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Total and Water Soluble Phosphorus Content of Feedlot Cattle Feces and Manure

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Summary

The percentage of feedlot feces and manure P that is water soluble was 41% (not accounting for additional soluble P from urine) and 24% respectively. The interaction of feces and urine with minerals and metals reduced the water solubility of P in feedlot manure relative to feces. Increasing dietary P level increased manure P concentration and water solubility of manure. Manure P from cattle fed feedlot diets containing 0.30% to 0.50% P was 28% water soluble P. The water solubility of P in feedlot feces and manure is an indicator of the potential for P runoff from feedlots and fields receiving manure.

Introduction

Of the P fed 80% to 88% is excreted in feces and urine by feedlot cattle. As dietary P intake increases, the form of P in runoff from fields receiving manure is impacted and may contribute to eutrophication.

Water solubility of P may affect the runoff potential of P in compost applied to crop fields (2003 *Nebraska Beef Report*, pp. 52-54). However, no research has been conducted on the water solubility of P in feedlot feces and manure. Furthermore, the differences in rate changes of soluble P to total P in feedlot manure and feces are unknown. The objective of our study was to evaluate the effect of dietary P on fecal and manure total P as well as water solubility of P in feces and manure of feedlot cattle.

Procedure

Two hundred fifty-four fecal samples and 158 manure samples from 15 University of Nebraska–Lincoln

feedlot cattle trials (1998 *Nebraska Beef Report*, pp. 77-80; 1998 *Nebraska Beef Report*, pp. 84-85; 1999 *Nebraska Beef Report*, pp. 60-62; 2000 *Nebraska Beef Report*, pp. 65-67; 2002 *Nebraska Beef Report*, pp. 45-48; 2002 *Nebraska Beef Report*, pp. 52-53; 2002 *Nebraska Beef Report*, pp. 54-57; 2003 *Nebraska Beef Report*, pp. 54-58; 2004 *Nebraska Beef Report*, pp. 49-51; 2004 *Nebraska Beef Report*, pp. 61-63; 2005 *Nebraska Beef Report*, pp. 51-53; 2005 *Nebraska Beef Report*, pp. 54-56) representing 1,608 cattle were analyzed for total P (TP) and water extractable P (WEP). Samples were from cattle fed diets containing 0.10% to 0.49% P. The cattle were consuming 20 to 57 g P and excreting 15 to 47 g P daily.

Fecal samples (feces collected directly from steers) were collected from mass-balance pen studies, individually fed animals, and from metabolism experiments. Multiple samples were taken for each experimental unit over time and frozen. The fecal samples from the mass-balance studies were freeze dried, and the other fecal samples were oven dried at 60°C for 48 hours. All fecal samples were composited by experimental unit within each experiment for laboratory analysis.

All manure samples (feces and urine mixed with soil over a feeding period) were collected from cattle fed in pens containing 8 to 11 steers at the University of Nebraska Mead Research Feedlot. In each study, manure was collected at the completion of the feeding period. As the manure was removed from each pen, approximately 20 samples were collected, frozen, freeze-dried, ground, and composited by pen within trial.

Total P (TP) of each sample was analyzed in duplicate by ashing 1 g of sample at 600°C for 6 hours, refluxing with 10 mL of 3 N HCl for 5 minutes, standardizing to 100 mL volume with double distilled water and filtering through filter paper (Whatman 42; 2.5 µm). Water extractable P (WEP), the

Table 1. Average, minimum, and maximum P and ash values for feces and manure samples analyzed in this study^{a,b}.

	Average	Minimum	Maximum
Feces			
Diet TP, %	0.29	0.10	0.49
TP, %	0.49	0.18	1.43
WEP:TP	0.41	0.20	0.80
Ash, %	12	4	30
Manure			
Diet TP, %	0.33	0.18	0.49
Diet TP, g/day	36	21	57
TP, %	0.37	0.21	0.64
WEP:TP	0.24	0.12	0.47
Ash, %	73	48	89

^aTP = total phosphorus, WEP = water extractable phosphorus

^bAll values are on a DM basis.

amount of P in a sample that is readily soluble in water, was analyzed in duplicate by shaking 0.5 g DM of each sample with 100 mL double distilled water at 150 rpm for 1 hour, a 50 mL aliquot was then centrifuged at 1,500 g for 10 minutes, 125 µL of concentrated HCl was added to a subsequent 14 mL aliquot of supernatant. All samples were stored at 4°C prior to colorimetric analysis with the molybdovanadate method on a spectrophotometer calibrated with standards developed in a matrix similar to each analytical procedure. Internal standards and blanks were included with each set of six samples for quality control.

The ratio of WEP:TP will be used as an index of the potential of P in a sample to be lost in runoff. An increase in WEP:TP means that the P in a sample is more likely to be lost in runoff than P from a sample that has a lower WEP:TP.

The fecal and the manure samples were analyzed independently. An iterative meta analysis methodology was utilized to integrate quantitative findings from multiple studies using the PROC MIXED procedure of SAS.

Results

The average, minimum, and maximum TP, WEP:TP, and % ash values for fecal and manure samples are presented in Table 1.

(Continued on next page)

As proportionally more P was fed in feedlot diets, there was a quadratic response in the concentration of manure TP (Figure 1). Fecal WEP:TP increased linearly as diet P increased. Fecal P averaged 0.41 WEP:TP; however, this average does not account for additional urinary soluble P contribution.

Cattle fed diets containing the highest concentration of P also produced manure with the highest concentration of TP. Increasing manure TP concentration resulted in a linear increase in manure WEP:TP (Figure 2). However, the increase was small. Increasing manure TP from 0.20% to 0.60% TP (diets containing 0.18% to 0.49% P) resulted in an 11 unit increase in WEP:TP.

In one trial, 0.35% and 0.70% Ca diets were individually fed to cattle. Feeding 0.70% dietary Ca reduced fecal WEP:TP from 0.60 to 0.48 (18% reduction). All other samples in this study were from cattle consuming diets containing 0.65% to 0.70% Ca.

Fecal samples contained a higher concentration of TP than manure samples, even though the fecal samples were collected from cattle fed diets containing less P than diets fed to cattle that manure samples were collected from. Diet TP, soil contamination, P loss in runoff and degree of OM loss (bacterial breakdown to CO₂) may affect TP concentration of manure. Increased soil contamination and manure P loss in runoff would be expected to decrease the concentration of TP in manure relative to feces. The net effect of decreased manure TP relative to feces was presumably caused primarily by soil contamination to feces and urine on the pen surface.

The WEP:TP of manure was less than the WEP:TP of feces, regardless of dietary P level (Table 1). This may be due to interaction of excreted P with minerals and soil metals. The interaction of Ca with P has been shown to decrease the WEP:TP of feces. Previous research has shown excreted P can interact with Ca, Al, and Fe from soil contamination

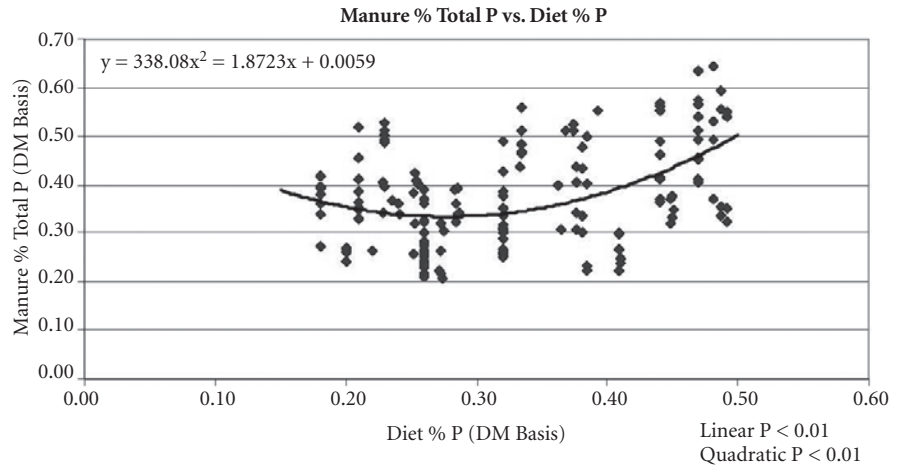


Figure 1. Quadratic relationship between the concentration of P in the diet and the concentration of manure P collected from the pen surface.

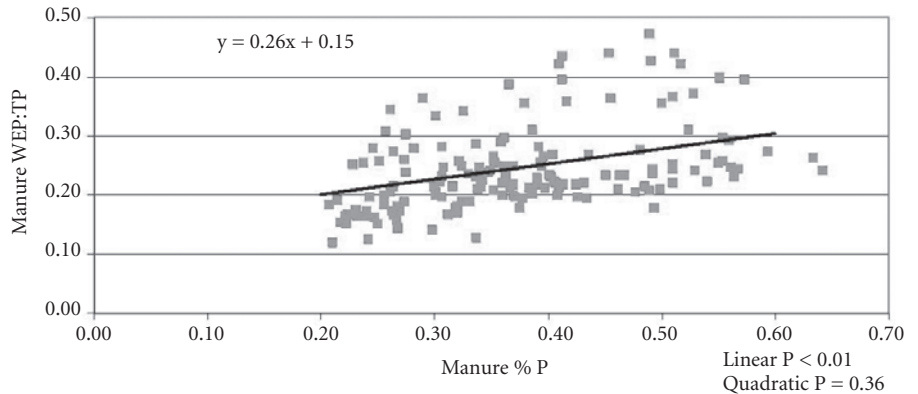


Figure 2. Linear increase in manure WEP:TP as manure TP concentration increased.

to cause a reduction in WEP:TP of manure by as much as 48%. The combined effects of the many positively charged ions in soil, when mixed with manure P from hoof action on the pen surface, may form immobilized phosphate compounds that are not water soluble.

Runoff events may remove proportionally more WEP than TP. However the loss of P in runoff from feedlot pens was less than 5% of excreted P. Back calculating manure P solubility to account for a 5% loss (all in WEP form) of manure TP increased manure WEP:TP 3.9 units. The calculated manure WEP:TP becomes 0.28 instead of the analyzed value of 0.24. However, this value is still less than the fecal WEP:TP value of 0.41. In addition, when urinary P is added to fecal WEP, the resulting mix of urine and feces is expected to be 0.52 WEP:

TP. This expected value is 24 units of solubility higher than the actual value. These results showed the mixing of fecal and urinary P with soil contamination on feedlot pen surfaces reduced the WEP:TP of the resulting manure.

When interpreting the results from this study for commercial feedlots, the reader is cautioned that the minimum and average TP values for feces and manure are influenced by data collected from cattle fed experiment diets containing lower P (as little as 0.10% diet DM from diets containing corn bran and grits) than industry.

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