UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Department of Animal Sciences

College of Agricultural, Consumer
and Environmental Sciences
132 Animal Sciences Laboratory
1207 West Gregory Drive
Urbana, IL 61801

RECEIVED
CLERK'S OFFICE
MAY 14 2001
STATE OF ILLINOIS
Pollution Control Board

May 9, 2001

R01-28
P.C. # 2

Dorothy M. Gunn
Clerk of the Board
Illinois Pollution Control Board
James R. Thompson Center
100 W. Randolph Street
Suite 11-500
Chicago, IL 60601

Dear Mrs. Gunn:

Enclosed is the original and nine copies of my public comment and research report on the proposed Livestock Waste Regulations, Adm. Code 506, Construction Standards. Please distribute this to the board members of the Illinois Pollution Control Board. Thank you.

Sincerely,

Ken W. Koelkebeck

Ken W. Koelkebeck
Associate Professor

KWK:njd

Enc.

c: R 01-28 Service List

Phone: 217-244-0195 Fax: 217-333-7861 E-mail: kkoelkeb@uiuc.edu

RECEIVED
CLERK'S OFFICE

MAY 1 4 2001

STATE OF ILLINOIS
Pollution Control Board

ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:

LIVESTOCK WASTE REGULATIONS
35 Ill. Adm. Code 506
Construction Standards

R01-28

PUBLIC COMMENT

Members of the Illinois Pollution Control Board, I thank you for allowing me to give public comment in regards to the proposed changes to the Livestock Waste Regulations – Code 506 – Construction Standards. I'm Ken Koelkebeck, Poultry Extension Specialist and Associate Professor in the Department of Animal Sciences, College of Agriculture, Consumer, and Environmental Sciences at the University of Illinois at Urbana-Champaign. I also serve as an Advisory Board Member for the Illinois State Turkey Growers Association and Executive-Secretary of the Illinois Poultry Industry Council. I have been in my current position for 14 years, and during that time, I have worked closely with the turkey and egg producers on a number of issues of importance to their industries.

Specifically, I would like to provide comment on the regulations contained in SUBPART C of Adm. Code 506 "Standards for the Design and Construction of Livestock Waste Handling Facilities other than Lagoons – Sections 506.301 through 506.314 and any other sections that are closely related". It is my understanding that any new facility or addition to an existing facility which classifies it as a new facility which is intended to house poultry (specifically turkey raising facilities and possibly laying hens) has to conform to certain construction standards related to the floors of these facilities. These proposed standards require that new facilities that are built must be constructed on ground that has the hydrolic conductivity or permeability standards of 1 10^{-7} cm/sec (sec. 506.304a.1.). In the event that a 1 x 10^{-7} cm/sec cannot be attained the facility would need to be constructed with a concrete floor. In addition, the producer or company must obtain a soil sample to determine the presence or non-presence of aquafer containing material within 5 ft. (sec. 506.302a.1.) of the facility floor. This regulation in addition to others not specifically mentioned here would greatly affect producers and companies in Illinois' Poultry Industry, specifically the turkey industry and to some extent the laying hen industry. These regulations would also negatively affect the possible expansion of the U.S. broiler industry looking to expand their operations into the State of Illinois. More important to the immediate concern is the effect of these rulings on the existing turkey industry in the state and the negative impact these rulings would have on any expansion of the current turkey industry.

In regards to these rulings, I was approached by an integrated turkey company that contracts turkey production in Southeastern Illinois about a year and a half ago. This company had several contract producers who were wanting to expand their current turkey growout facilities. They were informed that they had to meet the construction guidelines set forth in Section 506, that being needing to demonstrate a 1 x 10^{-7} cm/sec permeability underneath and within the proposed facility. The company then talked to the Department of Agriculture and decided to obtain some scientific data on the permeability of the soils and in addition wanted to know the extent of leaching of nutrients from the turkey manure within the soils. Therefore, the company contacted me to help them conduct a field research study.

Thus, a year ago last fall, I helped the company design and conduct a research study examining the degree of permeability and leaching of nitrogen, phosphorus, and potassium in soils from earthen floors within several turkey barns in Southeastern Illinois. I have included a copy of this study. For this project the company provided financial support along with some funding from the Illinois Council on Food and Agriculture Research (C-FAR) and the Department of Animal Sciences. We conducted this study during the months of December and January, 1999 and submitted a report of our findings and gave a presentation to the Department of Agriculture on February 14, 2000. In addition to this report, the findings of this study has been presented at the Annual Poultry Science Association meeting last summer in Montreal, Canada and the annual Midwest Poultry Federation meeting in St. Paul, Minnesota last month. A peer-reviewed manuscript was sent to the Journal of Applied Poultry Research on December 11, 2000 and is currently under review.

For this study, two turkey growout barns and one brooder barn were selected from three commercial turkey farms in Southeastern Illinois to be sampled for the presence of soil nutrients and permeability properties at specific depths. The three barns had been in existence housing turkeys for the past 10 to 12 years. For each barn, nine 5 ft. soil bores were taken from the inside and three 5 ft. bores were taken from the outside. The soil bores taken from the outside of the barns served as controls and one of these bores went an additional depth of 28 ft. to determine the type of soil near each of the three turkey barns. The soil bores were divided into five 1-ft. sections representing the top 5 ft. of depth and sent to a private laboratory for the analysis of total Kjeldahl nitrogen (TKN), nitrate nitrogen (NO3-N), total phosphorus (P2), potassium (K), pH, and percent organic matter (OM). In addition, core samples at three depths (1 to 3, 5 to 7, and 9 to 11 in) were taken to determine soil permeability.

The results of this study indicated that significantly greater concentration of total TKN were present in the first 3 ft. of soil depth for the inside vs. outside (control) samples for all farms. However, no differences in total TKN concentration were found between inside and outside samples at the 4- and 5-ft. depths. Similar results were found for NO3-N and K concentrations as noted for total TKN; however, total P2 concentrations were essentially the same between inside and outside samples for depths 2 to 5 ft. This indicated that total P2 did not migrate in the soil. The soil permeability results indicated that lower permeability occurred for the inside vs. outside samples at the 1 to 3- and 5 to 7-in depths for all farms averaged together. The permeability data also indicated that several inside permeabilities exceeded 1 x 10 minus 7 cm/sec. Thus, this study indicated that leaching of soil nutrients essentially stopped at the 4- to 5-ft. level within these turkey barns, and in addition, soil permeability was lowered by the pr3sence of growing turkeys inside these facilities.

Since I've been here at the University of Illinois, I have been actively engaged in promoting the expansion of the poultry industry in the State. If the proposed changes become law, it is my understanding that any further expansion of the turkey and layer industry in the State will be negatively affected. If turkey producers are forced to build new grow-out buildings that have to have a concrete floor to meet permeability, the additional cost of $25,000 to $30,000 will make it virtually impossible for the producer to secure a building loan. Also, when existing facilities depreciate in value and can no longer produce turkeys efficiently, total production volume in the State will decline because construction of new facilities would be cost prohibitive. Thus, in the end, the State will lose some 35 million dollars in net cash receipts that are generated per year. In addition, the money generated by the sale and consumption of nearly 3.5 million bushels of corn per year would be lost. Also, the State would not be able to receive any monetary benefits from any broiler companies looking to expand their production into Illinois.

Finally, our research findings reported earlier seem to support the contention that subsurface ground water would not be contaminated by the leaching of nutrients from within turkey facilities particularly in the area of the State in which we conducted the research. It is my opinion, based on our research findings, that new poultry (turkey and layer) facilities be allowed to be constructed without a concrete floor. Perhaps the language of the permeability values needed for soil within these facilities be modified to equal that of existing soil permeabilities obtained through present soil geographical measurements. In addition, perhaps the language of the present documentation on Livestock Waste Regulations further clarify the distinction between solid, semi-liquid, and liquid waste handling facilities. Perhaps some type of an exemption from the current construction standards, i.e., soil permeability be made for solid or dry livestock waste handling facilities, i.e., poultry (turkey, layer, and broiler houses). Thus, as written, the proposed construction standards would negatively affect expansion of the turkey and layer industries in the State, as well as prohibit any new poultry (i.e., broiler companies) from expanding into Illinois.

Respectively submitted,

Ken W. Koelkebeck

Ken W. Koelkebeck
Department of Animal Sciences
University of Illinois

The Degree of Permeability and Leaching of Nitrogen, Phosphorus, and Potassium in Soils from Earthen Floors Within Turkey Barns in Southeastern Illinois

by

Ken W. Koelkebeck, Ph.D.
Department of Animal Sciences
University of Illinois
Urbana, IL 61801

and

Scott Nally
Perdue Farms, Inc.
Washington, IN 47501

Financially Supported by:

Illinois Council on Food and Agriculture Research (C-FAR)

and

Perdue Farms, Inc.

Impact Statement: The impact of this research documents that soil permeability within a turkey barn can be dramatically lowered by compaction produced by turkeys, and shallow leaching of possible harmful soil nutrients from turkey manure should not contaminate subsurface ground water.

ABSTRACT

A field study was conducted to determine the degree of leaching of nitrogen, phosphorus, and potassium, and permeability of soils from earthen floors within several turkey barns. Two turkey grow out barns and one brooder barn were selected from three commercial turkey farms in Southeastern Illinois to be sampled for the presence of soil nutrients and permeability properties at specific depths. The three barns had been in existence housing turkeys for the past 10 to 12 years. For each barn, nine 5 ft. soil borings were taken from the inside and three 5 ft. bores were taken from the outside. The soil bores taken from the outside of the barns served as controls and one of these bores went to an additional depth of 28 ft. to determine the type of soil near each of the three turkey barns. The soil bores were divided into five 1-ft. sections representing the top 5 ft. of depth and sent to a private laboratory for the analysis of total Kjeldahl nitrogen (TKN), nitrate nitrogen (NO_3-N), total phosphorus (P_2), potassium (K), pH, and percent organic matter (OM).

In addition to the 5-ft. nutrient soil bores, a Uhland core sampling device was used to take 15 core samples (3" deep x 3" diameter cylindrical cores) from each barn to determine permeability. Three core samples at three depths (1-3", 5-7", 9-11") were taken from the inside and two samples at the same three depths were taken from the outside of each barn. Permeability measurements were then determined on all 45 core samples at the University of Illinois, Department of Natural Resources and Environmental Sciences Laboratory.

The results of this field study indicated that significantly greater concentration of total Kjeldahl nitrogen (TKN) were present in the first 3 ft. of soil depth for the inside vs outside (control) samples for all farms. However, no differences in total Kjeldahl nitrogen (TKN)

concentration were found between inside and outside samples for the 4- and 5-ft. deep samples. For nitrate nitrogen (NO_3-N), concentrations showed no differences between inside vs outside samples at any depth for farm B, however, inside vs outside samples differed at all depths for farms A and C. Similar results were found for potassium (K) concentrations as noted for total Kjeldahl nitrogen (TKN); however, total phosphorus (P_2) concentrations were essentially the same between inside and outside samples for depths 2-5 ft. This indicated that total phosphorus (P_2) did not migrate in the soil. The soil permeability results indicated that lower permeability occurred for the inside vs outside samples at the 1-3" and 5-7" depths for all farms averaged together. The permeability data also indicated that several inside permeabilities exceeded 1×10^{-7} cm/sec.

In summary, the present study indicated that even though some soil nutrients leached below the surface of the ground inside a turkey facility, leaching essentially stopped at the four to five ft. level. In addition, the degree of soil permeability may be lowered by the presence of turkeys inside a turkey grow out facility.

INTRODUCTION

In the past 10-15 years there has been considerable growth and expansion in the turkey industry in the State of Illinois particularly in the counties of Richland, Crawford, and Lawrence. Currently, about 1.3 million turkeys are raised per year in this part of the state. This increased production has brought about some concern by regulatory agencies over the possibility of contaminating ground water by leaching of nitrogen and phosphorus from within a turkey house. Studies conducted previously have reported higher concentrations of nitrogen in soil samples from beneath the floors of poultry houses than in soil samples from outside of houses where no birds were raised (Lomax, 1995). In addition, a report by Haberstroh (1997) found that nitrogen concentrations were higher in soils under turkey barn floors to a depth of five feet than in soils outside the barns. Thus, the present study was conducted to determine the degree of leaching of nitrogen, phosphorus, and potassium in the soil from within several turkey barns as compared to the nitrogen and phosphorus levels in the soil outside the barns. In addition, the degree of permeability or hydrolic conductivity was determined in the first 11 in. of soil within the turkey barns vs outside the barns.

BACKGROUND AND METHODS

Three turkey farms located in Lawrence and Crawford counties were selected for this study. On each farm, samples were taken for soil nutrient analysis and soil permeability from earthen floors from one of the turkey barns. Figure 1 shows the location of soil borings for soil nutrient analysis and permeability in and outside each barn. The description of each farm including information on the grow out system is described below. The soil type, percent clay and expected permeability for each farm is presented in Table 1. These farms were picked for sampling because they accurately represented the various sizes of turkey barns and locations of the most common soil types that typify those found in these counties in Southeastern Illinois.

Farm A

The first samples were taken from a farm located in Lawrence County, near Bridgeport, IL. Samples were taken from brooder barn number 1 (40 x 500 ft.). The farm housing capacity is 21,500 hens per flock and has been in existence since June 19, 1987.

Farm B

The second farm was located in Lawrence County, near the Illinois state line and consisted of three barns (40 x 500 ft.) which has raised turkeys since July 25, 1987. Samples were taken from growout barn number 2. The farm housing capacity is 21,500 hens per flock.

Farm C

Farm C was location in Crawford County, near Heathsville, IL. This farm consisted of a brooder barn built in 1986 and a growout barn built in December of 1990. Samples were taken from growout barn number 2 (50 x 500 ft.). The farm housing capacity is 13,500 hens per flock.

Soil Sampling Procedures and Technique

For each of the barns sampled on Farms A, B, and C there were a total of 12 soil borings; nine soil borings taken from within the barns and three soil borings taken from outside the barns. For this procedure, an Illinois State Geological Survey Probe truck was used to collect the soil bores. Samples were taken from a 5 x 10 ft. rectangular area 1/3, 1/2 , and 2/3 of the distance from one end of the barn. Samples were collected in this manner due to the ceiling height of each barn. In addition, soil borings were taken in three locations on the outside of each barn approximately 20 ft. from the side and end wall. For each bore, the first 5 ft. of depth was separated into five 1-ft. sections. The initial bore took a 4-ft. section, then went back in the same bore hole and removed the next 1-ft. section. Immediately after collecting the five 1-ft. sections, the separated soil bore samples were placed into pre-labeled plastic sample bags and transported in a Styrofoam cooler twice a day to Alvey Laboratories, Belleville, IL for analysis of soil nutrients.

After the soil bore samples were taken from a barn, core samples for permeability were taken. For soil permeability or hydrolic conductivity, a three inch diameter x three inch deep cylindrical soil core was taken using a Uhland core sampling device. For each barn, 15 individual core samples were taken at each location inside or outside of the barn (Figure 1). Three core samples were taken at three depths (approximately 1-3", 5-7", and 9-11") from the inside and two samples at the same depths were taken from the outside. All samples were carefully wrapped in aluminum foil to keep the sample intact and transported to Dr. Bill Simmons' laboratory, Department of Natural Resources and Environmental Sciences, University of Illinois to determine permeability or hydrolic conductivity.

In addition to the soil bore samples for soil nutrients and core samples for permeability, a core sample was taken outside each barn to a depth of about 28 ft. Pictures were taken of this core sample for each 4-ft. section to determine the type of soil (clay, sand, or clay/sand combination) present.

Soil Nutrient and Permeability Laboratory Analysis

After all soil samples were taken, the soil bore samples were analyzed for several soil nutrients and soil properties by Alvey Labs. They analyzed the samples for total Kjeldahl nitrogen (TKN), nitrate nitrogen (NO_3-N), total phosphorus (P_2), potassium (K), soil pH, and percent organic matter (OM). The TKN, NO_3-N, P_2 and K values were presented in parts per million concentration (ppm).

For the permeability or hydrolic conductivity values, the data are reported as cm/sec or the rate at which water flowed through each core. For each core sample, water was flushed through the core three times, then the average permeability was recorded.

Statistical Analysis

For the soil nutrient and permeability values presented, the data was analyzed by Analysis of Variance procedures consistent for a 3 x 2 x 5 (farm x location x depth) factorial arrangement of treatments. The data is presented for each farm (A, B, or C) and overall for all farms. The values for soil nutrients and permeabilities were compared for the inside vs the outside for each farm and all farms at each depth. The permeability data was analyzed on the log of the permeabilities, then transformed back to the original values.

RESULTS

Soil Nutrients, pH, and Organic Matter

For the individual farms A, B, and C, the results for soil nutrients, soil pH, and organic matter is presented in Tables 2, 3, 4, 5, 6, and 7. For farms A and B, the concentration of TKN was significantly greater ($P < .05$) for the inside vs outside locations for the top 3 ft. For farm C, the concentration of TKN was greater for the inside vs outside locations for the top 2 ft. TKN was not different between inside and outside locations for the 4- and 5-ft. depths for farms A and B, and 3- to 5-ft. depths for farm C.

Significantly greater concentrations of NO_3-N were found for inside vs outside locations for depths of 1 to 3 and 5 ft. for farm A (Table 3). There was an increase in NO_3-N concentration at the 5-ft. depth compared to the 4-ft. depth for farm A. Nitrate nitrogen concentration was not different ($P > .05$) for all inside vs outside depths for farm B, while NO_3-N concentrations were greater ($P < .05$) for inside vs outside locations at all depths for farm C.

The results obtained for P_2 show a different trend than that for TKN and NO_3-N (Table 4). No significant differences in P_2 concentrations between the inside and outside locations were found for farm A and C; however, greater ($P < .05$) P_2 concentrations were recorded for the inside vs outside locations at the 1-, 3-, and 5-ft. depths for farm B. P_2 did not differ between inside vs outside locations for farm B at the 2- and 4-ft. depths..

Table 5 depicts the results for K for farms A, B, and C. These results are similar to those shown for TKN in relation to the concentration of K at each depth for the inside vs outside samples. The concentration of K was found to be greater ($P < .05$) for the top 2-ft. for the inside vs outside locations for farms A and C, while no difference in K concentration was noted between the inside and outside locations at the 3- to 5-ft. depths (Table 5). For farm B, K concentrations were greater ($P < .05$) for the 1- to 3-ft. depths, while no differences in K concentration was noted at the 4- and 5-ft. depths for inside vs outside locations.

In addition to the soil nutrients measured, soil pH and OM were analyzed and are depicted for each farm in Tables 6 and 7. In general, soil pH for farms A and B were higher (more alkaline) for the inside vs outside samples at depths 1, 2, 3, and 1, 2, 3, and 4 ft., respectively for farm A and B (Table 6). For farm C, higher ($P < .05$) pH soils were recorded at the 3- and 4-ft. depths on the inside vs outside. For percent OM, no consistent results were found for the inside vs outside samples at all depths for each farm (Table 7).

Figures 2, 3, and 4 and Table 8 depicts the results for soil nutrients, soil pH, and percent OM for all three farms averaged together by each soil sample depth. For the most part, the results depicted in these figures and tables are similar to the data presented for the individual farms. In Figure 2, TKN concentration was greater ($P < .05$) for inside vs outside samples of soil depths of 1, 2, and 3 ft., but not for the 4 and 5 ft. samples ($P > .05$). In Figure 3, the results for NO_3-N averaged over all farms showed that greater ($P < .05$) concentrations occurring for inside vs outside samples at all depths (Figure 3). However, the magnitude of differences was very small at the 4- and 5-ft. depth compared to depths 1, 2, and 3 ft. The results for P_2 (Figure 4) closely follow that shown for the individual farms. The data presented in Table 8 for the concentration of K, soil pH, and percent OM shows a similar trend as those presented for the individual farms. For all farms averaged together, the concentration of K was greater for depth 1 to 4 ft. for inside vs outside samples, but not different for the 5-ft. samples. Higher ($P < .05$) soil pH (more alkaline) was found for the inside vs outside samples at 1, 2, and 3 ft.

Soil Permeability and Soil Type

Table 9 depicts the average soil permeability of the inside vs outside samples at the three depths measured for each farm. For farms A and C, average soil permeability was not different ($P > .05$) for inside vs outside samples at any of the three depths. For farm B, average permeability was lower ($P < .05$) for the first 1-3"-inside vs outside depth sample. The data presented in Table 10 shows that average permeability was significantly lower ($P < .05$) for the inside vs outside samples at the 1-3"- and 5-7"-depths for all farms averaged together.

For the type of soil found for each farm at a depth of 28 ft., the pictures of the 4-ft. sections revealed a clay base for all three farms. For farm A, bore samples were taken to a depth of 28 ft., and at that point the geoprobe hit limestone bedrock and could not penetrate any further. The samples taken to that point revealed a brownish gray clay soil type. The same type of soil samples were taken at farms B and C; however, at the 24-ft. depth the geoprobe boring unit hit aqueous material.

DISCUSSION

The purpose of the present study was to determine the degree of leaching of several soil nutrients and determine the permeability of soils from earthen floors within several turkey barns in comparison to that obtained from outside the barns. The data presented on the concentration of TKN and NO_3-N in particular were similar to that reported by Haberstroh (1997) and Zhu

(1999). In our study, increased concentrations of TKN were found for inside soil samples for the first 3-ft. depth, but not for the 4- and 5-ft. depth compared to outside samples. This indicates that over a 10 to 12 year period of growing turkeys in these buildings, TKN only migrated about 4 ft. below the surface of the ground within the turkey barns. The results for K were similar to the TKN results. The data presented for NO_3-N revealed that this nutrient migrated about 5 or more ft. below the surface of the inside of the turkey barns. A possible reason that NO_3-N seemed to migrate further in the soil from within the turkey barns was because the sub-floor of the inside of the barns were mixed with backfill (organically enriched) soil at the time of building construction. Further examination of the data presented for TKN, NO_3-N, P_2, and K indicated that concentrations of these soil nutrients actually tended to increase from the 4- to the 5-ft. depth both on the inside and outside. The reason for this can be explained by the sampling method used. Since the geoprobe truck probe unit could only take a 4-ft. deep sample, the unit had to extract that sample then re-enter the same bore to get the 5-ft. sample. Thus, some top soil probably fell in the bore hole and contaminated the 5-ft. sample. The data presented for P_2 indicated that this nutrient basically does not migrate in the soil like TKN and NO_3-N does.

In this study, the results presented for soil permeability indicate for the most part that the compaction produced by the turkeys inside the barns helped to lower the permeability of soil within the houses. This was particularly evident for farms B and C. For farm B much lower permeability values were found inside the turkey barn compared to the outside because a considerable amount of backfill dirt was packed onto the turkey barn floor during construction of the building. In fact, a majority of the houses constructed by Perdue Farms utilizes backfill dirt as a subbase for the barn floor. The reason that permeability of soil samples from the inside locations of farm A were the same as the outside may be due to the fact that the turkey barn on this farm was used mostly as a brooder, so the lighter birds would not have produced as much compaction as on farms B and C. It should also be noted that there were three inside permeability core samples that did not allow water to penetrate through them while only one outside sample did not allow the passage of water through it during the laboratory analysis.

Observation of the core samples that were taken from the 28-ft. cores showed that no aqueous material was observed to be present up to 20 ft. or so. These observations indicate that the presence of aqueous containing soil seems to be a least 20 ft. below the surface of the ground.

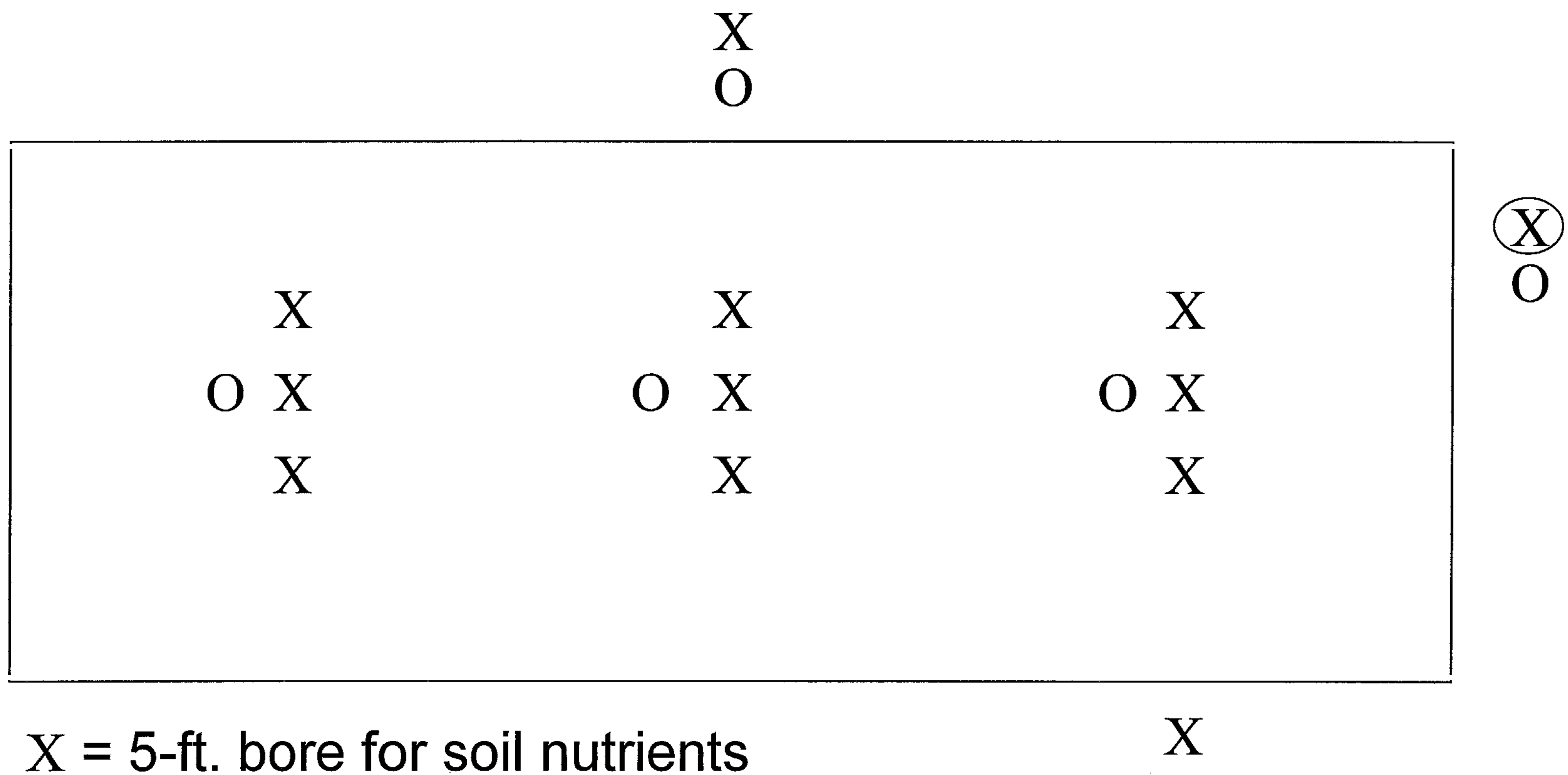
CONCLUSIONS

In summary, the results of this study indicated that soil nitrogen (TKN) was shown to leach below the surface of the ground inside turkey facilities to a depth of 4 ft. Nitrate nitrogen levels were found to penetrate a little further, but were dramatically reduced at 5 ft. vs 1 ft. inside the turkey barns. The results for P_2 indicate that the soil nutrient did not migrate in the soil like the results of TKN and NO_3-N. In addition, the raising of turkeys in these facilities seemed to dramatically lower permeability of soil within the turkey barns. Finally, since this study showed that possible harmful nutrients from turkey manure leached below the surface of the soil within a turkey barn just a few feet, it is highly unlikely that subsurface ground water would ever be contaminated.

REFERENCES

Haberstroh, G., 1997. Nitrogen concentrations under turkey barn floors. Water Quality Division, North Dakota Department of Health, Bismark, ND.

Zhu, J., 1999. A preliminary study on seepage from deep bedded and poultry litter systems. Minnesota Department of Agriculture, St. Paul, MN.



X = 5-ft. bore for soil nutrients

(X) = 28-ft. bore for soil type

O = 1-3”-, 5-7”-, and 9-11”- bore for permeability

Figure 1. Soil Sampling Locations from the Inside and Outside of Turkey Barns

TABLE 1. Description of Soil Type, Percent Clay, and Permeability for Each Farm[1]

	Soil Type	Depth	Percent Clay	Permeability
		(in)	(%)	(in/hr)
Farm A	14C2 Ava	0-10	27-35	.6-2.0
	silt loam	10-24	22-33	.6-2.0
		24-34	24-35	.2-.6
		34-50	20-30	<.06
		50-60	20-30	.2-.6
Farm B	12 Wynoose	0-9	15-25	.6-2.0
	silt loam	9-22	12-18	.06-.2
		22-45	35-42	<.06
		45-60	25-37	.06-.2
Farm C	214B Hosmer	0-6	10-17	.6-2.0
	silt loam	6-24	24-30	.6-2.0
		24-60	16-20	<.06

[1]Data were obtained from the local Illinois State Geological Survey Office.

TABLE 2. Average Concentration of Total Kjeldahl Nitrogen (TKN) at Each Depth for Inside and Outside Locations[1]

Farm	Depth	Location: Inside	Location: Outside
	(ft.)	(ppm)	(ppm)
Farm A	1	2974[a]	1111[b]
	2	1745[a]	448[b]
	3	902[a]	360[b]
	4	394[a]	337[a]
	5	433[a]	218[a]
Farm B	1	1663[a]	799[b]
	2	1315[a]	377[b]
	3	1147[a]	390[b]
	4	546[a]	310[a]
	5	683[a]	406[a]
Farm C	1	2172[a]	1097[b]
	2	1628[a]	977[b]
	3	656[a]	622[a]
	4	328[a]	311[a]
	5	355[a]	319[a]

[1]Means are the average of nine inside and three outside samples at each depth for farms A, B, and C.

[a,b]Means within a row and farm with no common superscript differ significantly ($P < .05$).

TABLE 3. Average Concentration of Nitrate Nitrogen (NO_3-N) at Each Depth for Inside and Outside Locations[1]

		Location	
Farm	Depth	Inside	Outside
	(ft.)	(ppm)	
Farm A	1	425^a	16^b
	2	403^a	13^b
	3	153^a	5^b
	4	34^a	7^a
	5	87^a	7^b
Farm B	1	90^a	65^a
	2	45^a	57^a
	3	11^a	45^a
	4	6^a	9^a
	5	10^a	40^a
Farm C	1	497^a	18^b
	2	495^a	17^b
	3	431^a	8^b
	4	185^a	7^b
	5	260^a	24^b

[1]Means are the average of nine inside and three outside samples at each depth for farms A, B, and C.

[a,b]Means within a row and farm with no common superscript differ significantly ($P < .05$).

TABLE 4. Average Concentration of Total Phosphorus (P_2) at Each Depth for Inside and Outside Locations[1]

Farm	Depth	Location	
		Inside	Outside
	(ft.)	--------(ppm)--------	
Farm A	1	108^a	66^a
	2	44^a	18^a
	3	39^a	17^a
	4	14^a	15^a
	5	36^a	20^a
Farm B	1	155^a	17^b
	2	51^a	12^a
	3	61^a	11^b
	4	30^a	17^a
	5	81^a	29^b
Farm C	1	98^a	64^a
	2	34^a	77^a
	3	10^a	41^a
	4	11^a	10^a
	5	29^a	14^a

[1]Means are the average of nine inside and three outside samples at each depth for farms A, B, and C.

[a,b]Means within a row and farm with no common superscript differ significantly ($P < .05$).

TABLE 5. Average Concentration of Potassium (K) at Each Depth for Inside and Outside Locations[1]

Farm	Depth	Location	
		Inside	Outside
	(ft.)	(ppm)	
Farm A	1	1645[a]	132[b]
	2	744[a]	105[b]
	3	217[a]	71[a]
	4	52[a]	71[a]
	5	101[a]	54[a]
Farm B	1	2486[a]	64[b]
	2	1639[a]	19[b]
	3	563[a]	41[b]
	4	103[a]	31[a]
	5	302[a]	27[a]
Farm C	1	2203[a]	190[b]
	2	1157[a]	116[b]
	3	349[a]	92[a]
	4	75[a]	85[a]
	5	148[a]	57[a]

[1]Means are the average of nine inside and three outside samples at each depth for farms A, B, and C.

[a,b]Means within a row and farm with no common superscript differ significantly ($P < .05$).

TABLE 6. Average Soil pH at Each Depth for Inside and Outside Locations[1]

		Location	
Farm	Depth	Inside	Outside
	(ft.)	(pH)	
Farm A	1	6.3^{a}	5.3^{b}
	2	5.8^{a}	4.9^{b}
	3	5.8^{a}	4.9^{b}
	4	5.1^{a}	4.8^{a}
	5	5.1^{a}	5.1^{a}
Farm B	1	8.2^{a}	5.6^{b}
	2	7.9^{a}	5.1^{b}
	3	7.3^{a}	5.0^{b}
	4	6.2^{a}	5.3^{b}
	5	6.4^{a}	5.2^{a}
Farm C	1	6.2^{a}	6.1^{a}
	2	5.1^{a}	5.7^{a}
	3	5.3^{b}	6.3^{a}
	4	4.9^{b}	5.8^{a}
	5	4.9^{a}	5.6^{a}

[1]Means are the average of nine inside and three outside samples at each depth for farms A, B, and C.

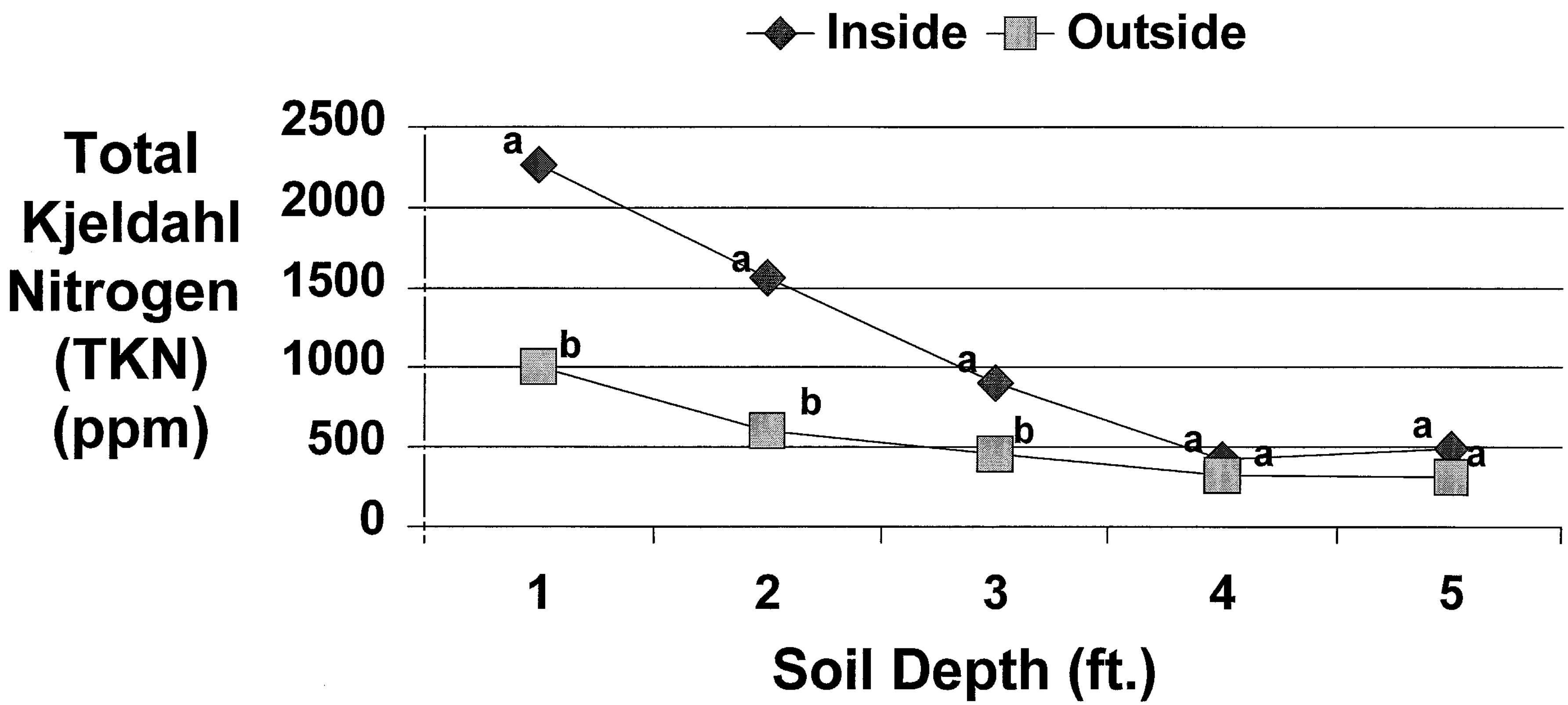
[a,b]Means within a row and farm with no common superscript differ significantly ($P < .05$).

TABLE 7. Average Percent Organic Matter (OM) of Soil at Each Depth for Inside and Outside Locations[1]

Farm	Depth	Location	
		Inside	Outside
	(ft.)	(%)	
Farm A	1	1.7[a]	2.1[a]
	2	1.7[a]	0.8[b]
	3	1.2[a]	0.7[a]
	4	0.6[a]	0.5[a]
	5	0.5[a]	0.4[a]
Farm B	1	0.9[a]	1.0[a]
	2	1.6[a]	0.5[b]
	3	2.1[a]	0.4[b]
	4	1.1[a]	0.3[b]
	5	0.8[a]	0.5[a]
Farm C	1	0.7[a]	1.5[a]
	2	0.9[b]	1.8[a]
	3	0.4[b]	1.7[a]
	4	0.4[a]	0.9[a]
	5	0.4[a]	0.2[a]

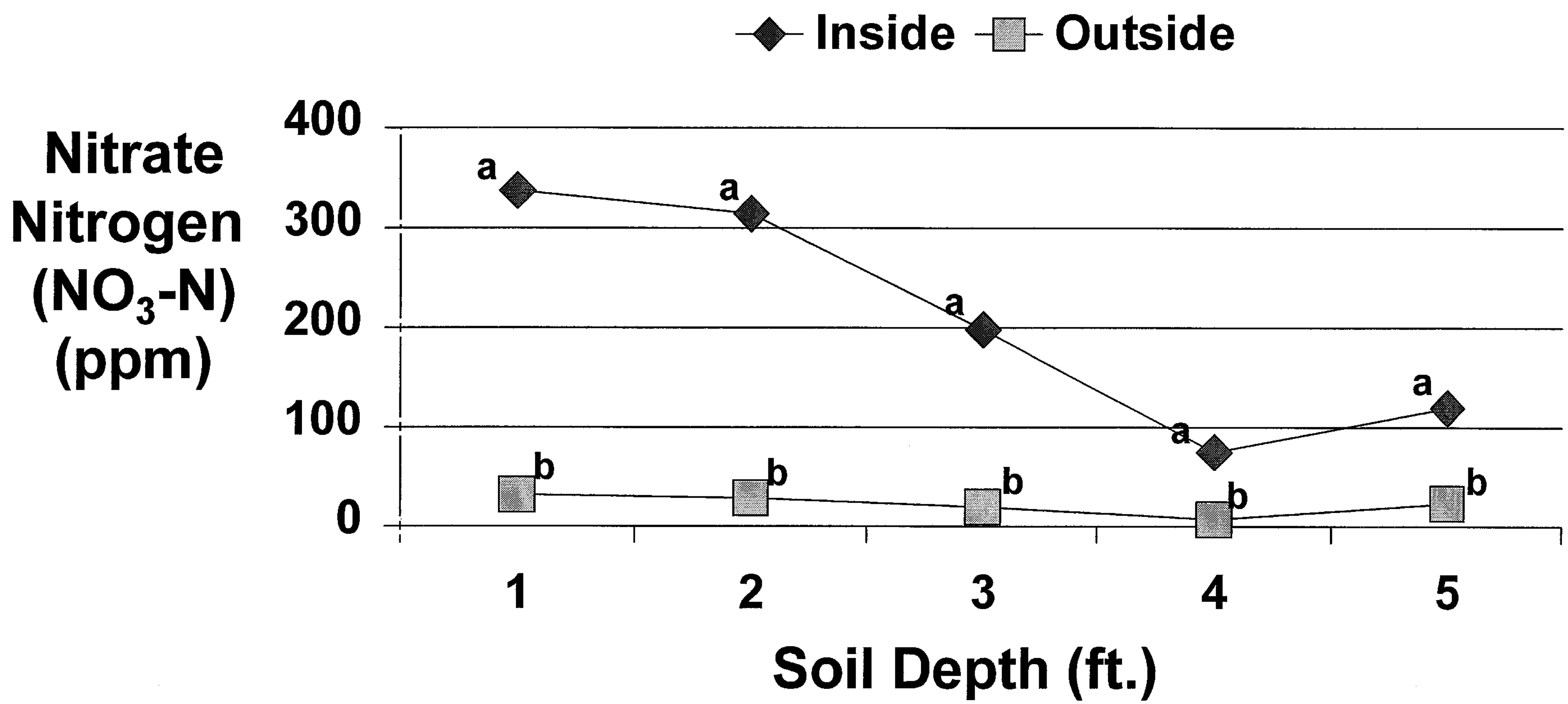
[1]Means are the average of nine inside and three outside samples at each depth for farms A, B, and C.

[a,b]Means within a row and farm with no common superscript differ significantly ($P < .05$).



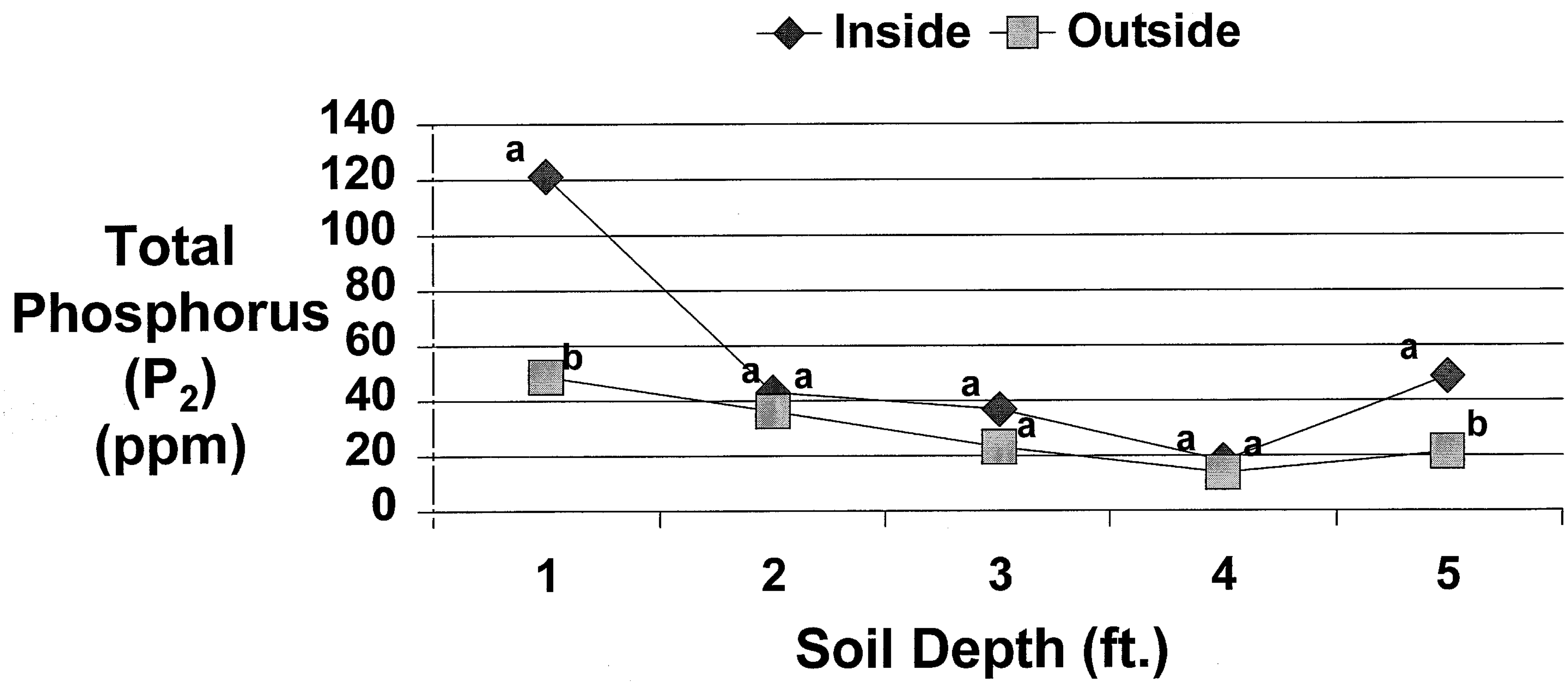
[a,b] Means within each depth with no common superscript differ significantly ($P<.05$).

Figure 2. Average concentration of total Kjeldahl nitrogen (TKN) for all farms at each depth and location. Means are the average of 27 inside and nine outside samples.



[a,b] Means within each depth with no common superscript differ significantly ($P<.05$).

Figure 3. Average concentration of nitrate nitrogen (NO_3-N) for all farms at each depth and location. Means are the average of 27 inside and nine outside samples.



[a,b] Means within each depth with no common superscript differ significantly ($P<.05$).

Figure 4. Average concentration of total phosphorus (P_2) for all farms at each depth and location. Means are the average of 27 inside and nine outside samples.

TABLE8.AverageConcentrationofPotassium(K),SoilpH,andPercentOrganicMatter(OM)forallFarmsatEachDepthand Location[1]

	K		pH		OM	
	Location		Location		Location	
Depth	Inside	Outside	Inside	Outside	Inside	Outside
(ft.)	---------------(ppm)---------------				----------------(%)----------------	
1	2111[a]	128[b]	6.9[a]	5.7[b]	1.1[a]	1.5[a]
2	1180[a]	80[b]	6.3[a]	5.2[b]	1.4[a]	1.0[a]
3	376[a]	68[b]	6.1[a]	5.4[b]	1.2[a]	0.9[a]
4	77[a]	63[b]	5.4[a]	5.3[a]	0.7[a]	0.6[a]
5	184[a]	46[a]	5.5[a]	5.3[a]	0.6[a]	0.4[a]

[1]Means are the average of 27 inside and nine outside samples for K, pH, and OM for all three farms.

[a,b]Means within a row and variable with no common superscript differ significantly ($P < .05$).

TABLE 9. Average Permeability of Soils at each Depth for Both Locations for Each Farm[1]

		Location	
Farm	Depth	Inside	Outside
	(in)	(cm/sec)	
Farm A	1-3"	1.09×10^{-4a}	1.74×10^{-5a}
	5-7"	7.62×10^{-5a}	8.19×10^{-5a}
	9-11"	1.77×10^{-4a}	6.70×10^{-5a}
Farm B	1-3"	1.59×10^{-7a}	1.16×10^{-2b}
	5-7"	2.35×10^{-8a}	1.76×10^{-3a}
	9-11"	4.33×10^{-6a}	1.81×10^{-7a}
Farm C	1-3"	5.09×10^{-7a}	1.25×10^{-3a}
	5-7"	1.93×10^{-6a}	2.13×10^{-3a}
	9-11"	1.52×10^{-6a}	2.20×10^{-4a}

[1]Mean permeability values are the average of three inside and two outside samples for each depth for farms A, B, and C. For each individual value that makes up the average value core samples were flushed with water three times, and the average permeability value was calculated. Two core samples were lost in the laboratory analysis: 1) farm A, 9-11" depth, inside; and 2) farm B, 5-7" depth, outside. Statistical analysis was computed on the log of the permeability values then transformed back to the original values.

[a,b]Means within a row and farm with no common superscript differ significantly ($P < .05$).

TABLE 10. Average Permeability of Soils at Each Depth for Both Locations for all Farms[1]

	Location	
Depth	Inside	Outside
(in)	(cm/sec)	
1-3 "	2.07×10^{-6a}	6.31×10^{-4b}
5-7"	1.51×10^{-6a}	5.57×10^{-4b}
9-11"	7.40×10^{-6a}	1.39×10^{-5a}

[1]Mean permeability values are the average of nine inside and six outside samples for each depth for all three farms averaged together. For each individual value that makes up the average value core samples were flushed with water three times, and the average permeability value was calculated. Two core samples were lost in the laboratory analysis: 1) farm A, 9-11" depth, inside; and 2) farm B, 5-7" depth, outside. Statistical analysis was computed on the log of the permeability values then transformed back to the original values.

[a,b]Means within a row with no common superscript differ significantly ($P < .05$).