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Beef Cattle: Manure Management*

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Abstract

Concerns about the effects of livestock operations on the environment revolve around the potential loss of nutrients, pathogens, endotoxins, and pharmacologically active compounds to the air, surface waters, or ground water. Proper management and nutrition can help to reduce these losses and make manure a more valuable by-product of cattle production. Environmental effects must become an inherent component of management decisions in animal feeding operations.

INTRODUCTION

Concerns about the effects of livestock operations on the environment generally relate to nutrients and other compounds excreted in manure. The U.S. beef cattle industry is comprised of three segments: cow-calf, stocker, and finishing. During the cow/calf and stocker phases, feces and urine are primarily deposited on pastures, but they can be a potential hazard in environmentally sensitive areas such as riparian areas. During the finishing phase cattle are concentrated in feedlots. The high density of animals, accumulation of excreted nutrients, the extraneous losses of these nutrients and compounds to the environment, and removal of manure are significant environmental concerns to feedlots.

MANURE: QUANTITIES AND QUALITIES

In general, beef cattle retain less than 20% of the nutrients they consume; hence, the remainder is ultimately excreted in feces and urine or lost as gaseous carbon dioxide or methane. In an average week, 1000 feeder calves weighing 340 kg will excrete approximately 15,000 kg of dry matter, 900 kg of nitrogen, 122 kg of phosphorus, and 272 kg of potassium. The manure may also contain pharmacologically active compounds (PAC: pesticide residues, antibiotics, exogenous and endogenous hormones), pathogens (primarily *E. coli*, *Salmonella*, *Listeria*, *Campylobacter*, and *Cryptosporidium*), and endotoxins.

MANURE HARVESTING AND TREATMENT

Most U.S. beef cattle are fed in open pens with native soil surfaces. Manure is normally scraped from the pens after each lot of cattle is finished (120–200 days). Manure may be stacked in the pen to improve pen drainage, immediately applied to fields, stockpiled for later use, or composted in windrows. During storage, some nitrogen and carbon is lost to the atmosphere. A typical chemical composition of feedlot manure is presented in Table 1.[1]

Manure collection and disposal costs can constitute up to 12% of the total operating costs of a feedyard.[2] The optimal type of equipment to clean pens and collect manure will vary depending upon pen size, manure use, and driver expertise.[2] More frequent manure collection may reduce dust and ammonia emissions, but may increase the cost of manure collection.

ENVIRONMENTAL ISSUES RELATING TO BEEF CATTLE

Water Quality

Nutrients, pathogens, endotoxins, and PAC in manure can potentially run off pasture or feedlot surfaces to surface waters or percolate into ground waters. The Clean Water

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Table 1 Typical composition of feedlot manure and bioavailability of nutrients to plants (% available/year)

Nutrient	Concentration, DM basis	Availability, % per year
Dry matter	50%–70%	—
Nitrogen	2.04%	20–50
Phosphorus	0.81%	60–90
Potassium	2.28%	>85
Calcium	1.98%	40–55
Magnesium	0.76%	40–55
Sodium	1.13%	—
Sulfur	—	40–55
Iron	3200 ppm	40–55
Manganese	—	40–55
Zinc	140 ppm	40–55

Source: From Boca Raton (see Ref. 1).

Act and its amendments gave the U.S. Environmental Protection Agency (EPA) the authority to regulate the discharge of pollutants to waters of the United States and to establish permitting programs for Animal Feeding Operations (AFO) (http://cfpub.epa.gov/npdes). The National Pollutant Discharge Elimination System (NPDES) requires AFO to meet effluent limitation guidelines (http://www.epa.gov/npdes/cafo/producers-guide: 40 CFR Parts 122 and 412) and to develop Comprehensive Nutrient Management Plans (CNMP) (www.nrcs.usda.gov/programs/afo/cnmp_guide_600.52.html) to protect or improve ground and surface water quality. When properly managed, no runoff from pens or manure storage areas will enter lakes and streams (i.e., waters of the U.S.) except in severe rainfall events. Most grazing operations are not point sources and thus are not regulated under the Clean Water Act. However, they may be regulated under state rules and (or) a Total Maximum Daily Load that sets pollution limits (http://www.epa.gov/npdes/stormwater.tmdl.cfm).

Air Quality

Nutrients in livestock excreta are degraded by a combination of anaerobic and aerobic processes (Fig. 1).[3] The atmospheric emissions of greatest concern vary with location. Feedyard air pollutants originate from the cattle, cattle pens, manure stockpiles, the feed mill, and retention ponds. Emissions are highly dependent upon animal stocking density, animal size, ration fed, manure and pen surface management, and ambient environmental conditions. Some reported atmospheric concentrations and emissions are presented in Table 2.

Most feedyard dust is organic, originating from manure and feed; and most particles are larger than 10 μm in diameter.[4] Feedyard odors consist of volatile organic compounds such as *p*-cresol, amines, volatile fatty acids, ammonia, and reduced sulfur compounds.[3] Ammonia emissions represent a loss of nitrogen fertilizer, and may also act as a precursor to the regional formation of small particulates (PM-2.5—particles with diameter less than 2.5 μm). They are predominately a byproduct of the hydrolysis of urinary urea. Atmospheric ammonia emissions at feedyards are higher during the day than the night and higher in summer than in winter,[5,6] primarily due to temperature and solar heating effects. Most pathogens are easily killed by radiation and desiccation; therefore, few living pathogenic bacteria are cultured from feedyard air. However, endotoxins are more resistant, and are potentially present in feedyard air.[7] The greenhouse gases methane and carbon dioxide may come from the animal directly (respiration and enteric fermentation) or by fermentation of manure. Emissions of nitrous oxide from a feedlot surface have not been determined, but are probably low.

Areas adjacent to a feedyard can receive nutrients via dry or wet deposition. These might be advantageous to crops that readily utilize nutrients, but may have detrimental effects on bodies of water and nutrient-sensitive plants near the feedyard.[8]

ENVIRONMENTAL CHALLENGES AND SOLUTIONS

In general, the quantity of manure dry matter produced and thus the cost of manure removal is affected by factors such as grain source, processing method, roughage concentration, and source. Within limits, nutrient inputs and losses can be decreased by proper ration formulation, management, quality control, and use of available technologies such as growth promoting implants and feed additives. Because nutrient requirements change with the physiological state of an animal, it may be possible to decrease dietary N concentrations as time on feed increases (i.e., phase feeding). Results have been more favorable with diets based on dry-rolled corn than with steam-flaked corn,[9,10] probably due to differences in the requirement for ruminally degradable protein. A number of management obstacles, such as additional labor and equipment requirements, currently limit the use of phase feeding systems in commercial feedyards. Adding a manure disposal charge to the cost of feed ingredients may help to limit the use of feeds that may increase environmental challenges (i.e., high P or low digestibility).

Grazing cattle do not redistribute nutrients evenly across pastures; as much as 50% of the manure can be deposited on less than 10% of the land. Proper supplement management (i.e., adequate feeder space, placing feeders away from streams, etc.) can help distribute manure more

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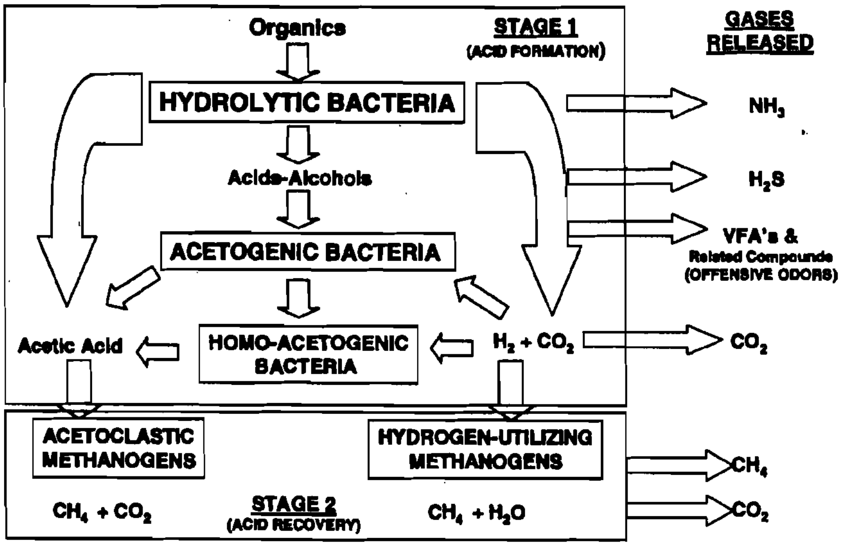

Fig. 1 Microbial breakdown of manure.

evenly across pastures. Limiting fertilizer inputs and use of buffer strips around surface waters can decrease nutrient runoff by 90% or more.

USES OF MANURE

Feedlot manure is primarily used as a fertilizer. However, nutrients, PACs, pathogens, etc. can be lost by surface runoff and leaching if manure is not well managed.[11] For example, most crops require a N:P ratio ranging from 5:1 to 8:1; whereas, the N:P ratio of feedyard manure is typically less than 3:1. Thus, if manure is applied to meet the N requirement of the crop, P may be over-applied. The availability of feedlot manure nutrients to plants is variable and generally slower than inorganic fertilizers (Table 1). Application of manure to pastures is normally not environmentally sustainable except when forage is cut for hay or silage. Fertilizer applications to fields and pastures should be done in conjunction with soil testing, and should be restricted in areas with high nutrient accumulations. The use of unfertilized buffer strips around riparian areas can decrease nutrient runoff to surface water.

Feedlot manure is sometimes composted. Although composting manure has a number of agronomic benefits;

Table 2 Reported values for atmospheric concentrations and atmospheric emissions from feedyards based on a number of publications

Item	Concentration	Emissions
Total suspended particles	54–1268 $\mu g/m^3$ (24 h mean)	7–127 kg/1000 head daily
PM-10, % of TSP	11%–38%	—
Ammonia	25–2200 $\mu g/m^3$ (hourly mean)	20%–55% of N intake
	—	3.6–47 $\mu g/m^2/s$
Volatile fatty acids	4–68 ppb	—
Acetic acid, % of VFA	54%–67%	—
Propionic acid	12%–22%	—
Butyric acid	17%–23%	—
p-Cresol	0.7–2.3 ppt	—
Phenol	0.4–1.1 ppt	—
Odors	—	1–840 odor units/m^2/s
Pathogens	Negligible	Negligible
Endotoxins	108–318 ng/m^3	—
Methane	—	30–60 g/animal daily
Hydrogen sulfide	1–98 ppb	0.2–4.3 $\mu g/m^2/s$

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20%–60% of initial mass, carbon and nitrogen are lost during the composting process. Anaerobic fermentation of manure to produce methane offers several advantages; however, the economics and technical expertise required to operate methane digesters have limited their application at feedlots.

Appreciable quantities of manure nutrients, PAC, pathogens, and endotoxins can end up in lagoons or retention ponds. Because they may contain high concentrations of salt or other nutrients, retention pond water should be carefully managed when used for irrigation or as a fertilizer. It appears that retention pond water can be used for control of dust without adversely affecting cattle health or performance.[12]

CONCLUSIONS

The public is increasingly demanding that animal agriculture be environmentally friendly. In order to meet these challenges, livestock producers will have to balance production efficiency with environmental concerns. Nutrient losses to the environment may be decreased by proper diet formulation, phase feeding, use of growth promoting technologies, and more careful management of manure.

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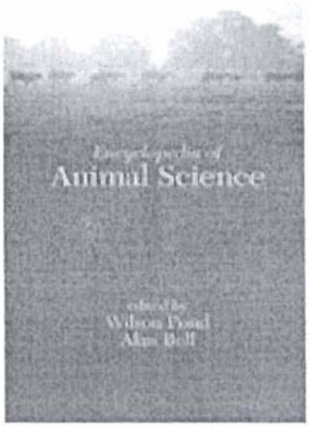

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