# COMPOSTING AS A MANAGEMENT ALTERNATIVE FOR BEEF FEEDLOT MANURE IN SOUTHERN ALBERTA, CANADA

***F.J. Larney, X. Hao***
*Agriculture and Agri-Food Canada, Research Centre, Lethbridge, Alberta T1J 4B1 Canada*
*larney@agr.gc.ca*

## ABSTRACT

Composting is gaining increased acceptance as a management alternative for the large volumes of manure produced by southern Alberta's beef cattle feedlots. Research on windrow composting of feedlot manure was initiated at the Lethbridge Research Centre of Agriculture and Agri-Food Canada in 1996. Early studies looked at the feasibility of summer and winter composting. Nutrient dynamics during composting, especially, nitrogen, phosphorus and carbon, has also been examined with straw-bedded and wood chip-bedded manure. Studies have been conducted on the effect of composting on *E. coli* elimination as well as on the loss of weed seed viability. This paper gives an overview of results from our composting research.

## INTRODUCTION

The cattle feedlot industry in the County of Lethbridge in southern Alberta is one of the most densely populated livestock regions in North America. In 2000, the County had a licensed capacity of almost 700,000 head of cattle in open feedlots, with some individual feedlots having >25,000 head. Due to its high water content (~70% w/w), it is uneconomical to haul raw manure more than 15-20 km. Therefore, most manure is land applied close to source at high application rates. This diminishes its traditional role as a soil amendment and it is often viewed as a disposal problem rather than the utilization of a valuable nutrient source. In the long-term, high manure application rates are unsustainable, leading to degradation of soil (Hao and Chang, 2003), water (Chang and Entz, 1996; Chang and Janzen, 1996) and air (Chang et al., 1998) quality.

Recently, composting has gained increased attention as a means of reducing the environmental impact of feedlot manure. In southern Alberta, several large feedlots are composting their manure for the agricultural market. Research on the composting of beef feedlot manure was initiated at the Lethbridge Research Centre in 1996. Research projects have been fully integrated in a multi-disciplinary approach to answer some of the common questions on this new manure management alternative.

## MATERIALS AND METHODS

Our composting experiments have been carried out on a concrete pad under an open-sided roofed structure at the Agriculture and Agri-Food Research Centre, Lethbridge, Alberta. This facility precludes water inputs from precipitation. Cereal straw has been traditionally used as a bedding material for feedlot cattle in the area. However, forest product companies are promoting the use of wood residuals as an alternative bedding source. The wood chip bedding is a mixture of bark, post peelings and sawdust. Consequently, we have examined the effect of straw vs. wood chip bedding feedstocks on nutrient dynamics (N, C and P) during composting.

Greenhouse gas (GHG) emissions are associated all aspects of livestock production.

Methane is emitted from the animals themselves and nitrous oxide is emitted from manure stockpiles and after land application of manure to soil. We have examined the effect of composting methods on GHG emissions (Hao et al., 2001; 2004).

Although pathogen elimination is a recognized benefit of composting (Rynk, 1992), the lack of definitive relationships between elimination and composting duration, substrates, and temperature conditions prompted a study on the fate of coliform bacteria during open-air windrow composting of beef feedlot manure in southern Alberta (Larney et al, 2003). Unlike fresh manure, compost is often promoted as being 'weed-free'. Many farmers are reluctant to spread raw manure for fear of introducing viable weed seeds to their fields and crops. Studies were conducted with five weed species in 1997 and thirteen in 1999 to examine the effect of feedlot manure composting on weed seed viability (Larney and Blackshaw, 2003). Weed seeds were buried in open-air compost windrows and recovered at various times during the thermophilic phase of composting.

For experiments, manure was removed with a loader and truck from open feedlot pens and deposited from the truck to form two replicates of each bedding type (straw, wood chips) which gave four individual compost windrows. At formation, windrows were about 10 m in length, 2.5 m wide at the base and 2 m high. Windrows were generally turned 7 times with a tractor-pull windrow turner. A typical schedule is turning at 7, 14, 21, 28 , 42, 56 and 84 d. The windrows are then rolled into curing piles and left for ~3 mo.

## RESULTS

Despite winter air temperatures as low as -40 ºC, windrow temperatures can be maintained at >60 ºC. A drawback with summer composting is the loss of moisture from the windrow by evaporative drying especially with high turning frequencies. This necessitates the haulage of water to windrows which is an added expense. We found that water mass loss with winter composting (44% of initial) was significantly lower than that for summer composting (83% of initial) [Larney et al. 2000]. However, summer composting resulted in higher volume reduction (72% of initial) than winter composting (51% of initial) which resulted in lower haulage requirements for the finished compost. Water content dropped from 70% at pen cleaning to 35% for finished compost. Water mass loss was up to 80%. Dry matter loss reductions were in the range of 20-30%. Bulk density increased 3-4 fold during composting. Changes such as reduced water content and increased bulk density has implications for haulage of nutrients in the form of compost vs. raw manure.

In three trials (1998, 1999, 2000) comparing straw vs. wood chip bedding (Larney et al., 2002), available N (KCl extract) as a percent of total N was not affected by bedding in 1998 and 1999 but was significantly higher in wood chip-bedded manure (24.2%) than straw-bedded manure (11.4%) in 2000 (Fig. 1). For finished compost, available N as a percent of total N was significantly higher in wood chip-bedded material than straw-bedded in all 3 yr. Available N as a percent of total N varied from 4.6-6.3% for straw-bedded compost and from 6.8-11.0% for wood chip-bedded compost. In all three years, available N as a percent of total N decreased with composting. The sharpest decrease was for straw-bedded material in 1999, which fell from 43.7% of total N in the available form for raw manure to only 4.6% for compost. This much lower levels of available N, compared to raw manure, should be taken into account when compost is used in cropping systems as a source of plant nutrients.

For straw–bedded manure (average of three trials 1998-2000), total C concentration decreased with composting from 30.5% to 21.1%. Total N concentration decreased from 1.84% to

1.69%. In a 1997 study, nitrate-N increased from 6 mg kg$^{-1}$ to 550 mg kg during active composting while ammonium-N decreased from 2270 to 500 mg kg$^{-1}$. Unlike N, P is not lost during composting unless the windrows are subjected to runoff. Total P concentrations generally increase during composting, e.g. from a 3 yr average of 0.40% to 0.53%.

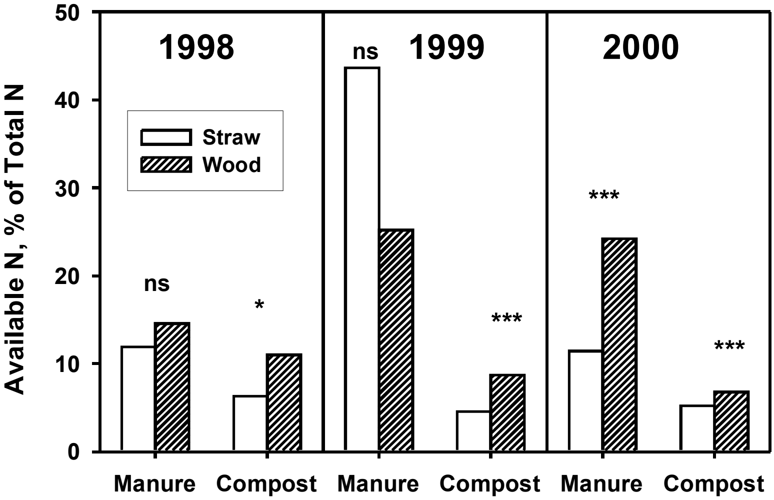


***Figure 1**. Effect of bedding type on available N as a % of total N for raw manure and finished compost, 1998-2000. Bedding effect significant: *5% level; ***0.1% level; ns = non-significant.*

Carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$) are GHGs. Since $CH_4$ is 21 times more harmful, and nitrous oxide 310 times more harmful than carbon dioxide in their global warming effects, greenhouse gas emissions are expressed as $CO_2$-C equivalents. In a 1997 study, GHG emissions from active composting were 397 kg $CO_2$-C Mg$^{-1}$ of manure (Hao et al., 2001). Hao et al. (2004) reported that most C was lost as $CO_2$ with $CH_4$ accounting for <6%. However, the net contribution to greenhouse gas emissions was greater for $CH_4$ since it is 21 times more effective at trapping heat than $CO_2$. $N_2O$ emissions were 0.077 kg N Mg$^{-1}$ for straw-bedded manure (SBM) and 0.084 kg N Mg$^{-1}$ for wood-bedded manure (WBM), accounting for 1-6% of total N loss. Total GHG emissions as $CO_2$-C equivalent were not significantly different between SBM (368 ±19 kg Mg$^{-1}$) and WBM (349 ± 24 kg Mg$^{-1}$).

There was a rapid decline in *E. coli* levels in the first 7 d of composting with > 99.95% elimination even though windrow temperatures averaged only 34-42 ºC (Larney et al. 2003). After one month *E. coli* was no longer detectable by culturing methods. There was no difference between wood chip and straw compost in *E. coli* levels or persistence. Desiccation likely played a minor role in coliform elimination, since water loss was low (<0.07 kg kg$^{-1}$) in the first 7 d of composting. However, total aerobic heterotroph populations remained high (>7.0 $\log_{10}$ CFU g$^{-1}$ dry wt.) throughout the composting period possibly causing an antagonistic effect toward coliform bacteria. Land application of compost, with its non-detectable levels of *E. coli* compared to raw manure, should minimize environmental risk in areas of intensive livestock production.

## CONCLUSIONS

Our results demonstrate beneficial effects of compost and composting for beef cattle feedlot manure in southern Alberta. The bottom line is that composting enables the export of nutrients from areas of high nutrient loading to soils which may be deficient in nutrients. This reduces the risk of environmental issues (water, soil and air quality degradation) in high nutrient loading areas and enhances soil quality in nutrient deficient areas.

## REFERENCES

Chang, C., Cho, C.M., Janzen, H.H. 1998. Nitrous oxide emission from long term manured soils. Soil Sci. Soc. Am. J., 62: 677-682.

Chang, C., Entz, T. 1996. Nitrate leaching losses under repeated cattle feedlot manure applications in southern Alberta. J. Environ. Qual., 25: 145 153.

Chang, C., Janzen, H.H. 1996. Long term fate of nitrogen from annual feedlot manure applications. J. Environ. Qual., 25:785 790.

Hao, X., Chang, C. 2003. Does long-term heavy cattle manure application increase salinity of a clay loam soil in semi-arid southern Alberta?, Agric. Ecosys. Environ., 94: 89-103.

Hao, X., Chang, C., Larney, F.J. 2004. Carbon, nitrogen balances and greenhouse gas emission during cattle feedlot manure composting. J. Environ. Qual., 33: 37-44.

Hao, X, Chang, C., Larney, F.J., Travis, G.R. 2001. Greenhouse gas emissions during cattle feedlot manure composting. J. Environ. Qual., 30: 376-386.

Larney, F.J., Blackshaw, R.E. 2003. Weed seed viability in composted beef cattle feedlot manure. J. Environ. Qual., 32: 1105-1113.

Larney, F.J., Olson, A.F., Carcamo, A.A., Chang, C. 2000. Physical changes during active and passive composting of beef feedlot manure in winter and summer. Bioresour. Technol., 75: 139-148.

Larney, F.J., Olson, A.F., DeMaere, P.R. 2002. Implications of feedlot manure composting for land application of nitrogen. *Proc. 39th Ann. Alberta Soil Sci. Workshop*, Nisku, Alberta, Canada, February 19-20, 2002, pp. 23-27.

Larney, F.J., Yanke, L.J., Miller, J.J., McAllister, T.A. 2003. Fate of coliform bacteria in composted beef cattle feedlot manure. J. Environ. Qual., 32: 1508-1515.

Rynk, R. 1992. On-farm composting handbook. Publ. NRAES-54, Northeast Regional Agric. Eng. Serv., Ithaca, NY.