The Reduction in Hydraulic Conductivity of a Feedyard Surface after Eight Months of Stocking

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ABSTRACT

A new university research feedlot was constructed in March 1998. An experiment was conducted to monitor physical changes in soil properties in the feedlot surface as it matured. Three distinct areas characterize each pen: (1) the water trough area, (2) the apron area, and (3) the bottom area. Prior to introducing livestock to the new feedlot, soil samples were obtained from four pens. Three relatively undisturbed soil cores were obtained from each of the three areas within each pen. These samples were taken from the first 15 cm of the soil surface and were tested for saturated hydraulic conductivity using a flexible wall permeameter. Additional samples were collected from borings approximately two meters in depth. The borings were divided into 15 cm increments, and samples were analyzed for electrical conductivity. Identical soil samples were collected and analyzed eight months later. The saturated hydraulic conductivity of soils sampled prior to livestock using the pens indicated hydraulic conductivities on the order of 10^{-5} cm/s, while samples taken eight months after cattle used the pens indicated hydraulic conductivities on the order of 10^{-6} cm/s. Mean saturated hydraulic conductivity values decreased by 23 times for the apron area, 5 times for the water trough area, and 33 times for the bottom area, indicating that infiltration of water into the feedlot surface is significantly reduced with time resulting from the manure pack and compaction of hooves.

INTRODUCTION

The profile of a feedlot surface varies significantly from most natural soil profiles. Feedlots do not sustain vegetation, therefore plant roots play no role in soil water extraction. Feedlot profiles generally have more uniform moisture content than cropped land profiles (Mielke et al., 1974). An extensive layer of organic matter accumulates over time on the original soil surface which changes the physical and biochemical nature of the profile. Soil compaction by livestock also significantly changes physical properties of the soil. When examining soil profile conditions of cattle feedlots, Mielke et al. (1974) found that the feedlot surface seals itself due to a combination of compaction and plugging from soil particle dispersion caused by manure or manure byproducts. They also found that texture of the soil profiles under the feedlots appeared to have little effect on the water movement into the profile or runoff characteristics for a mature feedlot. Rowsell et al. (1985) found organic solids lodged between soil particles when examining soil that had been exposed to manure infiltration. Biochemical mechanisms can develop that destroy the macrostructure of the soil (Barrington and Madramootoo, 1989). Much research has found that feedlot surfaces have negligible seepage and chemical transport through the profile after a seal has been formed. However, none of the research mentioned here has actually quantified the reduction in hydraulic conductivities, which we are now capable of doing using a flexible wall permeameter. Also, much of the previous sealing research has been done on swine manure and under continuously saturated conditions, significantly different from most cattle feedlots. The purpose of this experiment was to investigate seal formation and solute movement with time at a newly constructed feedyard.

MATERIALS AND METHODS

Soil cores were obtained at West Texas A&M University's new beef cattle feedlot. The feedlot has 30 identical pens of dimensions 6 x 26 m, each with a capacity of 8-10 head. Four pens were selected for this study. This paper presents results of two of the pens located 30 m apart.

Soil cores were collected from just below the concrete apron, adjacent to the concrete pad at the water trough, and from the bottom area within each pen. Three soil cores were collected at each location in the pen as shown in Figure 1. The cores were obtained by driving a thin-wall sampler (Shelby tube) (7.3 cm dia., 30 cm length) into the ground with a sledge hammer. A specially designed metal holder was placed over the top of the tube to prevent damage to the tube. Soil cores were collected immediately after construction of the feedyard, and again after 8 months of stocking.

Additional soil samples were collected at depth increments of 15 cm from one boring at each location (apron, water trough, bottom) within the pen to maximum depths of 2.5 m. In this paper, we present solute movement results from two of the four pens. Samples were collected using either a tractor-mounted hydraulic probe (Giddings probe) or if the soil was too hard then a hand auger was used. Individual soil samples were analyzed for moisture content, electrical conductivity (2 part water to 1 part soil by weight), and nutrients. Additional soil cores and depth samples were collected in the drainage channel located downgradient of the pens, and in a control area just outside of the pen area. The control area was not affected by hoof action, but it had been cleared during construction activities so was similar to the initial conditions in the pens. The control area was covered with a geotextile to prevent weed and grass growth in the area which might have affected soil conditions over the 8-month period.

The soil cores were extruded using a hydraulic ram. Cores were weighed, measured, and trimmed. Cores were placed into latex membranes, then the saturated hydraulic conductivity of each core was measured using a flexible wall permeameter (SoilTest Tri-Flex 2) per ASTM Method D 5084 (ASTM, 1996).

Statistical analyses were performed using Excel and SPSS Version 7.0. Hydraulic conductivity data were log-transformed prior to running ANOVA and LSD comparisons because hydraulic conductivity data has been shown to be lognormally distributed (Freeze and Cherry, 1979).

RESULTS AND DISCUSSION

A summary of the saturated hydraulic conductivity data is shown in Table 1. The geometric mean hydraulic conductivities of the 12 samples at each location were statistically compared between the initial and 8 month time periods. Initially, there were no statistically significant differences between geometric mean hydraulic conductivities at different locations within the pen, an indication that compaction during the construction of the pens was relatively uniform. Hydraulic conductivities decreased after 8 months at all locations within the pen. Hydraulic conductivity values decreased by 23 times for the apron area, 5 times for the water trough area, and 33 times for the bottom area. There was no difference in geometric mean hydraulic conductivities for the control between the initial and 8 month time periods.

Final hydraulic conductivities were lowest in the bottom area. This is the area that cattle frequent most often except for when they are eating or drinking. We observed that the bottom area was more difficult to core and obtain samples than the other two areas.

There is evidence of solute movement based on elevated electrical conductivity readings at depths of about 150 cm at the apron and water trough areas in Pen 2, and in the bottom area in Pen 1 (Figures 2 and 3). No observable differences were observed in the apron and water trough areas of Pen 1. Electrical conductivities were elevated at the bottom area in Pen 1 (Figure 4), but not in Pen 2. It appears that most infiltration took place in the bottom area in Pen 1, while in Pen 2 most infiltration took place in the apron and water trough areas. There was little difference in electrical conductivity with depth in the control area (Figure 5).

REFERENCES

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Rowsell, J.G., M.H. Miller and P.H. Groenevelt. 1985. Self-sealing of earthen manure storage ponds II. Rate and mechanism of sealing. Journal of Environmental Quality 14:539-543.

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Table 1. Summary of saturated hydraulic conductivity measurements initially and after 8 months.

Sampling Date	Sampling Location	Geometric Mean Hydraulic Conductivity (cm/sec)
Initial		
	Apron	1.42E-05 a
	Water Trough	9.27E-06 a
	Bottom	1.77E-05 a
	Control	3.98E-05 a
8 Months		
	Apron	6.21E-07 c
	Water Trough	1.85E-06 b
	Bottom	5.34E-07 c
	Control	2.14E-05 a

Using LSD comparisons, means within a column with different letters are significantly different at $\alpha=0.05$.

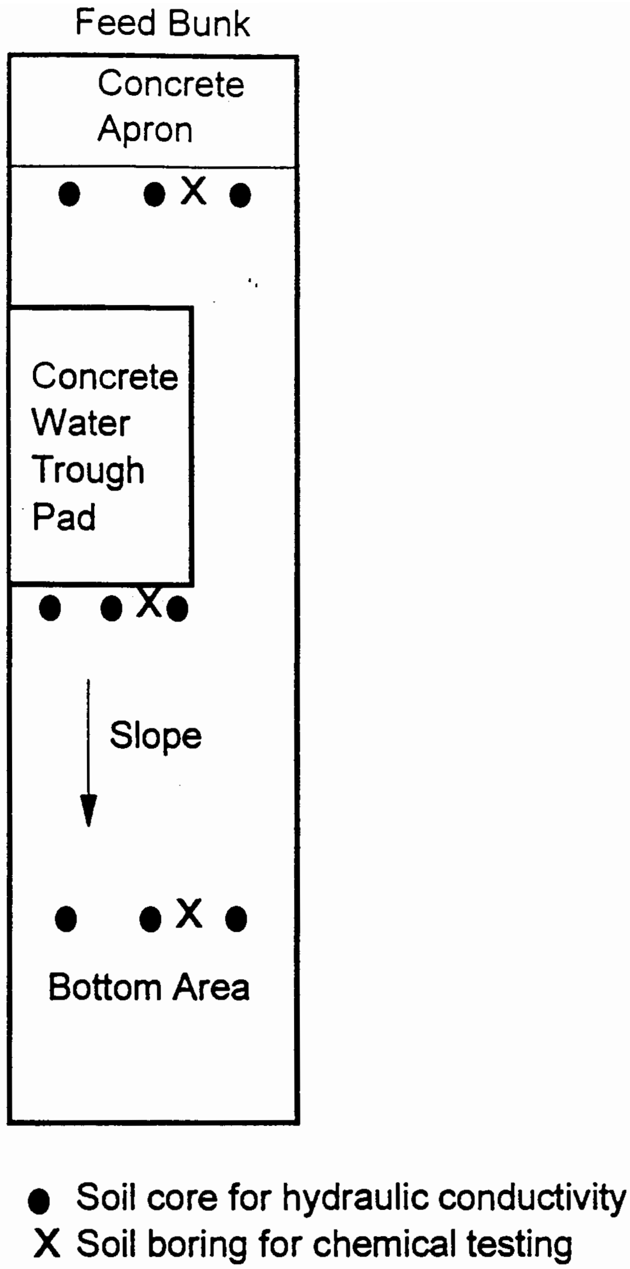
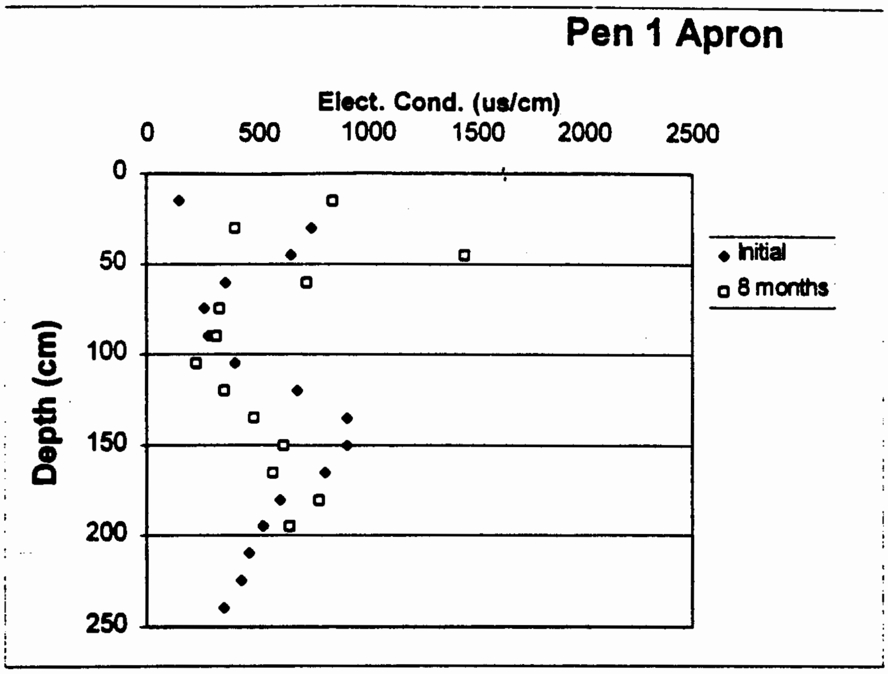


Figure 1. Sample locations for soil cores and soil borings.



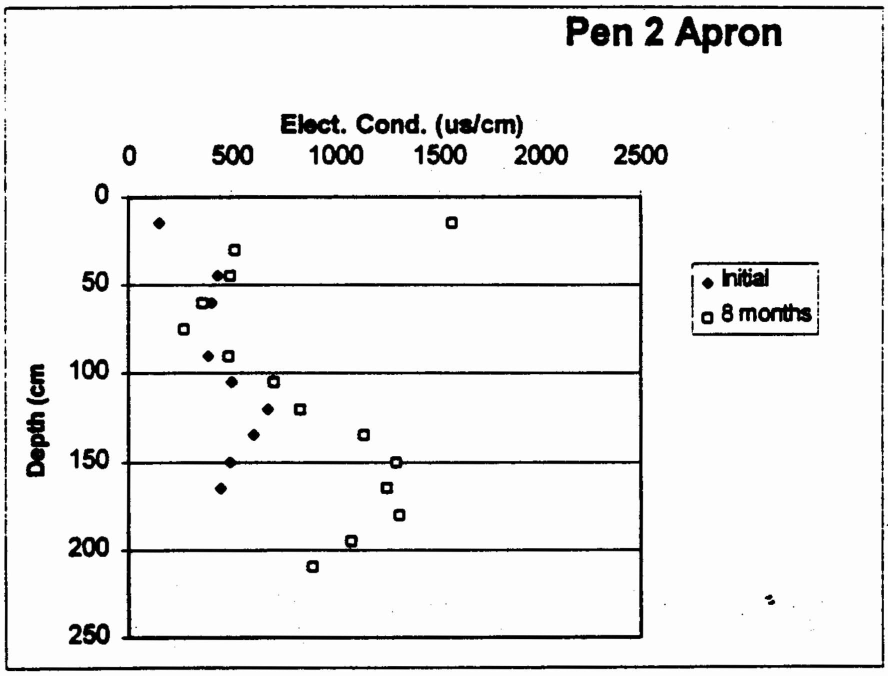
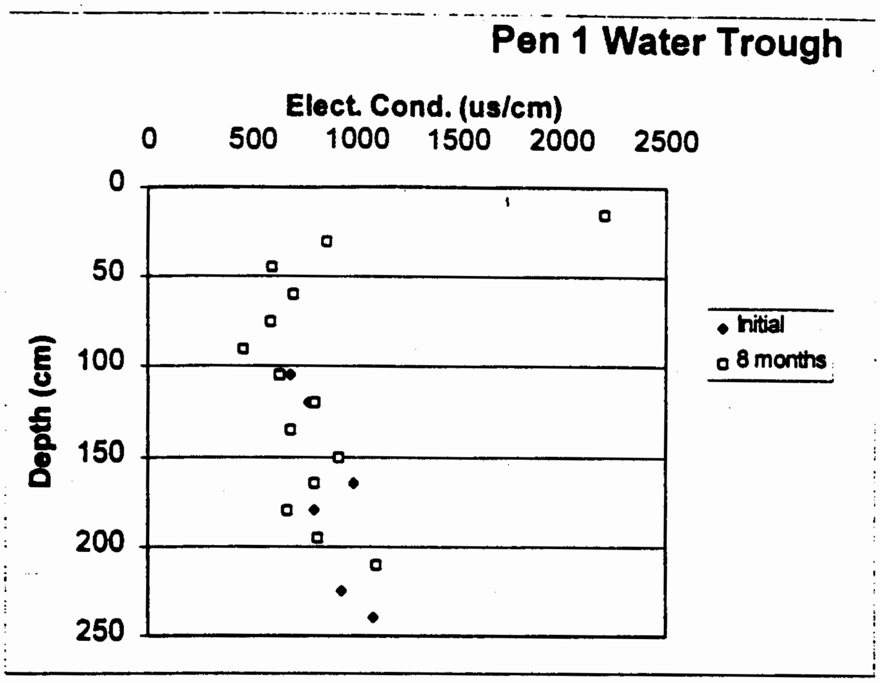


Figure 2. Graphs of soil electrical conductivity with depth for apron area.



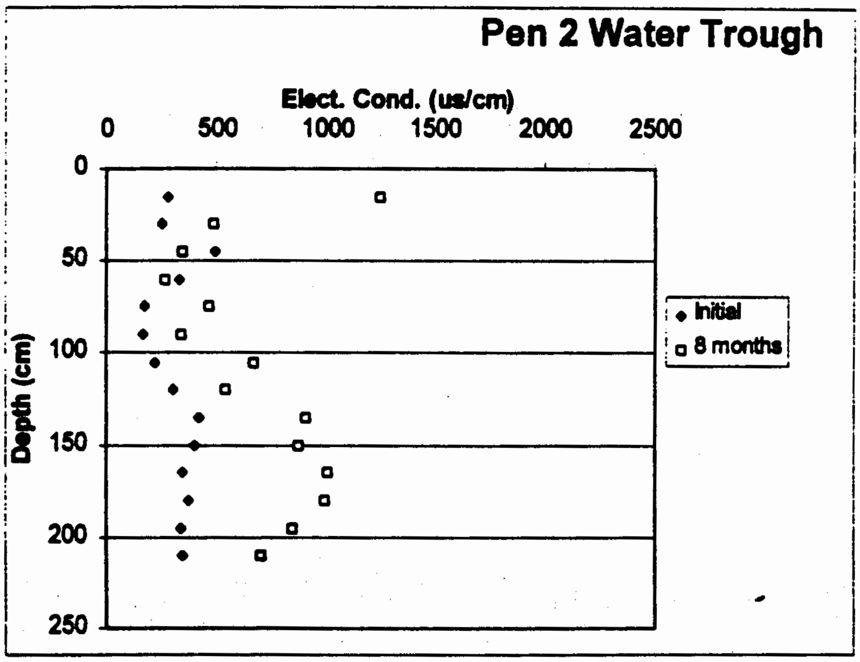
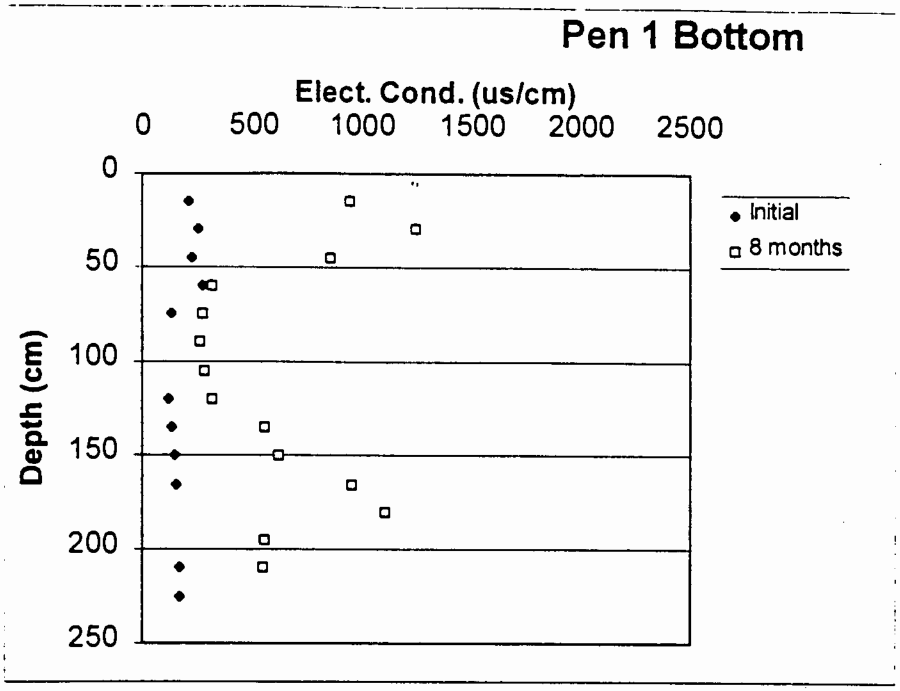


Figure 3. Graphs of soil electrical conductivity with depth for water trough area.



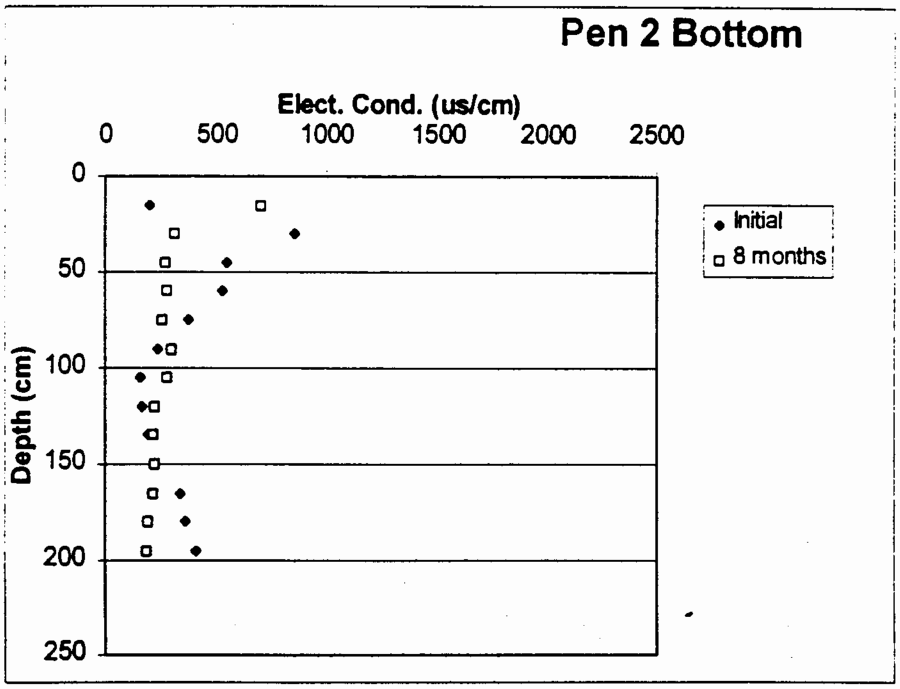


Figure 4. Graphs of soil electrical conductivity with depth for bottom area.

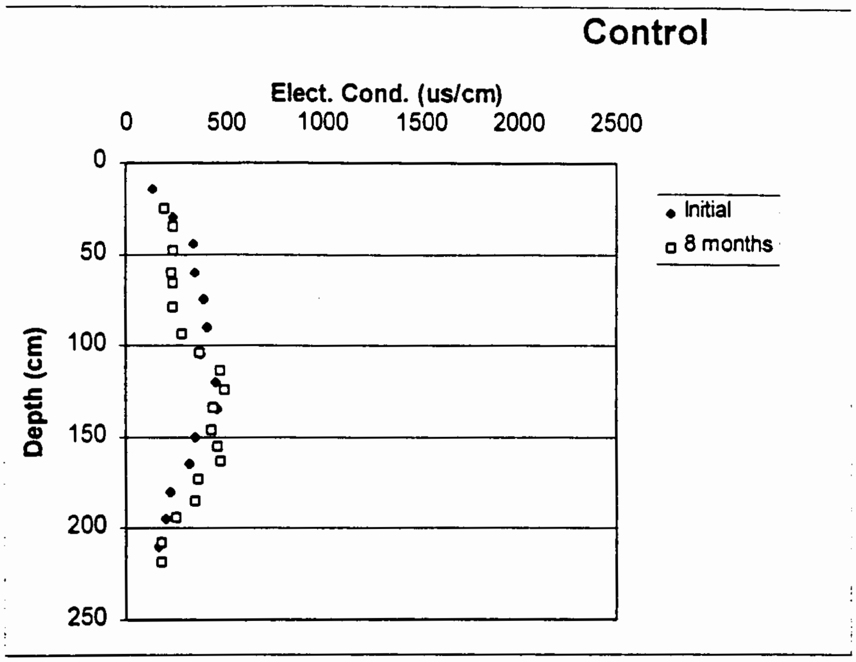


Figure 5. Graph of soil electrical conductivity with depth for the control area outside of the feedlot pens.