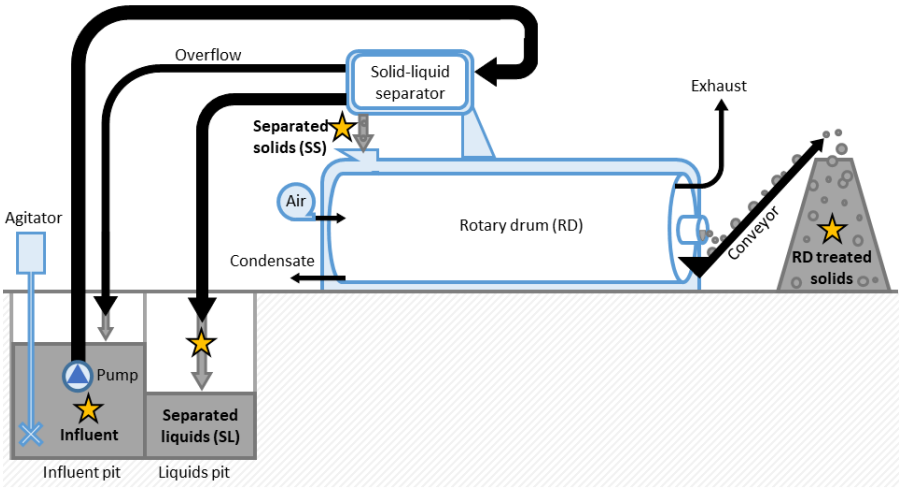

Figure 1. Schematic of solid-liquid separator and rotary drum composting system (blue), plumbing and conveyors (black arrows), and material flows (grey). Yellow stars indicate sample locations.[7]

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