The Fate of Antimicrobial Residues in Livestock Manure

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Key Points

- Antimicrobials administered to beef cattle in feed were detected in manure.
- Antimicrobial concentrations in manure decreased during stockpiling and windrow composting.
- Antimicrobials were transported in simulated rainfall runoff from feedlot pens, composting windrows, and from soil amended with beef cattle manure.
- Antimicrobials were detected in feedlot catch basins and water from supply canals in irrigation districts in Alberta.

Introduction

Most feedlot cattle in western Canada are administered veterinary antimicrobials therapeutically to treat, control, and prevent disease and sub-therapeutically to promote growth through improved feed efficiency. A portion of the administered veterinary antimicrobials is excreted in urine and feces either unchanged or as metabolites, some of which may still have biological activity. Veterinary antimicrobials undergo degradation in feedlot pens, during stockpiling, windrow composting, and after land application of manure. However, the antimicrobials may move from feedlots, manure storage locations, and manure-amended crop and pasture land in rainfall or snowmelt runoff. Further, runoff from such locations may contaminate surface and ground water with antimicrobials. Beef cattle manure from feedlots in Alberta has been shown to contain veterinary antimicrobials such as chlortetracycline, sulfamethazine, and tylosin (Cessna et al. 2011; Sura et al. 2014). In addition, commercial feedlot soil (Aust et al. 2008), runoff from feedlots (Sura et al. unpublished), manure-amended soils (Amarakoon et al. 2014), and surface and ground water near confined animal feeding operations (Campagnolo et al. 2002; Watanabe et al. 2010) have been shown to contain veterinary antimicrobials. To thoroughly understand the fate of veterinary antimicrobials fed to feedlot cattle, various studies were undertaken. The transport of veterinary antimicrobials in runoff from feedlot pens and their presence in catch basins have been studied, as well as their dissipation during composting and stockpiling of feedlot manure, and their transport in runoff after land application of manure. In addition, irrigation water from selected supply canals in several irrigation districts in Alberta was analyzed for the presence of veterinary antimicrobials used in Alberta feedlots.

Methods

Field studies were conducted in a research feedlot at the Lethbridge Research Centre, Lethbridge, Alberta during a period of 3 years (2010 to 2013). Cattle were administered one of four antimicrobials in their diet: chlortetracycline (CTC), chlortetracycline + sulfamethazine (CTCSMZ), tylosin (TYL), or no antimicrobials - control (CON). Accumulated manure in the pens was used to investigate the dissipation of veterinary antimicrobials during stockpiling, windrow composting, and after land application of manure (60 tonnes per hectare). In addition, concentrations of veterinary antimicrobials in catch basin water, in simulated rainfall runoff from pens, composting windrows, and manure-amended soil, and in irrigation water were also quantified.

Results and Discussion

Results indicated that feedlot cattle manure contained the administered veterinary antimicrobials. Mean concentrations in raw dry-weight manure during the 3-year study were: chlortetracycline in CTC (2340 $\mu g\ kg^{-1}$), chlortetracycline in CTCSMZ (2790 $\mu g\ kg^{-1}$), sulfamethazine in CTCSMZ (500 $\mu g\ kg^{-1}$), and tylosin in TYL (70 $\mu g\ kg^{-1}$). Antimicrobial concentrations in manure decreased significantly during stockpiling and windrow composting. Dissipation half-life (half-life is the time period for an antimicrobial to decrease to 50% of initial concentration and is a measure of persistence of antimicrobial in the manure) values during stockpiling were 20.8 d (sulfamethazine) > 6.0 d (chlortetracycline in CTCSMZ) > 4.7 d (tylosin) > 1.8 d (chlortetracycline in CTC). These half-lives were significantly lower than those observed during windrow composting; 31.9 d (tylosin) > 26.8 d (sulfamethazine) > 20.9 d (chlortetracycline in CTC) > 15.2 d (chlortetracycline in CTCSMZ). These studies show that the manure management options of stockpiling and windrow composting are effective in significantly decreasing veterinary antimicrobial concentrations before land application. Antimicrobial concentrations in simulated rainfall runoff were much higher from feedlot pens (e.g., chlortetracycline, 2600 $\mu g\ L^{-1}$) than those from composting windrows (chlortetracycline, 1060 $\mu g\ L^{-1}$) or from manure-amended soils (chlortetracycline, 30.1 $\mu g\ L^{-1}$). Antimicrobials were detected in irrigation water from some irrigation districts, but at concentrations much lower (e.g., chlortetracycline, 0.069 $\mu g\ L^{-1}$) than those in runoff from manure-amended cropland and lower than maximum safe levels in food (e.g., chlortetracycline, 200 $\mu g\ kg^{-1}$ in meat; Health Canada 2014). Antimicrobials (e.g., tetracycline, 0.11 $\mu g\ L^{-1}$; tylosin, 0.056 $\mu g\ L^{-1}$; monensin, 0.31 $\mu g\ L^{-1}$) were also detected in catch basin and holding pond water in commercial feedlot facilities. Findings from these studies offer manure management options to aid cattle producers in mitigating environmental contamination with veterinary antimicrobials.

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