NITRATE TESTING CLINICS[1]

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ABSTRACT

Thirty-eight nitrate testing clinics were held in 36 Michigan counties in the spring of 1989. A mobile testing van was equipped for nitrate analysis of soil and water samples. Over 2,200 soil samples and 1500 water samples were analyzed for nitrate N using the nitrate ion-specific electrode. More than 50 percent of the soil samples contained less than 30 lb of nitrate N in the surface two feet. Only 35 percent of the 1,100 fields were given a nitrogen credit based on the residual nitrate test. The average adjustment for these fields was 37 lb N per acre. The average for all fields was 13 lb N per acre.

Twenty percent of the domestic wells sampled in this study exceeded the Public Health Department drinking water standard of 10 ppm nitrate N. A subsequent three day clinic in July indicated that only 12 percent of the Michigan wells exceeded the 10 ppm standard. Water from livestock wells and tile drains had considerably more nitrate N than domestic wells. Deep irrigation wells had less nitrate than domestic drinking wells. Domestic wells less than 50 feet deep had more nitrates than those over 50 feet deep. Wells less than 50 feet from livestock facilities had more nitrate than wells more than 50 feet away. Distance from septic systems was not correlated with nitrate N levels found in well water.

OBJECTIVES

Nitrate contamination of groundwater in Michigan is becoming an increasing public concern. Fertilizer N, animal manures and rural septic systems have been implicated as possible non-point sources of contamination. A program of monitoring nitrate N in soil and well water was initiated in the spring of 1989 throughout the state of Michigan. The objectives of the program were to (1) offer soil and water nitrate N analysis to farmers and rural residents, (2) provide a quick turn-around time and interpretation of the analysis and (3) provide farmers with reduced N fertilizer recommendations based on the nitrate N found in two foot soil samples.

METHODS

A nitrate test clinic program was offered to the Michigan Cooperative Extension Service counties in March of 1989. A mobile nitrate testing van was equipped with an electric generator, a nitrate ion-specific electrode, an electronic balance for weighing soil samples, a mechanical sample shaker, a computer and a printer for printing out the report.

Farmers were asked to bring in two soils samples (0-12 and 12-24 inches deep) from each field representing no more than 20 acres. They were instructed to freeze or air dry the samples if they were taken more than one day before the clinic. Water samples

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were collected the day of the clinic or refrigerated if taken before the clinic. A fee of $1.00 for water, $3.00 for the first soil sample and $2.00 for the second sample or $5.00 per field was charged for the soil nitrate analysis.

The nitrate extraction and analysis procedure for soil samples was that described by North Central Regional Publication No. 221, "Recommended Chemical Soil Test Procedures for the North Central Region" (Bulletin No. 499 October 1988). Sulfamic acid was not used in the soil extract because we did not anticipate serious interference problems with chlorides or nitrites in the samples. Nitrate analysis of the soil extract was made on the decanted but unfiltered soil-water slurry. Nitrate analysis of water was made on a 50 ml sample after adding one ml of 2M ammonium sulfate to obtain a constant ionic strength in all samples. A model 501 Orion digital ion-analyzer equipped with an Orion nitrate electrode was used to determine the nitrate N in both soil and water samples.

RESULTS

Thirty-eight nitrate testing clinics were conducted between March 30 and June 15, 1989. A total of 2,206 soil samples from 1,103 fields and 745 water samples were analyzed for nitrate. A statistical analysis of the data was performed using a one-way analysis of variance along with simple and multiple regression analysis.

Soil Nitrate Analysis

Figure 1 shows the frequency distribution of nitrate N in the top two feet of soil for 1,103 fields. A large number of fields (315) averaged only 10 lbs of nitrate N in the surface two feet. Many of these fields were sandy soils. Table 1 shows that sandy and loamy sand soils had significantly less nitrate in the 12-24 and 0-24 inch depth than fine textured soils.

Table 1. Average nitrate N content by soil management group for spring soil samples tested at 38 nitrate test clinics in 1989.

Soil Management Group	Number of Observations	Soil Depth[1]		
		0-12"	12-24"	0-24"
		---------lb NO_3-N/A---------		
Clay Loam	255	28	26a	54a
Loam	136	28	27a	55a
Sandy Loam	311	25	18b	42b
Loamy Sand	126	28	14b	42b
Sand	15	29	18ab	47ab
Organic	24	31	24ab	55ab
Total 867	Average 27	21	48	

[1] Any two means followed by different letters are significantly different as measured by the Duncan's multiple range test (p=.05).

Figure 2 shows the percentage of fields and their corresponding nitrate N concentration in two feet. Fifty-four percent of the fields contained less than 30 lbs of nitrate N. These fields did not receive a reduced N recommendation because a background level of 30 lb of nitrate N per acre-2 feet had to be exceeded before any credit was given. This decision was made due to a lack of sufficient research information and experience with nitrate testing in Michigan. Only 35 percent of the fields (382) were given a reduced N recommendation based on this procedure. The average adjustment for these fields was 37 lb of N per acre. The average reduction for all fields was 13 lb N per acre. Assuming each field represents 20 acres, we estimate that 175 of the 500 farmers who tested their soil could have saved 282,680 lb of N by following the reduced N recommendations. This represents a savings of $56,536 to approximately 175 farmers ($323 per farmer for an investment of $10 to $20) without risk of reduced yield from the lower rate of N. Extrapolating this information to the entire state's two million acres of corn using a savings of 13 lb N per acre on each acre and $.20 per pound of N fertilizer, the potential savings to the Michigan farmer in 1989 could have been $5.2 million.

There are currently 42 on-farm N fertilizer demonstrations established in 27 counties to evaluate the reliability and accuracy of the MSU nitrate test. This data will be reported on later this winter.

Further analysis of the data shows that samples from manured fields contained significantly more nitrate that non-manured fields (Table 2). Table 3 shows that time of manure application also influenced the amount of nitrate N in the soil profile. Significantly more nitrate N was found in those fields where manure was spring applied than fall applied, particularly in the 0-12 inch samples.

Table 2. Average nitrate N content of manured and non-manured fields for spring soil samples tested at 38 nitrate test clinics in 1989.

Fields Indicating Manure	Number of Observations	Soil Depth[1] 0-12"	12-24"	0-24"
		----------lb NO_3-N/A---------		
No	498	24b	19b	43b
Yes	307	33a	23a	56a
Total	805	Average 27	21	48

[1] Any two means followed by different letters are significantly different as measured by the Duncan's multiple range test (p=.05).

Information was also gathered on the amount of N fertilizer used in the previous year. The analysis of this data shown in Table 4 indicates that the N rate in 1988 did not significantly affect the amount of nitrate found in the spring of 1989. A number of single and multiple correlations between previous N rate, soil texture and nitrate N concentrations were performed on the data, but none where found to be highly correlated. A high correlation (R^2=.94) was found between the 0-12 inch depth and the 0-24 inch depth (Figure 3). The equation for predicting the amount of nitrate N in two feet from the amount in the surface foot is:

$$Y = 1.66 * X$$

where "Y" equals the amount of nitrate N in the top two feet and "X" equals the amount of nitrate N in the top foot.

Table 3. Average nitrate N content of spring, winter or fall manured fields for spring soil samples tested at 38 nitrate test clinics in 1989.

Manure Application Time	Number of Observations	Soil Depth[1] 0-12"	12-24"	0-24"
		----------lb NO_3-N/A---------		
Spring-89	115	44a	26	69a
Winter-89	34	29b	20	50b
Fall-88	136	23b	22	45b
Total	285	Average 32	23	55

[1] Any two means followed by different letters are significantly different as measured by the Duncan's multiple range test (p=.05).

Table 4. Average nitrate N content by previous N rate groups for spring soil samples tested at 38 Nitrate Test Clinics in 1989.

Nitrogen Rate Group	Number of Observations	Soil Depth[1] 0-12"	12-24"	0-24"
-lb N/A-		----------lb NO_3-N/A---------		
1-50	88	22	22	44
50-100	161	30	23	53
100-150	172	27	22	50
150-200	137	25	21	46
200+	20	26	14	42
Total	578	Average 27	22	49

[1] None of the means were significantly different (p=.05).

Additional testing is needed to determine if this occurrence will be true in other years. The correlation between the 0-12 and 12-24 inch depth, shown in Figure 4, was considerably lower (R^2=.72).

Water Nitrate Analysis

The data for water samples is shown graphically in Figures 5-11. Figure 5 shows nitrate concentrations of 512 domestic wells in 36 counties. Sixty-four percent of the wells had less than 6 ppm of nitrate N. Sixteen percent had concentrations of 6-10 ppm. Twenty percent of the wells were above the public health standard of 10 ppm. This percentage is considerably higher than the Ag Expo Clinic run on July 18-20 where only 12 percent of 815 well water samples were above the 10 ppm standard.

Of the 745 water samples tested in the 38 clinics, 14 were designated as livestock wells rather than domestic drinking wells. The data for these wells is shown in

Figure 6. Thirty-six percent of these wells tested greater than 10 ppm of nitrate N. One sample tested greater than 40 ppm of nitrate N.

Forty-two samples were from drain tiles. This water contained considerably more nitrate N than wells. These data are shown in Figure 7. Nine samples tested in the 80 to 100 ppm range. The average for these 42 samples was 30 ppm. Several river water samples averaged only 4 ppm of nitrate N. From this data one might conclude that surface runoff water contains much less nitrate than tile drainage from agriculture land. One might also conclude that excess N from the 1988 drought moved downward to the tile lines and showed up in the spring drainage water.

Twenty-four irrigation wells were sampled in Montcalm county. This is an intensively irrigated potato area with sandy soils. The data in Figure 8 shows that 71 percent of the wells had 10 or less ppm of nitrate N. Most of these wells are greater than 100 feet deep.

Information was also collected on well depth. The data for 567 wells in 36 counties are shown in Figure 9. There were 131 wells less than 50 feet deep, 228 wells 50-100 feet deep and 208 wells over 100 feet deep. The nitrate concentration of shallow wells (9 ppm) was more than double that of deep wells (4 ppm). Other studies have also shown that shallow wells are the first to become contaminated with nitrate N.

Well distance from livestock may also influence nitrate contamination of wells. Most of the wells in this study (325) were more than 100 feet from livestock facilities. Twenty-eight wells were closer than 50 feet and 54 wells were between 50 and 100 feet from livestock. The concentration of nitrate N in wells located less than 50 feet from the livestock facilities, shown in Figure 10, averaged 12 ppm while those wells that were between 50 and 100 feet from livestock facilities averaged only 6 ppm.

Well distance from septic systems was also obtained in this study. There was no significant correlation between nitrate N concentration and distance from septic systems. Only 43 of 488 wells were located less than 50 feet from septic systems.

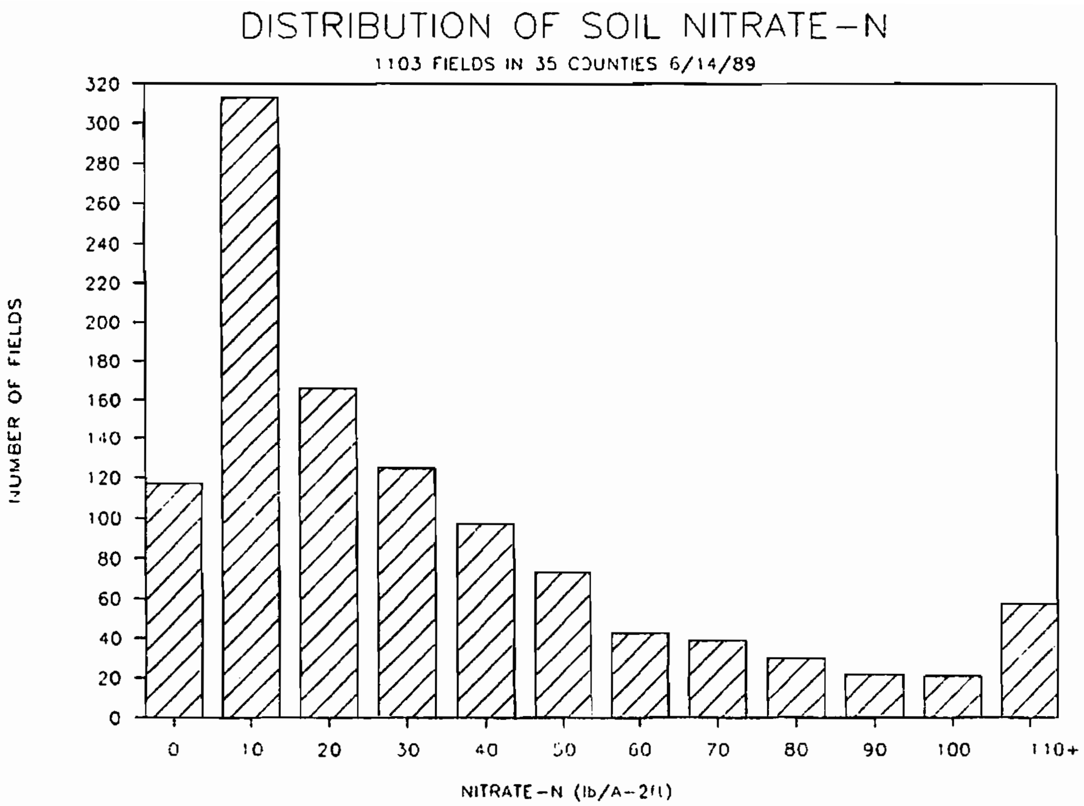

Figure 1. Frequency distribution of soil nitrate N in 1103 fields.

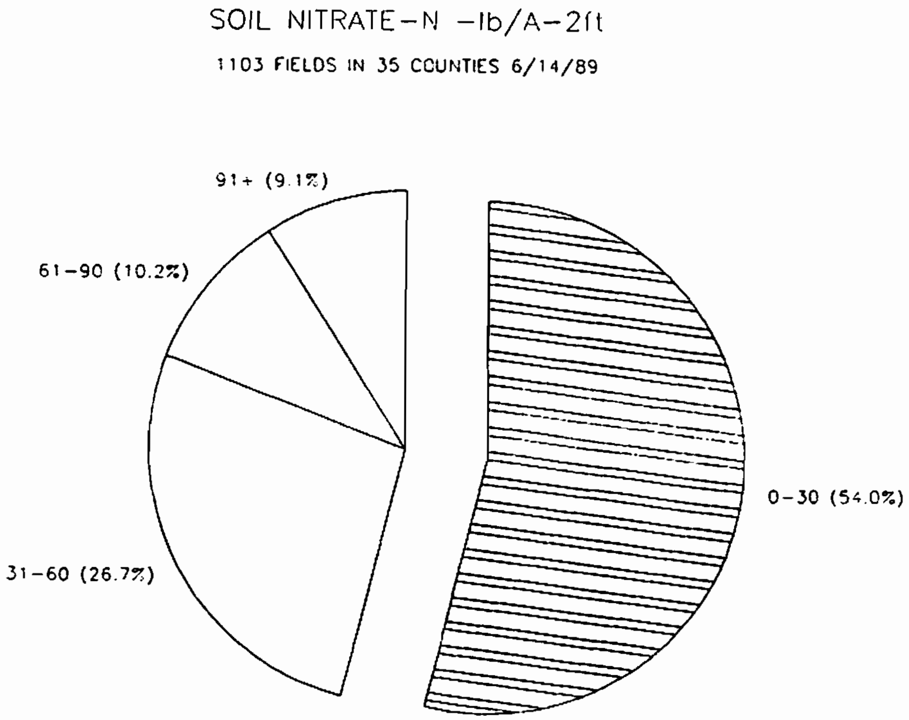

Figure 2. Four levels of soil nitrate N in 1103 fields.

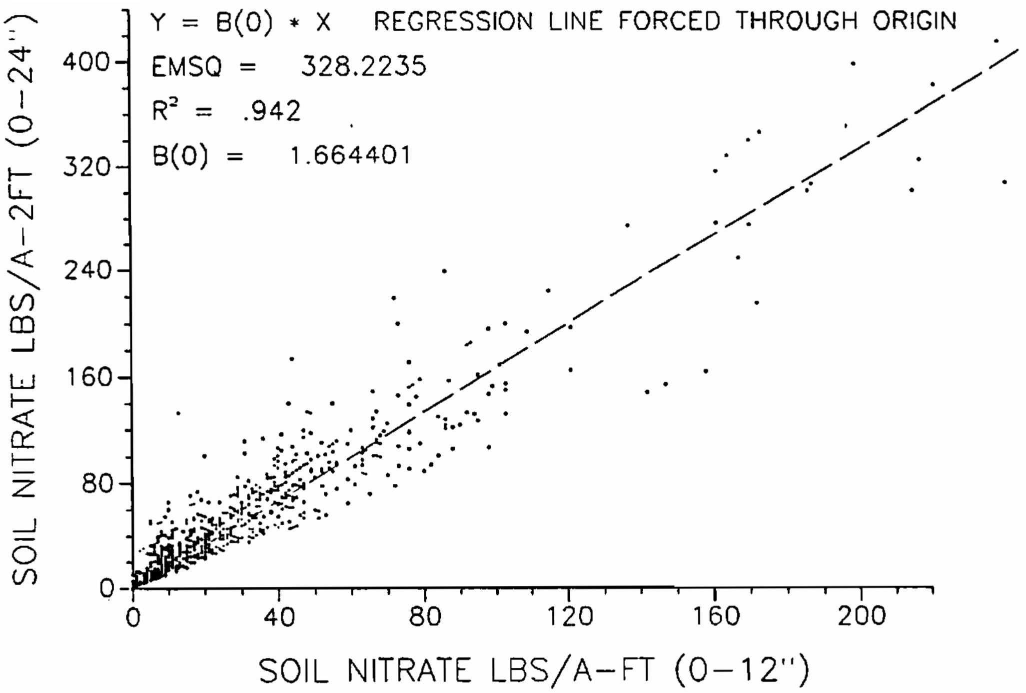

Figure 3. Regression line for soil nitrate in 0-24 inch samples as predicted by nitrate level in the 0-12 inch samples.

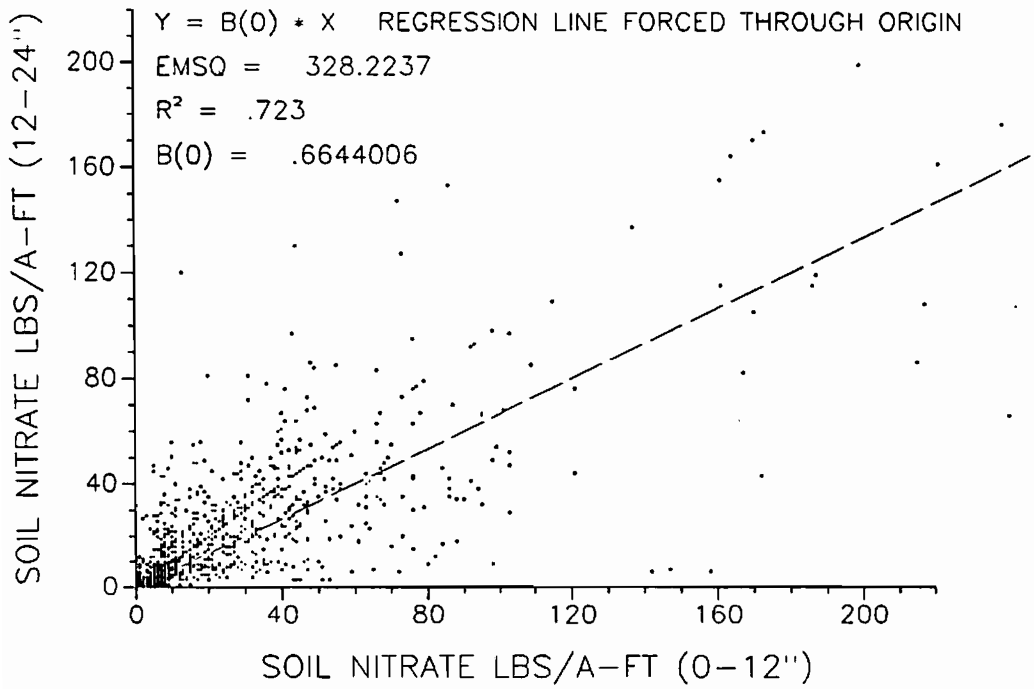

Figure 4. Regression line for soil nitrate in 12-24 inch samples as predicted by nitrate level in the 0-12 inch samples.

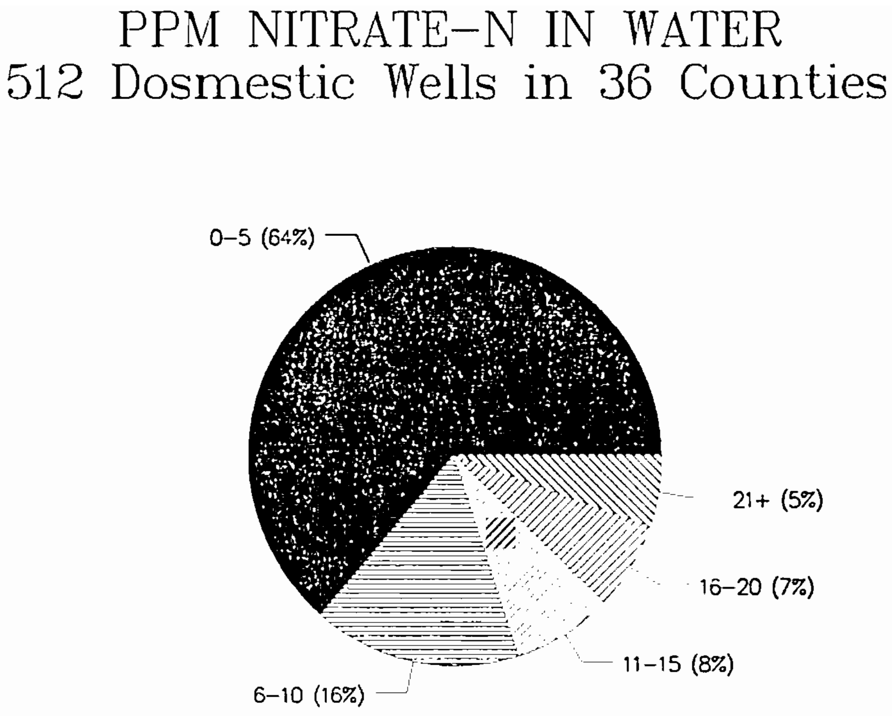

Figure 5. Concentration of nitrate N in domestic wells.

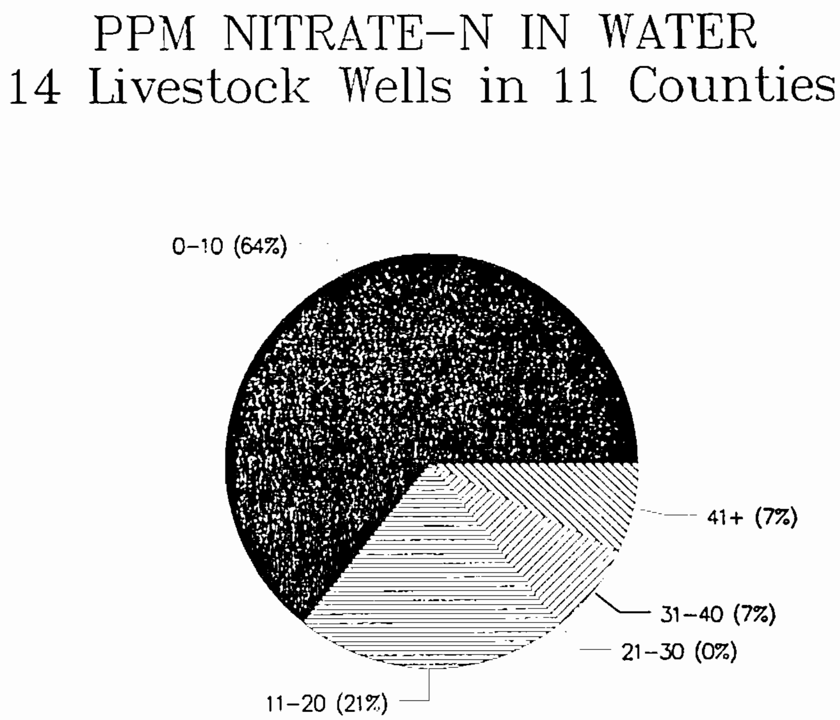

Figure 6. Concentration of nitrate N in livestock wells

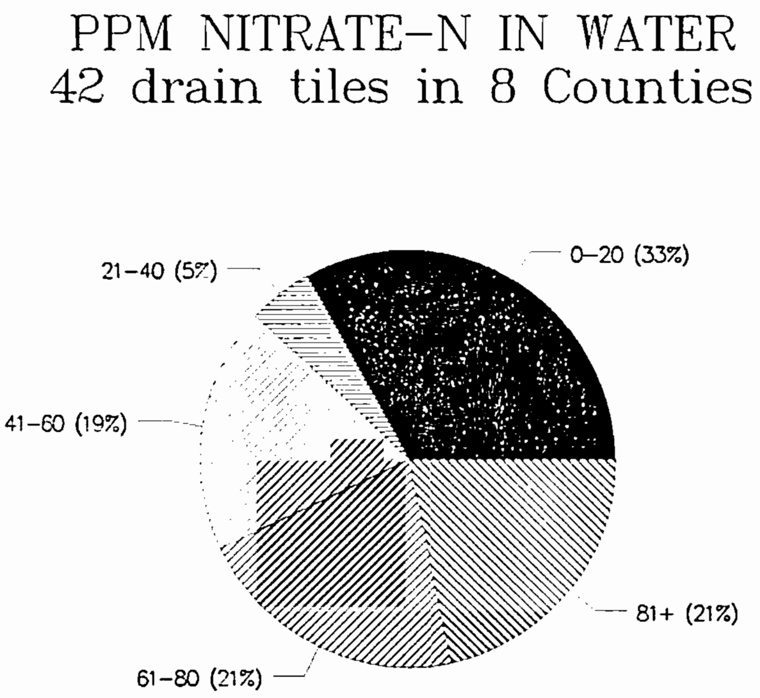

Figure 7. Concentration of nitrate N in drainage water.

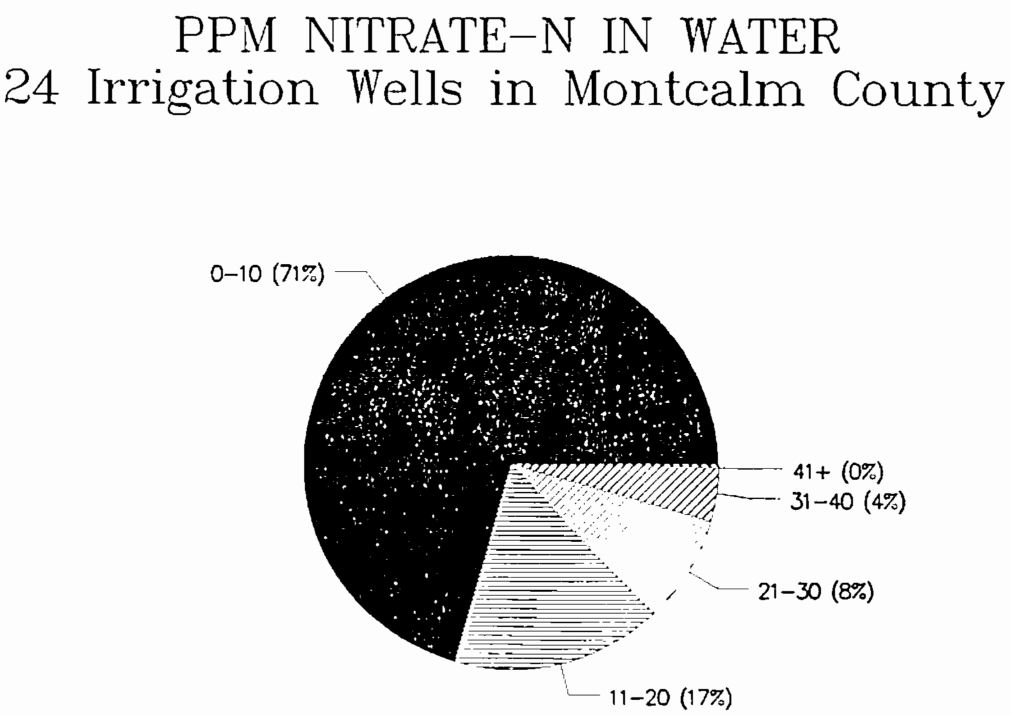

Figure 8. Concentration of nitrate N in irrigation wells.

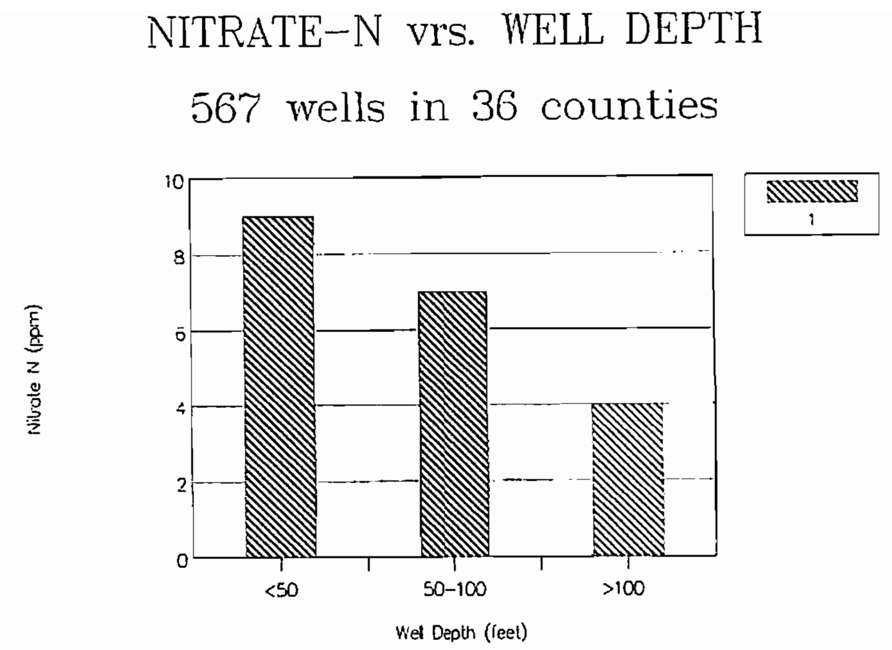

Figure 9. Concentration of nitrate N in domestic wells as related to well depth.

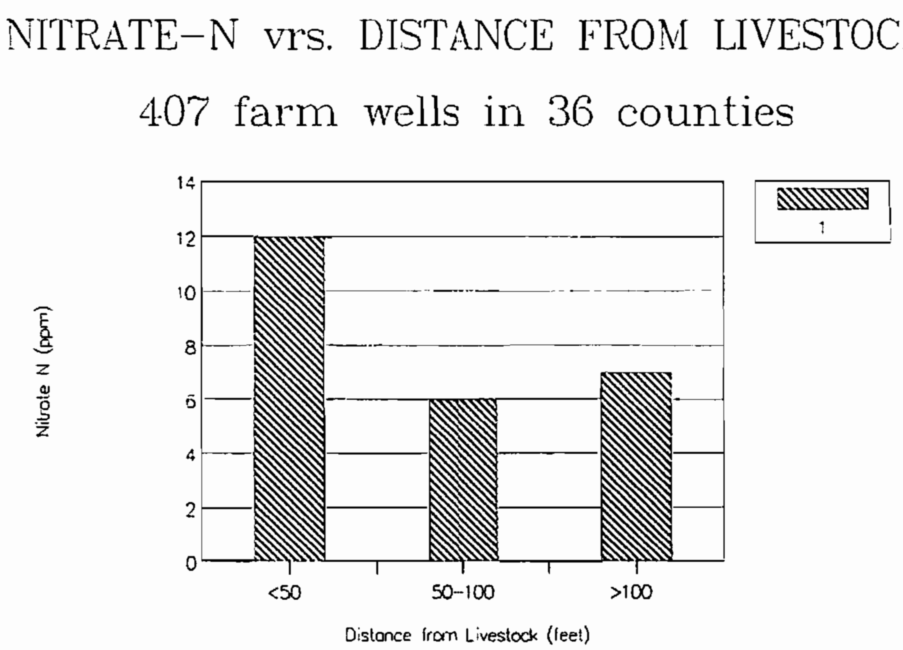

Figure 10. Concentration of nitrate N in farm wells as related to distance from livestock.

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