Eddy County Ground Water Pilot Survey

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Ground water quality is important in North Dakota. Ground water is the primary source of drinking water for virtually all rural North Dakota residents. Recently, both nitrate and pesticide concentrations in a limited number of water samples have raised concerns regarding the state's ground water quality. Further, agriculture's impact on ground water quality in North Dakota is complex and not yet well defined.

Nitrates are the most likely potential ground water contaminants. Nitrogen products are widely used as agricultural fertilizers, and nitrates from these compounds move readily with water. As a result, high nitrate levels in ground water are often associated with nitrogen fertilizer use. Nitrogen products are an essential part of food production, but researchers have reported excessive nitrate levels in ground water almost nationwide (6). Nitrogen is also a natural constituent of nearly all soils, waters, mammal wastes and vegetative tissue, and therefore it can appear in ground water from numerous sources.

Contaminant movement into ground water is influenced by many factors, including sorption properties of both the contaminant and the soil medium. Further, contaminant decomposition rates are influenced by factors such as moisture, temperature, pH, microbial populations, and other existing substrates.

In addition, contaminant solubility is influenced by many of the same factors including pH, temperature, and chemical constituents of the soil water. Finally, contaminant movement is influenced most by the presence and progress of soil water, which not only provides a medium for capillary movement and diffusion of potential ground water contaminants but also influences rates of microbial degradation of those materials (9).

Synthetic organic pesticides have been detected in ground water in extremely small amounts almost nationwide. Although pesticides in the environment may decompose in different ways (photodecomposition, microbial, chemical hydrolysis, etc.), some, some as picloram (trade name for Tordon), may persist in the environment long enough to pose a potential threat to ground water.

Picloram is a synthetic herbicide used in North Dakota primarily for leafy spurge *(Euphorbia esula* L.) control. Researchers have studied picloram concentrations in ground waters and found that although the half-life of picloram is approximately 13 months in soil, its persistence in underground water may be much longer (5).

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Picloram is decomposed in soil by both naturally occurring microbes and sunlight's ultraviolet radiation. Plant phytotoxic levels in soil, however, have been found five years after a picloram application, indicating its persistence potential under the proper conditions. Further, picloram's high solubility in water allows it to move readily with water through soil (5). Therefore, its movement rate is determined mostly by soil type and factors governing water flow.

Ground water quality concerns expressed by Eddy County, North Dakota, officials prompted a ground water survey to determine the status of picloram in the county's subsurface water.

Observation wells installed by the U.S. Bureau of Reclamation in Eddy County permit sampling the county's ground water at satisfactory intervals and locations. Further, Eddy County's relatively small size allows a county-wide water quality pilot survey requiring a modest number of water samples.

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The purpose of this study was to survey Eddy County ground water for picloram and inorganic chemical concentrations from observation wells and flowing springs.

MATERIALS AND METHODS

Initial ground water samples were taken in Eddy County on 27 June 1988 (sampling date 1). Separate water samples were collected for picloram and inorganic chemical analyses from five observation wells and three flowing springs. Observation wells included U.S. Bureau of Reclamation sites (No.) 67B, 68B, 82, 171, and 231 along with three flowing springs: No. 1, No. 2, and No. 3 (Figure 1). First date sample analysis for organics was accomplished by NDDHCL.

A second sampling was undertaken in October 1988 (sampling date 2) to expand investigations in an area determined positive for picloram from sampling date 1. The second sampling date included observation wells near a well (No. 171) that tested positive for picloram in an effort to

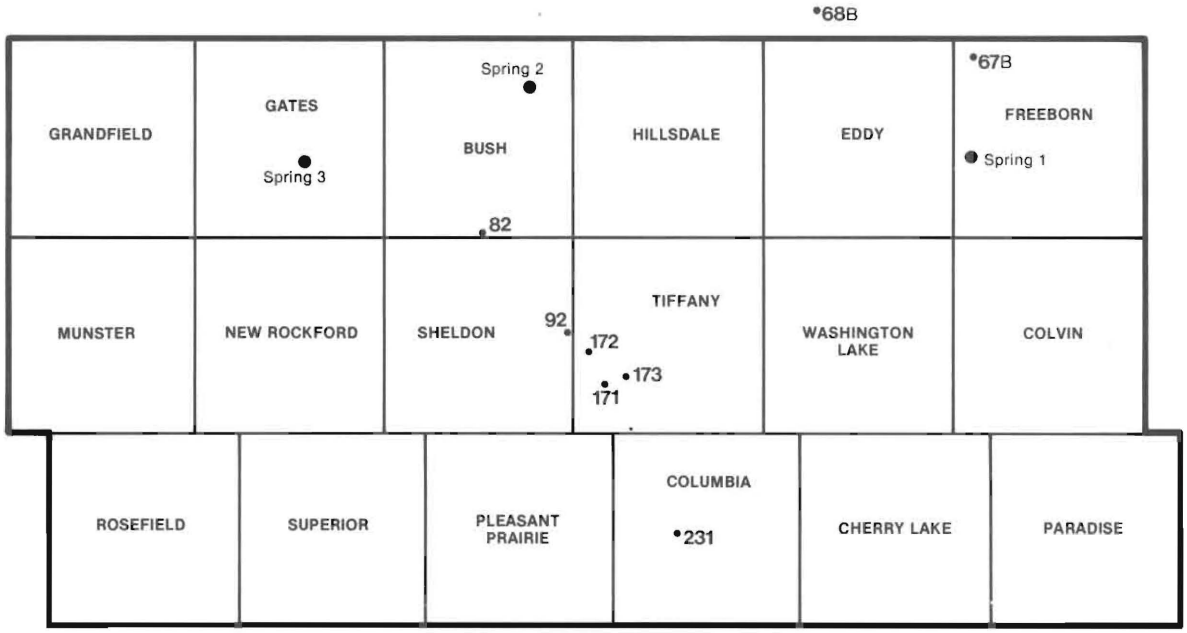

Figure 1. Eddy County, North Dakota.

identify both the size and direction of the picloram contaminant load. Wells sampled during the second survey included No. 92, 171, 172, and 173 (Figure 1). This area is commonly known as Robinson Coulee in the Tiffany Flats area located in central Eddy County. Second date sample analysis was performed by the Minnesota Valley Testing Laboratories, New Ulm, Minnesota, and the NDSU soils laboratory performed inorganic chemical analyses.

A hand-operated positive displacement piston pump was used to draw water from observation wells into sampling containers. Pump and equipment were rinsed and flushed with distilled water, and 5 gallons of water was removed from observation wells before sampling at each site. In addition, observation well caps were rinsed with distilled water before opening.

Ground water sampled for picloram analysis was stored and transported in amber quart glass jars (two quarts per sample) and placed inside a chest type, ice-packed cooler.

Ground water samples for inorganic chemical analysis were drawn and also placed in an chest-type, ice-packed cooler and 200-ml samples were analyzed by the NDSU soils laboratory.

RESULTS AND DISCUSSION

Soils vary widely in their ability to permeate water through a given profile. This internal water movement rate directly affects chemical (organic and inorganic) leaching through a soil profile. Excessively drained soils allow rapid water percolation which may permit equally rapid movement of water soluble chemicals.

Observation wells and flowing springs for ground water sampling were selected on the basis of worst case conditions for picloram movement into the water table (internally well-drained soils, shallow water tables, consistent picloram-use areas) (Table 1) (15).

Near neutral ground water pH was standard at most ground water sampling locations with the range being 7.3 to 7.9 (Table 2). Sodium absorption ratios (SAR) were below 2 and HCO3 levels were below 351 ppm, except for well site 82 which recorded HCO3 levels of 478 ppm. Nitrate-nitrogen (NO3-N) levels from the observation wells sampled were below Health Advisory Levels (HAL) of 10 ppm with the exception of two locations. Ground water samples from spring 1 and well site 67B contained the highest nitrate-nitrogen levels at 13 and 14 ppm, respectively. Nitrate-nitrogen levels in water higher than 10 ppm may cause health concerns when given to infants.

Highest levels for both total dissolved solids (TDS) and electrical conductivity (EC) were recorded from well site 82 at 1153 ppm and 1119 uMHO/cm, respectively (Table 2). Observation well site 82 also contained highest levels of Cl, SO4, Ca, and Mg.

Inorganic analysis also was performed on ground water sampled during date 2 (Table 3). Observation well site 171 was the only well duplicated from date 1. The results of this latest ground water analysis are from the Tiffany Flats area, located in Eddy County.

Ground water pH in the Tiffany Flats are of Eddy County is somewhat higher than other areas of the county but SAR levels are still below 2 (Table 3). HCO3 levels are below 300

ppm with the exception of well site 171, which was recorded at 322 ppm. This well, the only one duplicated between sampling dates 1 and 2, had 357 ppm HCO3 on sampling date 1. Nitrate-nitrogen levels were well below HAL with the range being 3 to 6 ppm. However, these nitrate-nitrogen levels are somewhat elevated when compared to nitrate-nitrogen levels from other Eddy County wells. Water analysis results from observation well site 173 had the highest EC, TDS, C1, SO4, Ca, and Mg levels of wells sampled during sampling date 2. Observation well site 173 is located downgrade from wells No. 92, 171, and 172, and receives surface water runoff from a large area.

Inorganic minerals such as zinc (Zn), iron (Fe), manganese (Mn), and copper (Cu) were found in only trace amounts at all locations from sampling date 1 (Table 4).

No picloram (below detection limit) was detected from flowing springs sampled (Table 5). In addition, during the first sampling date picloram was detected only in observation well No. 171 at 1.17 parts per billion (ppb). This discovery prompted a second ground water sampling survey from wells adjoining No. 171 in an effort to identify both the size of the area affected and direction (and hopefully the source) of the picloram concern.

The second ground water survey, confined to the Tiffany Flats area, had observation well sites 92 and 172 located upgrade from observation well site 171. Test results from both sites 92 and 172 showed no detectable picloram concentrations (Table 6). Ground water from well sites 171 and 173, located in Robinson Coulee downgrade from site 171, had picloram concentrations at 3.56 and 2.32 ppb, respectively. A survey of the immediate area determined point source contamination was not a factor. In addition, this area receives surface water drainage from a rather large territory. Well site 173 is in crop land, downgrade from site 171 in pasture.

Table 1. Soil associations at selected observation well sites in Eddy County.

Observation well site	Soil series association	Description
67B	Towner-Hiemdahl Swenoda	Nearly level, moderately well, drained, coarse to medium texture.
68B	Brandtford-Binford-Kensal	Nearly level, well to excessively drained, medium textured.
82	Maryland-Borup	Nearly level, poorly drained, medium textured.
171	Claire-Lohnes-Hamar	Gently undulating, excessively drained, coarse textured.
231	Claire-Lohnes-Hamar	Gently undulating, excessively drained, coarse textured.
Spring 1	Lamoure-Buse-Walsh	Level to steep, moderately well drained, medium textured.
Spring 2	Lamoure-Buse-Walsh	Level to steep, moderately well drained, medium textured.
Spring 3	Heimdahl-Emerick	Nearly level to hilly, well drained, medium textured.
172	Brandtford-Binford-Kensal	Nearly level, well to excessively drained, medium textured.
173	Claire-Lohnes-Hamar	Gently undulating, excessively drained, coarse textured.
92	Brandtford-Binford-Kensal	Nearly level, well to excessively drained, medium textured.

Note: soil drainage refers to internal soil drainage.

Table 2. Inorganic chemicals in ground water in Eddy County from sampling date 1.

Observation well	pH	EC	TDS	CO3	HCO3	C1	SO4	Ca	Mg	Na	K	NO3-N	SAR
(site)		uMHO/cm	ppm										
Spring 1	7.9	532	448	0	258	4	81	72	26	4	4	13	0.1
Spring 2	7.6	443	434	0	251	4	73	74	19	10	4	6	0.3
Spring 3	7.4	576	594	0	337	6	106	98	27	14	7	0.5	0.3
231	7.8	665	668	0	351	7	143	87	35	32	12	0.5	0.7
82	7.4	1119	1153	0	478	79	299	156	65	68	8	2	1.2
171	7.5	642	633	0	351	5	113	69	21	68	6	0.7	1.8
67B	7.7	354	329	0	183	2	63	63	13	1	3	14	0.04
68B	7.3	332	302	0	212	8	13	17	27	14	11	3	0.5

Table 3. Inorganic chemical analysis of ground water from sampling date 2.

Observation well	pH	EC	TDS	CO3	HCO3	C1	SO4	Ca	Mg	Na	K	NO3-N	SAR
(Site)		uMHO/cm	ppm										
92	7.8	543	492	0	290	7	69	62	16	42	4	4	1.2
171	7.7	651	496	0	322	4	51	71	22	23	3	3	0.6
172	7.7	565	571	0	247	8	166	75	20	52	4	6	1.4
173	7.7	749	654	0	283	11	191	98	27	39	4	5	0.9

The Environmental Protection Agency (EPA) has established Health Advisory Levels (HAL) for both nitrate-nitrogen and picloram contained in drinking water. Consuming water containing nitrate-nitrogen or picloram at or below the HAL is not expected to produce adverse health effects. Picloram's lifetime HAL is 490 ppb while the HAL for nitrate-nitrogen is 10 ppm. The lifetime HAL assumes a person drinks this water every day for a period of 70 years.

Water table depths are extremely important. Shallow ground water is potentially more susceptible to contamination than deeper water levels. Ground water tables in Eddy County are characterized as being very shallow (Table 7). In early spring of 1988, water levels were less than 5 feet from the soil surface. However, as the hot, dry growing season progressed, ground water levels correspondingly declined.

Analysis of both the surrounding landscape (Table 8) and local producers' herbicide spraying practices indicates that the source of picloram in these two wells (No. 171, No. 173) came from roadside spraying operations. Chemical applications to roadside ditches are commonplace in this area of Eddy County to control noxious weeds. These conclusions do not accuse misapplication of picloram. It is a fact that picloram applied at recommended rates persists in soils for more than one year (5). It is further hypothesized that picloram residues were carried to Robinson Coulee by spring snowmelt waters. Rainfall during the 1988 growing season was extremely limited, negating runoff for this growing season (Table 9).

Table 4. Zinc, iron, manganese, and copper levels from the Eddy County ground water survey.

Observation Well	Zn	Fe	Mn	Cu
(site)	ppm			
Spring 1	0.00	0.00	0.03	0.10
Spring 2	0.02	0.03	0.03	0.09
Spring 3	0.00	0.06	0.38	0.09
231	0.04	0.09	0.32	0.09
82	0.06	0.06	0.11	0.10
171	0.01	0.06	0.04	0.11
67B	0.04	0.05	0.03	0.09
68B	0.12	0.13	0.14	0.12

Table 5. Land use, soil texture and picloram detection by ground water sample location for sampling date 1.

Observation well	Land use	Soil texture	Picloram detection (ppb)
Spring 1	Pasture	loam	<1
Spring 2	Pasture	sand	<1
Spring 3	Pasture	sandy-loam	<1
231	Pasture	sand	<1
82	Pasture	loam	<1
171	Pasture	loam	1.17
67B	Crop	sand	<1
68B	Crop	sand	<1

minimum detection level = 1 ppb

Table 6. Land use, soil texture, and picloram detection by ground water sample location for sampling date 2.

Observation well	Land use	Soil texture	Picloram detection (ppb)
(site)			
92	Crop	loam	<1
171	Pasture	loam	3.56
172	Crop	loam	<1
173	Crop	loam	2.32

minimum detection level = 1 ppb

Table 7. Ground water depths from the soil surface by observation well location in 1988.

Observation well	February-March	May	August	October
(site)	feet			
82	3.2	3.0	5.8	6.3
92	4.9	4.2	6.0	6.3
171	4.1	3.4	4.8	4.9
172	—	2.9	7.1	7.5
173	—	—	4.8	4.8
231	5.2	5.2	6.7	6.8

Table 8. Observation well screen depths and ground surface elevations from sampled well sites.

Observation well	Screen depth (feet)	Ground surface elevations (feet above sea level)
(site)		
67B	15	1472.83
68B	14	1470.60
82	12	1528.11
92	19	1519.97
171	9	1514.24
172	18	1519.80
173	10	1513.65
231	10	1507.00

Table 9. 1988 participation summary.

Month	Precipitation (inches)
January	1.18
February	0.06
March	1.28
April	0.35
May	1.15
June	2.27
July	0.87
August	2.29
September	0.76
October	0.03

SUMMARY

A ground water quality pilot survey was performed in Eddy County during the summer of 1988 (sampling date 1) to determine picloram (trade name Tordon) and nitrate-nitrogen concentrations in Eddy County's subsurface water. Water tables in Eddy County are shallow, and picloram is used extensively in this county for leafy spurge *(Euphorbia esula* L.) control. Soils in the county are generally coarse-textured and have rapid water intake rates.

Inorganic analysis revealed nitrate-nitrogen levels above Health Advisory Levels of 10 ppm at two locations. Picloram was detected in one observation well during sampling date 1.

A second expanded well sampling survey (sampling date 2) discovered a second well with picloram levels above detection limits. Results from both observation well sites 171 and 173 revealed picloram at 3.56 and 2.32 ppb, respectively, which are well below the Health Advisory Level of 490 ppb. Observation well site 173 is located in Robinson Coulee and receives surface water drainage from a large area. Ground water from observation well site 173 also contained highest levels of natural inorganic constituents.

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