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ABSTRACT

Nitrate concentrations in ground water are low, less than 10 mg/l, in most parts of Hall County. Water from 46 percent of the sampled wells had nitrate concentrations greater than 10 mg/l, and 13 percent had greater than 45 mg/l. Sharp contrasts in concentrations occurring within short distances are common. Seasonal changes and a progressive increase of nitrate concentrations have occurred in some observed wells. Concentrations decrease with increasing well depth and well penetration below the water table. Nitrate in ground water is stratified where the concentration is high. Highest concentrations are found at or near the water table in the vicinity of sampled wells located close to a potential nitrate source. Potential sources of nitrate in the ground water of Hall County are fertilizers, feedlots, septic-tank effluents, seepage from the Wood River, precipitation, and soil fertility. Whereas seepage from the Wood River contributes nitrate to ground water adjacent to the stream, seepage from the Platte River dilutes the nitrate content of ground water. The hydraulic conductivity of the unsaturated zone is an important factor in controlling nitrate content of ground water.

INTRODUCTION

Hall County has an area of 540 square miles (345,000 acres) and is in the south-central section of Nebraska. The population of the county was 40,910 in 1971. Grand Island is the largest town (Figure 1).

The purpose of this paper is to evaluate nitrate concentrations in the ground water of Hall County in relation to soil types, streams, hydrogeologic factors, and cultural practices and to correlate the concentrations with selected physical and chemical parameters of wells and ground water, respectively.

Excessive amounts of nitrate in water supplies are potential hazards to infant health. Awareness of nitrate poisoning (cyanosis) led the U.S. Public Health Service (1962) to establish a concentration limit of 10 mg/l nitrate-nitrogen or 45 mg/l nitrate in drinking waters. This recommended limit is exceeded in water sampled in some parts of the county.

The principal stream in Hall County is the Platte River. Other major drainages are the Wood River and Prairie Creek. All streams flow in a northeastward direction. The county consists of three physiographic regions: bottom land, terrace, and uplands. The bottom land is 4 to 10 miles wide and rises 5 to 10 feet above the Platte River bed. A nearly flat terrace lies 25 to 40 feet above the bottom land. Uplands are found in the northwestern and southeastern parts of the county and lie 40 to 120 feet above the Platte River bottom land.

All water for municipal, domestic, industrial, and agricultural demands is supplied from wells in Hall County. Pleistocene sands and gravels and the Ogallala Formation of Tertiary age are the aquifers penetrated by the sampled wells. Pleistocene sands and gravels are the major aquifer and underlie the entire county. The Ogallala Formation, principally of poorly indurated quartzitic siltstone, is in the western and southern parts of the county and is overlain by the Pleistocene sands and gravels. Depth to water ranges from less than 10 feet in the Platte River bottom land to more than 100 feet in the uplands. In the terrace, it is about 10 to 40 feet. The water table has an average slope of about 7 ft/mile to the east-northeast. Average flow rate was estimated to be about 25 ft/year in western Hall County and 54 ft/year in the eastern part.

In the summer of 1971, 161 water samples from wells were collected and analyzed for this study. The U.S. Geological Survey (1965-1970) has been analyzing samples of ground water and surface

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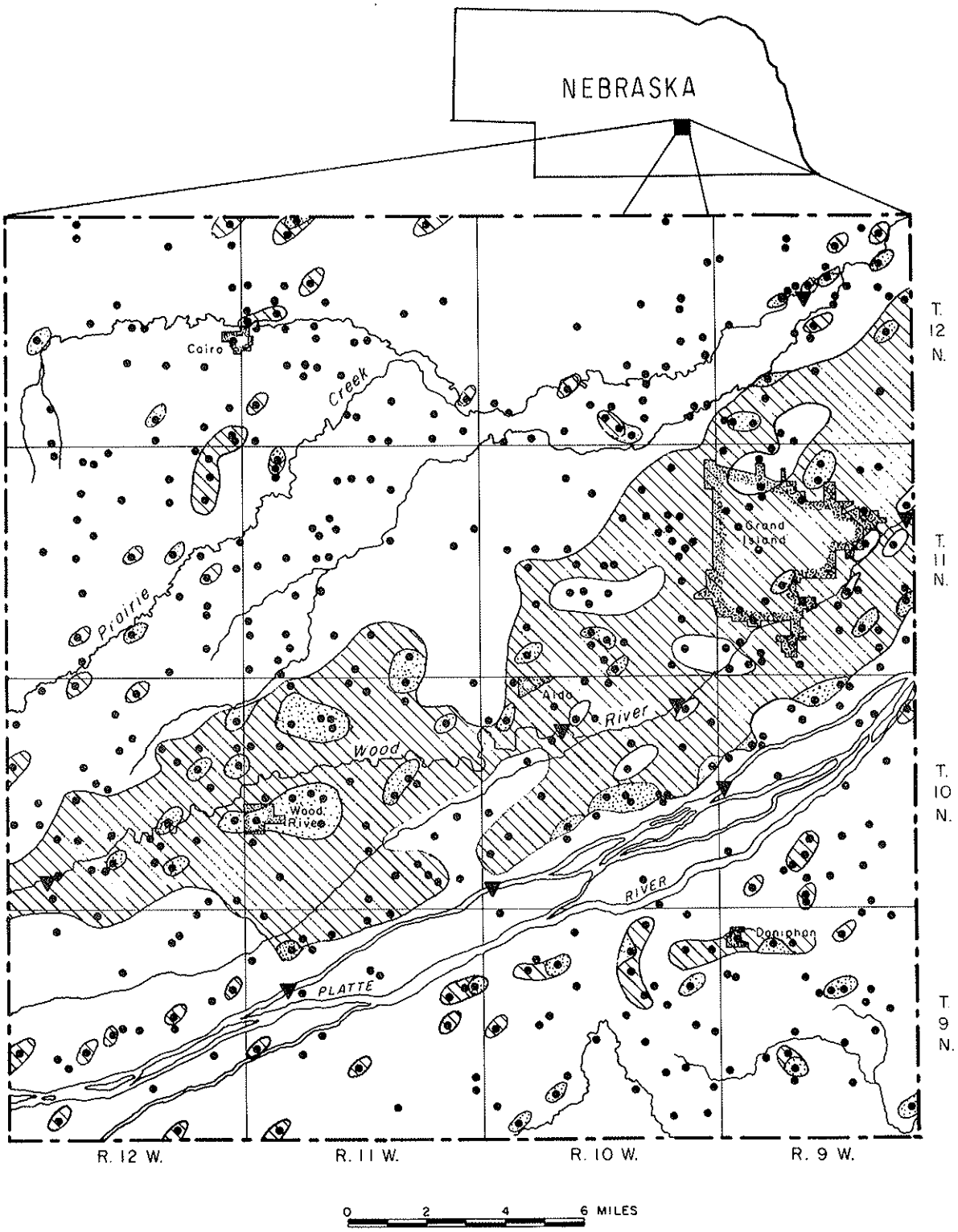


Fig. 1. Distribution of nitrate content of ground water in Hall County, Nebraska.

water for a number of years. The Grand Island-Hall County Health Department, in cooperation with the County Extension Service, made nitrate analyses on well-water samples from Hall County in the summer of 1971; many of these analyses were used in this study.

In correlation of nitrate in water samples with selected parameters, linear regression analysis (Downie and Heath, 1965) was used and the population distribution of nitrate in the study area was assumed to be normal.

AREAL DISTRIBUTION OF NITRATE CONCENTRATION

Nitrate concentrations in ground water are generally low, less than 10 mg/l, in the sparsely populated north-central part of the county (Figure 1) where dune-like sandy hills are dominant and agricultural activities are limited. (Nitrate concentration is reported as nitrate ion [NO_3] in mg/l in this paper. This can be converted to elemental nitrogen [N] by dividing by 4.428.) Nitrate in the ground water in this area probably originates from natural sources such as precipitation and the decomposition of organic materials in the soils. Therefore, concentrations less than 10 mg/l nitrate are assumed as naturally occurring in ground water in this area. Seim *et al.* (1972) indicate, from five collection sites in Nebraska, that precipitation supplies ammonium- and nitrate-nitrogen compounds ranging 5 to 10 mg/l per year nitrate to the land surface. Junge (1958) also presented similar results.

Ground water with low nitrate concentrations occurs beneath the uplands and also beneath the Platte River bottom land. The high concentrations in ground water in these areas could result from local sources of nitrate and are generally related to poor well construction. Conversely, a relatively large area on the terrace, from west of Wood River to east of Grand Island, in Hall County, through which the Wood River flows is apparently underlain by ground water containing 10 mg/l and greater of nitrate (Figure 1).

Nitrate concentrations determined in 511 well-water samples in Hall County varied from a trace to 270 mg/l and averaged about 14 mg/l. The results of the analyses are summarized in Table 1.

Nitrate concentrations in water samples taken from closely located wells vary greatly from well to to well. This situation is best seen along the edges of the nitrate-enriched ground-water body in the terrace north of the Platte River. Concentrations of only a trace occur in water from some wells whereas water from other nearby wells contains as much as 50 to 100 mg/l nitrate. Such contrasts observed in short distances suggest that in most of Hall County the nitrate enrichment of ground water generally is not a regional problem but rather a local one due primarily to conditions existing at or near individual wells. Because of this generally local character of nitrate enrichment, Figure 1 is a necessarily generalized presentation of areal distribution of nitrate in ground water in Hall County. Thus, any specific area on this map may actually be underlain by water having a different concentration.

Table 1. Nitrate Concentrations in Wells Sampled in Hall County, Nebraska

Nitrate concentration mg/l	*Sampled wells*	
	No.	*Percent*
Less than 10	276	54.0
10 and greater	235	46.0
Total wells	511	100.0
45 and greater	65	12.7

CORRELATION OF NITRATE CONCENTRATION WITH SELECTED PARAMETERS

Nitrate Concentration with Respect to Time

Monthly distribution of nitrate concentration in selected wells near Grand Island is plotted in Figure 2. High concentrations generally occur in winter months and low ones in the late summer and early fall. The seasonal fluctuation of nitrate con-

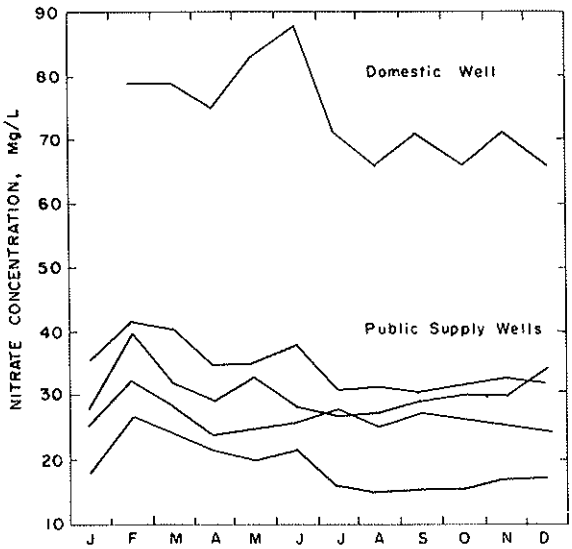


Fig. 2. Monthly nitrate concentration of ground water at selected wells in 1971.

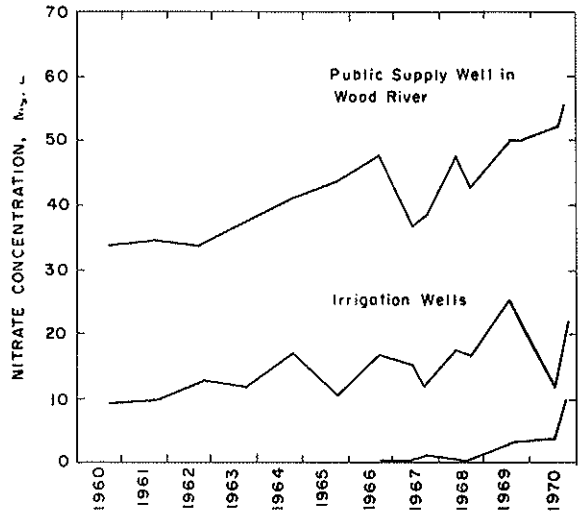


Fig. 3. Trends in nitrate concentration of ground water at selected wells.

centration is due to variations in the nitrate supply and the available water at or near land surface.

A few wells in Hall County were sampled annually and analyzed for nitrate between 1960 and 1970. The results of analyses for water from three of these wells, located in the area between Wood River and Grand Island, are plotted in Figure 3. An increase of nitrate through the years of record is apparent. On the other hand, water from three other wells, located in the northern part of the county, contains low nitrate concentrations (less than 5 mg/l). No increase is indicated during the record period. Some of man's increasing cultural activities are the possible cause of nitrate enrichment of the ground water in the area between Wood River and Grand Island.

Nitrate Concentration and Soil Association

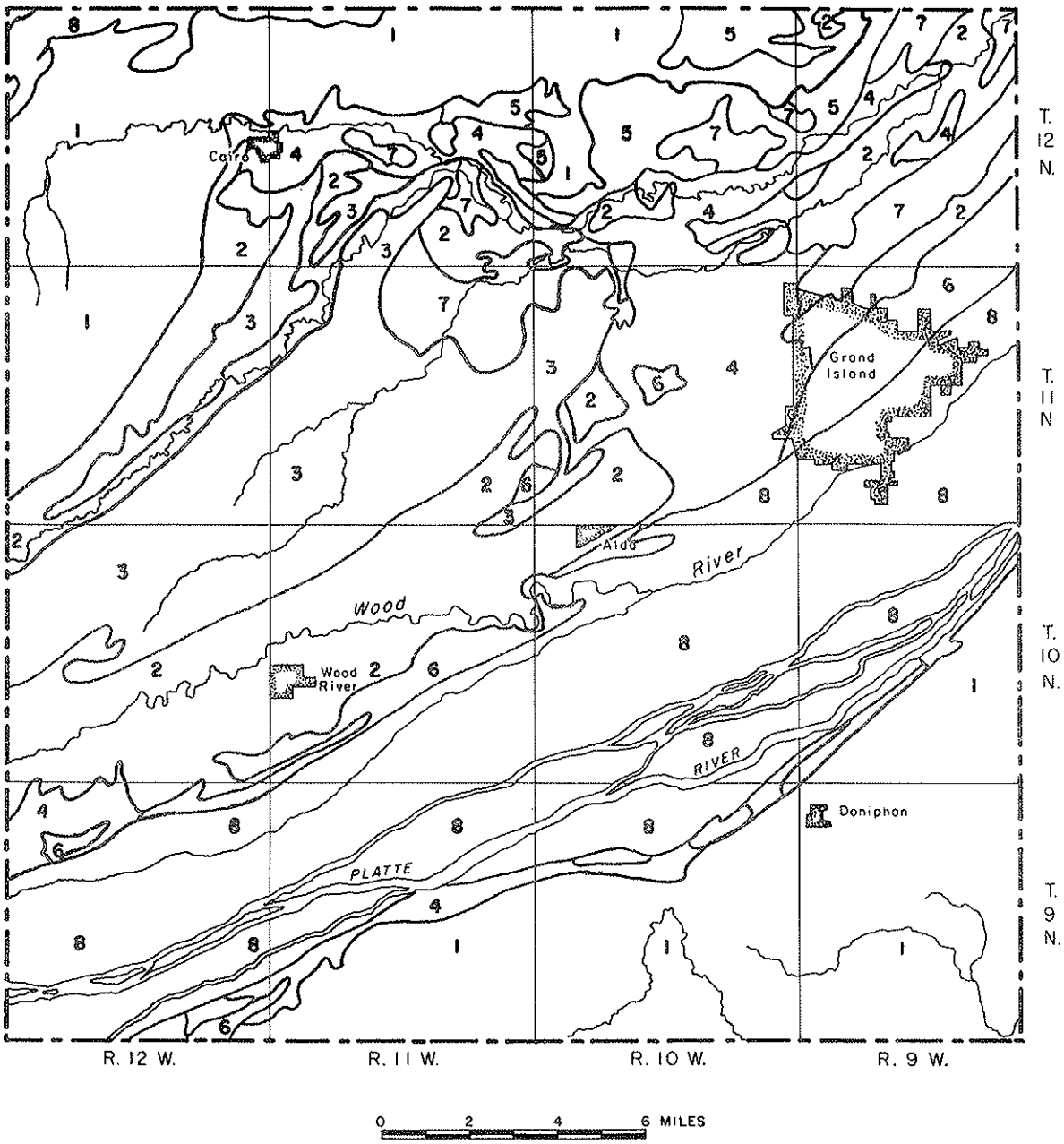
Yost *et al.* (1962) reported 11 soil associations in Hall County; a modified distribution of soil associations is presented in Figure 4. Surficial layers of soils in Hall County are principally silt, silty clay, and sand. Bottom land soils contain more sand at the surface than those of the terrace and uplands. Silty clay and clay subsoils mostly occur in the terrace. Butler, Wood River, and Exline soil series have claypan subsoils and occupy large areas between Wood River and Cairo. More sand and less silt and clay are found in the subsoils of the bottom land soils. Silty clay subsoils are common in the uplands. Natural fertility of Hord, Hall, and Wood River soil series is high.

Water samples from wells in areas of four soil associations—Hord-Hall, Ortello-Thurman, Wann-Leshara-Cass, and O'Neill-Meadin—indicate that water from more than 50 percent of the wells have nitrate concentrations of 10 mg/l and greater (Table 2). Of the 235 samples containing 10 mg/l and greater nitrate, 166 (70.6 percent) were from wells located in the above-mentioned associations. Of the 65 water samples containing 45 mg/l and greater nitrate concentrations, 27 (41.5 percent) were from wells located in the Hord-Hall soil association.

Soil fertility, farming practices, and moderate permeability of soils and underlying material in the unsaturated zone are among the factors relating to high nitrate concentrations in ground water found beneath the Hord-Hall soil association, which occurs principally between Wood River and Grand Island. Cultivation accelerates the decomposition of organic materials and the oxidation of nitrogen compounds to nitrate in this soil association, and

Table 2. Nitrate Concentration in Wells Sampled Related to Soil Associations in Hall County, Nebraska

Soil association	*Topographic position*	*Nitrate concentration, mg/l*				
		Less than 10		*10 and greater*		*45 and greater*
		No.	*Percent*	*No.*	*Percent*	*No.*
Kenesaw-Holdrege	Upland	36	69.2	16	30.8	3
Hastings-Butler	Upland	27	75.0	9	25.0	6
Valentine-Thurman	Upland	16	64.0	9	36.0	1
Hord-Hall	Terrace	36	33.7	71	66.3	27
Wood River	Terrace	47	78.3	13	21.7	1
Ortello-Thurman	Terrace	23	37.7	38	62.3	7
Ovina-Elsmere	Terrace	12	100.0	—	—	—
O'Neill-Meadin	Terrace	1	7.7	12	92.3	5
Exline-Wood River-Silver Creek	Terrace	14	73.7	5	26.3	2
Wann-Leshara-Cass	Bottom land	37	45.1	45	54.9	8
Platte-Sarpy	Bottom land	27	61.4	17	38.7	5
Total wells		276		235		65



SOIL ASSOCIATIONS

1	Kenesaw–Holdrege, Hastings–Butler, and Valentine–Thurman	5	Ovina–Elsmere
2	Hord–Hall	6	O'Neill–Meadin
3	Wood River	7	Exline–Wood River–Silver Creek
4	Ortello–Thurman	8	Wann–Leshara–Cass, and Platte–Sarpy

Fig. 4. Soil associations in Hall County, Nebraska (modified after Yost *et al.*, 1962).

infiltrating precipitation and irrigation water transports the nitrate to ground water. Moderately rapid to rapid permeabilities (hydraulic conductivity), shallow to moderately deep water table, and certain farming practices increase the potential of leaching of nitrate to ground water in areas of Ortello-Thurman, Wann-Leshara-Cass, and O'Neill-Meadin soil associations. On the other hand, slow permeability of the clay and silty clay subsoils probably accounts for the low concentration of nitrate in water beneath the Wood River soil association.

Nitrate Concentration and Hydraulic Conductivity of the Unsaturated Zone

Because grain size is related to hydraulic conductivity and, in turn, to rate of recharge, nitrate concentrations in water samples were correlated with the sand percentages of the unsaturated zone. High hydraulic conductivities characterize sediments in the unsaturated zone of the terrace, the area between Wood River and Grand Island, and the northern part of the county, where 50 to 75 percent of the material is sand. The highest conductivities are associated with bottom land sediments along the Platte River, where the sand percentage exceeds 75. Fine-grained sediments are dominant in the uplands and in parts of the terrace, the area between Wood River and Cairo; thus, the hydraulic conductivity and rate of recharge probably are least in these areas.

The percentage of samples containing 10 mg/l and greater nitrate concentrations increases with increasing sand percentage (Table 3); whereas that of samples having less than 10 mg/l nitrate decreases with increasing sand percentage. The number of samples having 45 mg/l and greater nitrate concentration is the highest, 34 (52.3 percent), where the sand percentage is greater than 75.

The evidence in Table 3 indicates that the hydraulic conductivity of the unsaturated zone is the most important factor controlling the nitrate content of ground water when excessive water and nitrate are available at the land surface. The nitrate content of ground water is very likely to increase in an area where the hydraulic conductivity of the unsaturated zone is high. High nitrate concentrations in ground water where the unsaturated zone has a low percentage of sand are mostly due to poor well construction.

Nitrate Concentrations and Streams

A stream that flows on permeable materials can lose water to or gain water from the adjacent ground-water body. Thus, a significant relation exists between the chemical quality of the stream and that of the adjacent ground water.

Low nitrate concentrations occur in ground water beneath the Platte River bottom land (Figure 1), despite conditions such as a shallow water table, fertile soils, application of extensive nitrogenous fertilizer and irrigation, wastes from a relatively large human and animal population, rapid to very rapid soil permeability, and sand and gravel parent material, which would normally make the ground water in this area rich in nitrate. The Platte River, however, alters the situation. The Platte is a losing stream in most years and has low nitrate concentrations—less than 1.3 mg/l (Piskin, in press). Therefore, the seepage from the river dilutes the nitrate content of nearby ground water.

The Wood River flows through the nitrate-rich area between Wood River and Grand Island (Figure 1). The Wood River is a losing stream west of Alda and goes dry in many reaches during the late fall and winter months of most years. At such times, sewage-disposal plant effluents of several towns located upstream from Grand Island are the major contributors of water to the stream bed. The nitrate concentrations of the effluents are not significantly high, about 15 mg/l; on the other hand, effluents would normally be expected to be rich in organic materials and ammonia nitrogen (Piskin, in press).

Table 3. Nitrate Concentration in Water Samples and Sand Percentage in the Unsaturated Zone in Hall County, Nebraska

Percent of sand in the unsaturated zone	*Nitrate concentration, mg/l*					
	Less than 10		*10 and greater*		*45 and greater*	
	No.	*Percent*	*No.*	*Percent*	*No.*	*Percent*
Less than 25	63	77.8	18	22.2	7	8.6
25-50	45	73.8	16	26.2	1	1.6
50-75	69	47.6	76	54.2	23	15.9
Greater than 75	99	44.2	125	55.8	34	15.2
Total wells	276	—	235	—	65	—

Table 4. Linear Correlation Coefficient, r, Between Nitrate in Ground Water and Selected Parameters in Hall County, Nebraska

Parameter	*Degrees of freedom*	*r*	*Comment*
Nitrate vs orthophosphate	159	+0.141	Insignificant
*Nitrate vs orthophosphate	89	+0.341	Significant at 1% level
Nitrate vs chloride	159	+0.067	Insignificant
**Nitrate vs chloride	31	+0.370	Significant at 5% level
Nitrate vs well depth	138	−0.226	Significant at 1% level
Nitrate vs depth to water	159	−0.039	Insignificant
Nitrate vs well penetration below water table	138	−0.312	Significant at 1% level

* Irrigation wells

** Two stock and 31 domestic wells

During dry periods decomposition of organic materials in sludge deposited in the stream bed is accelerated and nitrogen compounds are oxidized to nitrate (nitrification). Nitrate can leach to the ground-water reservoir with the early runoff from precipitation. Also, sludge sediments deposited at the high level of the creek shores will be oxidized during low-flow periods and the nitrate produced may later be leached downward. This type of seepage from the Wood River is believed to be one of the sources of high nitrate concentrations in ground water near the stream.

Nitrate Concentration and Fertilizer

Cropland fertilized and irrigated steadily increased in Hall County in the last decade and amounted to 245,300 and 164,200 acres in 1971, respectively (State [Nebraska] — Federal Division Agricultural Statistics, 1971). However, in spite of the large acreages irrigated and fertilized in the uplands, bottom land, and in the other parts of the county, only local nitrate-rich ground water occurs in these areas with the exception of the area between Wood River and Grand Island. Therefore, it generally appears that fertilizers are not contributing significant amounts of nitrate to the ground water in Hall County at the present time. However, over-application of fertilizer and irrigation, particularly on highly permeable sandy materials, almost surely would result in the leaching of nitrates to ground water.

Most of the fertilizers applied in Hall County are nitrogenous and phosphate types. As some nitrate and phosphate may leach from fertilizers to the ground-water body, correlations, through linear regression analyses, were made between nitrate and orthophosphate concentrations in water samples from 161 wells, and in all irrigation-well water samples (91). Correlation coefficient, r, values of +0.141 and +0.341 were obtained for the 161 and 91 samples, respectively (Table 4). The former value is insignificant (Rohlf and Sokal, 1969); however, the latter value which is significant at the one-percent level generally indicates that nitrate increases with increasing orthophosphate in water from irrigation wells. This result suggests that fertilizers may be a source of nitrate and orthophosphate in ground water below sandy croplands when excessive amounts of fertilizers and irrigation are applied. Ground water in the aquifer between Wood River and Grand Island contains high nitrate orthophosphate concentrations, where the materials in the unsaturated zone have moderate to high permeability (Piskin, in press). Therefore, it seems that fertilizers do contribute some nitrate to ground water in that part of Hall County.

Nitrate Concentration and Septic Tanks

Septic-tank effluents are believed to be a source of nitrate to water in some wells in Hall County. About 36 percent of the population of the county is dependent upon septic tanks in rural areas and in most communities. In new housing developments near the southern and northwestern parts of Grand Island, which are not yet in the central-sewage system, septic-tank density is high. Effluents are probably contributing significant amounts of nitrogenous compounds to the ground water in these areas where sandy soils and coarse material characterize the unsaturated zone. Water from some of the domestic wells near Grand Island and in rural areas contains relatively high concentrations of nitrate and chloride, both of which may derive from septic-tank effluents (Piskin, in press). Improper location of wells with respect to septic tanks will increase the potential for the leaching of effluents to the well and ground-water system.

As domestic wells are generally located close to septic tanks and as septic-tank effluents are

likely to contribute nitrate and chloride to ground water, the concentrations of these two chemicals in water samples from all 161 wells and from 33 domestic wells were correlated through linear regression analyses. A correlation coefficient of +0.067 was obtained for 161 samples and +0.370 for 33 samples (Table 4). The former is insignificant. However, the latter is significant at the five-percent level and indicates that nitrate generally increases with increasing chloride in water from domestic wells. It can be concluded, therefore, that septic-tank effluents contribute nitrate and chloride to ground water in parts of Hall County.

Nitrate Concentration and Feedlots

Runoff from a feedlot or seepage at the feedlot site also is a likely contributor of nitrate and other nitrogenous compounds to the ground water in Hall County. Table 5 contains a list of sampled wells that are located at or near (generally less than 300 feet) a registered feedlot. Samples from four wells near feedlots in the area between Wood River and Grand Island had high nitrate concentrations. Because there appear to be other sources of nitrate in this area, further research would be necessary to establish the relationship of nitrate to feedlots. Five wells sampled near feedlots elsewhere in the county had water containing less than 5.0 mg/l nitrate; one had high and another moderately high concentrations. Because an undisturbed manure layer in a feedlot is relatively impermeable, seepage at the feedlot site may not be a significant nitrate contributor to the ground-water body. Potential for pollution from the seepage of runoff is, however, increased by permeable soils and by poor well location and construction.

Table 5. Nitrate Concentrations in Water from Wells At or Near Registered Feedlots in Hall County, Nebraska

Well number	*Nitrate concentration, mg/l*
9N- 9W- 8c	Less than 5.0
10N-10W- 1c	Less than 5.0
10N-12W-18bb	23
*10N-12W-23c	64
*10N-12W-28d	49
*11N-10W-10dc	33
*11N-10W-34bc**	35
11N-11W-21b	Less than 5.0
12N- 9W-10d	71
12N- 9W-22b	Less than 5.0
12N-11W-20c	Less than 5.0

* Located in the high nitrate concentration area between Wood River and Grand Island

** Irrigation well; others are domestic wells

Table 6. Nitrate Concentration and Water Use in Hall County, Nebraska

Nitrate concentration mg/l	*Wells*					
	Irrigation		*Public*		*Domestic**	
	No.	*Percent*	*No.*	*Percent*	*No.*	*Percent*
Less than 10	45	45.9	19	47.5	212	56.8
10 and greater	53	54.0	21	52.5	161	43.1
Total wells	98	99.9	40	100.0	373	99.9
45 and greater	12	12.2	1	2.5	52	13.9

* This column includes two stock and three observation wells

Nitrate Concentration and Water Use

Nitrate concentration in ground water and water use are examined in Table 6. Nitrate concentrations of 10 mg/l and greater were found in 54.0, 52.5, and 43.1 percent of the sampled irrigation, public, and domestic wells, respectively. Of the 235 samples containing 10 mg/l and greater concentrations, 161 (68.5 percent) occur in domestic wells. The limit of 45 mg/l nitrate was exceeded in a total of 65 wells, or in 13.9, 12.2, and 2.5 percent of the domestic, irrigation, and public-supply wells, respectively. Of these 65 wells, 52 (80.0 percent) are domestic wells. Over-all data indicate that a slightly larger percent of irrigation wells contain 10 mg/l and greater nitrate than other wells do, but that concentrations are relatively higher in domestic wells than others.

Nitrate Concentration and Well Depth

A linear regression analysis applied to well depth and nitrate concentration on 140 samples produced an r value of −0.226 (Table 4). This figure is significant at the one-percent level and the negative sign indicates an inverse relation between the two variables, i.e., nitrate concentration increases generally with decreasing well depth in Hall County if a nitrate source is near the well.

Nitrate Concentration and Depth to Water

Little or no nitrate is removed from the infiltrating water beneath the root zone. Thus, depth to water generally has no appreciable effect in the nitrate content in ground water. In fact, the correlation coefficient, r, of −0.039 (Table 4) obtained between the nitrate concentration and depth to water of 161 samples analyzed by the writer indicates no relation between the two variables on a county-wide basis.

Depth to water is generally controlled by topography. Data on the relation of nitrate con-

Table 7. Nitrate Concentration and Depth to Water in Sampled Wells, and Topography, Hall County, Nebraska

Topography and depth to water	*Nitrate concentration, mg/l*					
	Less than 10		*10 and greater*		*45 and greater*	
	No.	*Percent*	*No.*	*Percent*	*No.*	*Percent*
Bottom land, 0-10 ft	54	19.6	68	28.9	17	26.2
Terrace, 10-40 ft	107	38.8	132	56.2	39	60.0
Upland, greater than 40 ft	115	41.7	35	14.9	9	13.8
Total wells	276	100.1	235	100.0	65	100.0

centrations to topography and depth to water in 511 sampled wells (Table 7) indicate that the higher concentrations of nitrate in ground water occur more commonly in wells in the terrace than in wells on the bottom land where depth to water is less and on the uplands where depth to water is greater than that of the terrace.

Nitrate Concentration and Well Penetration Below the Water Table

Nitrate concentrations in the ground water from sampled wells are related in Table 8 to well penetration below the water table. (Well penetration below the water table is defined as that portion of the well below the water table in feet.) The data in this table indicate that the percentages of the samples having 10 mg/l and greater concentrations decrease sharply with increasing well penetration below the water table.

A linear regression analysis of the data in Table 8 resulted in an r value of −0.312 (Table 4) which is significant at the one-percent level and indicates that there is an inverse correlation between well penetration below the water table and nitrate concentration. Therefore, evidence from Table 8 and regression analysis suggest stratification of nitrate in the ground water adjacent to wells which yield water containing 10 mg/l and greater concentrations; the nitrate concentration is likely to be higher near the water table than at greater depths below the water table. This suggests that deep penetration of wells below the water table is desirable in areas susceptible to pollution.

SUMMARY

In this study, nitrate concentrations of less than 10 mg/l are assumed to occur naturally in the ground water of Hall County. Higher concentrations are most common in water from wells on the terrace in the area along the Wood River from west of Wood River to east of Grand Island. Great differences in the nitrate concentrations of water samples taken from closely located wells indicate that the nitrate enrichment of ground water is local and results from conditions existing at or near wells.

Hydraulic conductivity of the unsaturated zone is the most important factor controlling the nitrate content of ground water, where excessive amounts of nitrate and water are available at the land surface. High nitrate concentrations are associated with high hydraulic conductivity.

Seasonal fluctuations and a progressive increase of nitrate were observed in successive water samples taken from some wells. The former are due to changes in the amounts of water and nitrate available and the latter is due to man's increased cultural activities.

Table 8. Nitrate Concentration and Well Penetration Below the Water Table in Hall County, Nebraska

Well penetration below water table, ft	*Nitrate concentration in samples, mg/l*					
	Less than 10		*10 and greater*		*45 and greater*	
	No.	*Percent*	*No.*	*Percent*	*No.*	*Percent*
Less than 50	17	25.4	25	34.2	11	73.3
50- 99	28	41.8	43	58.9	4	26.7
100-149	18	26.8	4	5.5	—	—
150-199	4	6.0	1	1.4	—	—
Total wells	67	100.0	73	100.0	15	100.0

Most of the samples containing more than 45 mg/l are associated with the Hord-Hall soil association. Leaching from fertile soils appears to contribute nitrate to ground water.

Seepage from the Wood River, into which effluents from several sewage-disposal plants are discharged, elevates the nitrate content of the ground water adjacent to that stream. On the other hand, seepage from the Platte River dilutes the nitrate content of ground water.

Nitrate contribution from fertilizer to ground water is difficult to evaluate; however, it seems that fertilizers are not contributing significantly to ground-water pollution in Hall County at the present time.

Seepage from septic-tank effluents and feedlot runoff appears to be a major source of nitrate in ground water in highly localized rural and urban areas of Hall County. Nitrate contribution from these sources is accelerated by the permeable soils and poorly constructed and improperly located wells.

About 54 percent of the irrigation wells sampled contain 10 mg/l and greater nitrate; however, 80 percent of the samples having 45 mg/l and greater nitrate concentrations are associated with domestic wells. Nitrate in ground water decreases with the increasing well depth and well penetration below the water table. Nitrate in ground water is stratified where the concentration is high. Highest concentrations are at or near the water table in the immediate area of sampled wells which are close to a potential nitrate source.

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