

The Nitrate Contamination of Private Well Water in Rural Northwest Kansas

Ryan Hargitt

ABSTRACT

Twenty percent of the 36 billion pounds of nitrogen added to the environment in 1995 by America's agricultural producers was not used up by the crops fertilized with it (Pouring It On, 1996). Instead, this 7 billion pounds of excess nitrogen eventually entered the reservoirs, rivers, and groundwater from which we get our drinking water supply. The concentration of nitrate-nitrogen in the private wells of five different farms in rural northwest Kansas was determined in mg/L, parts per million (ppm), using the DR-EL2 portable spectrophotometer. Samples were collected on a bimonthly basis beginning September 9, 2000 and continuing through January 23, 2001. Three samples were collected from each farm every two weeks for a total of 150 samples: one collected directly from the well, one from the household water tap, and one from a livestock water tap. The analysis of the samples produced results with similar trends seen for each of the five farmsteads with the nitrate concentrations peaking in December. Two of the farmsteads contained numerous samples exceeding the 10mg/L safe limit for nitrate-nitrogen over the five-month period for this study.

Keywords: *nitrate-nitrogen, private wells, DR-EL2 Portable Spectrophotometer, rural Northwest Kansas*

INTRODUCTION

Nitrogen is a naturally occurring compound. In natural ecosystems the gains and losses of nitrogen are in balance, and it remains this way until additional nitrogen is added to the ecosystem, upsetting the balance. Three parts per million (ppm) is the generally accepted cutoff point between naturally occurring nitrate and nitrate contamination due to human sources. In many regions of the country the primary cause of nitrate contamination is from the over application of fertilizer by farmers. "Agricultural activities, primarily row crop and livestock production, account for over 80 percent of all nitrogen added to the environment" (Nolan, 1996). Additional sources of nitrogen include "feedlots, septic systems, and other waste treatment systems" (Jasa, 1998).

Nitrogen occurs naturally in the soil in organic forms from decaying plant and animal residues. Bacteria in the soil convert various forms of nitrogen to nitrate, a nitrogen/oxygen ion (NO_3^-). This is desirable as a majority of the nitrogen used by plant is absorbed in the nitrate form. However, nitrate is highly leachable and readily moves with water through the soil profile. If there is excessive rainfall or over-irrigation, nitrate will be leached below the plant's root zone and may eventually reach groundwater. (Jasa, 1998).

Nitrate contamination in groundwater is often the result of either point or nonpoint sources. Point sources include sewage disposal systems and livestock facilities, while fertilized cropland, parks, golf courses, lawns, and gardens" are considered nonpoint sources of nitrate-nitrogen. To reduce the potential of nitrate contamination of well water one must select a proper site, make sure it is at an adequate distance from potential sources of contamination, and make

sure it is properly constructed and maintained.

Concern about the risk of nitrate contamination led the federal government to set a standard for city water systems of no more than ten milligrams of nitrate per liter of water in 1977. The regulations set for city water systems do not cover private wells however. Approximately 23 million people in the U.S. depend on private water wells for their drinking water supply. The maintenance of these private water wells for water safety is solely up to the user, but this maintenance is often neglected. "Surveys indicate that 9 percent of all household wells, and more than 13 percent of wells in the Midwest have water contaminated by excessive nitrate" (Health, Oct96). In Kansas, particularly, a recent study found that 28% of Kansas's farmstead wells were contaminated by nitrates (Powell et.al, 1992). Private water supplies should be tested annually for nitrates to detect contamination early because "nitrate in water is undetectable without testing because it is colorless, odorless, and tasteless" (Jasa, 1998).

The presence of nitrates in drinking water is especially harmful to infants and young farm animals because their stomachs are relatively non-acidic, allowing bacteria that convert nitrates into dangerous nitrites to flourish in this non-acidic environment. The nitrites react with hemoglobin, the body's oxygen transporting mechanism, and convert it to methemoglobin, a form that is incapable of carrying oxygen. "This creates the condition known as methemoglobinemia (sometimes referred to as 'blue baby syndrome,')..." (Jasa, 1998). By six months of age, however, the HCl concentration in the stomach will rise, killing the bacteria that convert nitrates to nitrites. Nitrate contamination is therefore not as much of a concern for adults or children older than

approximately 6 months. However, “older persons who have a gastrointestinal system disorder producing a pH level which allows for an increase in bacteria growth may be at a greater risk that the general population” (Jasa, 1998). Excessive amounts have been known to cause adult illnesses.

While symptoms of nitrate toxicity have appeared in livestock, the levels that produce toxicity are much higher than for humans. Nitrate poisoning in livestock depends more on feed than on water. Nitrate-contaminated water usually is a problem only when the water adds to the high-nitrate concentrations already present in some feeds and the animal is under physiological stress (Water on Tap, 1997). This has been known to lead to spontaneous abortions in cattle.

Recent studies have indicated, however, that the 10mg/L nitrate-nitrogen federal drinking water standard contains no safety factor. Infants, under six months of age, who drink formula that has been mixed with water that is contaminated with nitrate at or higher than the standard, can easily suffer from methemoglobinemia. “Repeated consumption over a period of days or weeks can cause severe blue baby syndrome, and even death” (Nolan, 1996).

The area where the samples were collected for this study, Gove County in rural northwest Kansas, lies in the highly productive agricultural region known as the Corn Belt, where 50% of the nation’s fertilizer” is used.

The most recent studies by the United States Geological Survey (USGS) have found that groundwater wells in agricultural regions are much more heavily contaminated than wells in urban, forest, or rangeland regions. The research will determine whether or not the private wells analyzed are safe for human and livestock use (Nolan 1996).

MATERIALS AND METHODS

Water samples for nitrate contamination were collected on a bimonthly basis starting on September 9th, 2000 and continuing through January 23rd, 2000. Five farms were selected for this study with a total of 30 separate samples being collected throughout the research from each farm. Every other week I will travel to each farm where I will collect three separate samples, 200ml each. Each sample will be collected in a sterile sample bottle. Although only 25 ml is needed of each sample, I collected 200 ml each time in case I needed to run the sample more than once. One sample was collected directly from the well water supply source, the second sample from the drinking water tap, and the last sample from a livestock water tap.

All 150 samples were analyzed for nitrate concentration using a DR-EL/2 portable spectrophotometer. Procedure:

1. Take a water sample by filling a clean 25-ml graduated cylinder to the 25-ml mark. Pour the sample into a clean sample cell. *See Note A.*
2. Add the contents of one NitraVer V Nitrate

Reagent Powder Pillow to the sample cell, stopper, and shake vigorously for **exactly** one minute. *See Note B.* An amber color will develop if nitrate nitrogen is present. To allow time for proper color development, wait at least 5 minutes but not more than 15 minutes before completing Steps 3 and 4.

3. Fill another sample cell with about 25 ml of the original water sample and place it in the cell holder. Insert the Nitrogen, Nitrate (NitraVer V Method) Meter Scale in the meter and adjust the Wavelength dial to 500 nm. Adjust the LIGHT CONTROL for a meter reading of zero mg/l.
4. Place the prepared sample in the cell holder and read the mg/l nitrate nitrogen (N). *See Notes C and D.*

Notes:

- A. The sample cells and stopper should be rinsed by shaking with portions of demineralized water several times before each test. NitraVer V Nitrate Reagent is slightly temperature sensitive. For best results, the test should be performed with a sample temperature of 20° to 24°C (68° to 75°F).
- B. A deposit of unoxidized metal and drying agent will remain after NitraVer V Nitrate Reagent Powder has dissolved. This will have no effect on the test results. The extent of color development in the nitrate nitrogen test using NitraVer V Nitrate Reagent Powder is partially affected by shaking time and technique of the analyst. For most accurate results, the analyst should make successive tests on a solution containing a known amount of nitrate and adjust his or her shaking time to obtain the most accurate results.
- C. The results can be expressed as mg/l nitrate (No₃) by multiplying the mg/l nitrate nitrogen (N) by 4.4.
- D. Most accurate results can be obtained by running a simultaneous reagent blank in demineralized water and using this to zero the instrument in Step 3 (DR-EL/2 Methods Manual, 1973).

RESULTS

Neil Hargitt Farm:

Sep. 9:	Well-2.86mg/L	Liv.-3.08mg/L	Tap-3.30mg/L
Sep.23:	Well-3.17mg/L	Liv.-3.30mg/L	Tap-3.52mg/L
Oct. 7:	Well-3.52mg/L	Liv.-3.08mg/L	Tap-3.52mg/L
Oct.21:	Well-3.30mg/L	Liv.-3.52mg/L	Tap-3.30mg/L
Nov. 4:	Well-3.74mg/L	Liv.-3.80mg/L	Tap-3.80mg/L
Nov.18:	Well-3.96mg/L	Liv.-3.52mg/L	Tap-3.74mg/L
Dec. 2:	Well-3.52mg/L	Liv.-3.30mg/L	Tap-3.52mg/L
Dec.16:	Well-3.74mg/L	Liv.-3.30mg/L	Tap-3.80mg/L
Jan. 1:	Well-4.18mg/L	Liv.-3.80mg/L	Tap-3.96mg/L
Jan.23:	Well-3.52mg/L	Liv.-3.74mg/L	Tap-3.52mg/L

Well-

Mean(x)=3.55
 Standard Deviation(s)=0.383
 Five-Number Summary (Min, Q₁, Median, Q₃, Max)
 2.86, 3.30, 3.52, 3.74, 4.18

Liv.-
 x=3.44
 s=0.275
 3.08, 3.30, 3.41, 3.74, 4.18

Tap-
 x=3.60
 s=0.220
 3.30, 3.52, 3.52, 3.80, 3.96

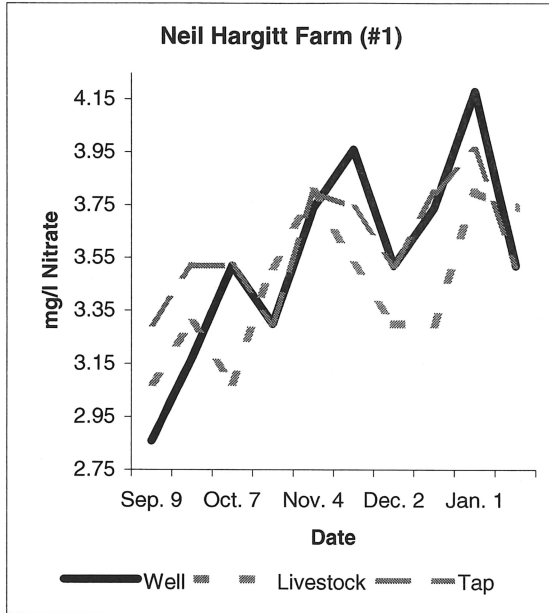


Figure 1. Date of sample collection as a function of mg/L Nitrate concentration for Farm #1. Nitrate concentration reached a peak on January 1st.

Wendall Hargitt Farm: (mg/L)

Sep. 9:	Well-9.68	Liv.-11.0	Tap-11.44
Sep.23:	Well-10.56	Liv.-11.88	Tap-11.0
Oct. 7:	Well-10.12	Liv.-11.44	Tap-11.0
Oct.21:	Well-11.0	Liv.-10.56	Tap-10.12
Nov. 4:	Well-10.56	Liv.-11.0	Tap-9.68
Nov.18:	Well-11.44	Liv.-11.88	Tap-10.12
Dec. 2:	Well-11.88	Liv.-11.44	Tap-11.0
De.16:	Well-12.32	Liv.-11.88	Tap-11.88
Jan. 1:	Well-11.44	Liv-11.0	Tap10.56
Jan.23:	Well-10.56	Liv-11.0	Tap-10.56

Well-
 x=11.0
 s=0.815
 9.68, 10.56, 10.78, 11.44, 12.32

Liv.-
 x=11.3
 s=0.466
 10.56, 11.0, 11.22, 11.88, 11.88

Tap-
 x=10.7
 s=0.662

9.68, 10.12, 10.78, 11.0, 11.88

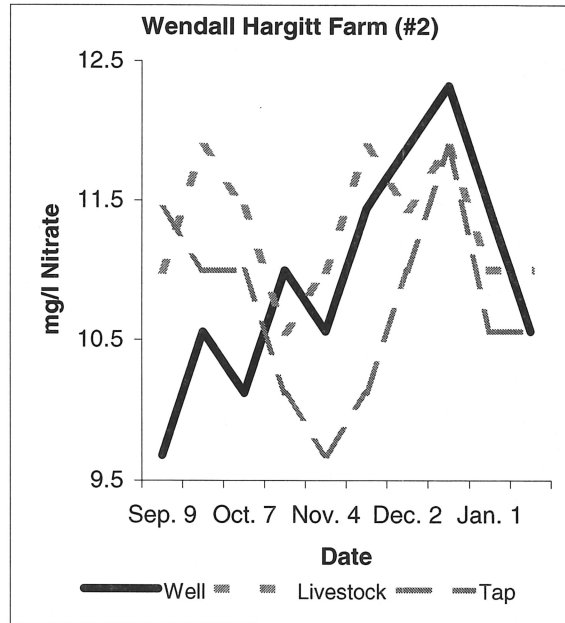


Figure 2. Date of sample collection as a function of mg/L nitrate concentration for Farm #2.

Tom Stewart Farm: (mg/L)

Sep. 9:	Well-9.68	Liv.-10.12	Tap-9.24
Sep.23:	Well-9.24	Liv.-10.12	Tap-8.80
Oct. 7:	Well-9.24	Liv.-10.56	Tap-9.24
Oct.21:	Well-9.68	Liv.-11.0	Tap-9.68
Nov. 4:	Well-9.68	Liv.-10.12	Tap-10.12
Nov.18:	Well-10.12	Liv.-10.56	Tap-10.56
Dec. 2:	Well-11.0	Liv.-11.44	Tap-10.56
Dec.16:	Well-11.0	Liv.-11.0	Tap-10.12
Jan. 1:	Well-10.12	Liv.-10.56	Tap-10.12
Jan.23:	Well-9.24	Liv.-10.12	Tap-9.68

Well-
 x=9.90
 s=0.664
 9.24, 9.24, 9.68, 10.12, 11.0

Liv.-
 x=10.6
 s=0.464
 10.12, 10.12, 10.56, 11.0, 11.44

Tap-
 x=9.81
 s=0.589
 8.80, 9.24, 9.90, 10.12, 10.56

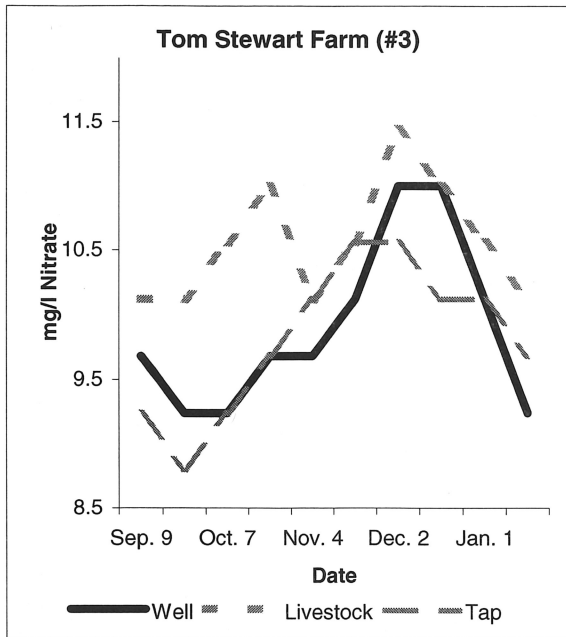


Figure 3. Date of sample collection as a function of mg/L nitrate concentration for Farm #3.

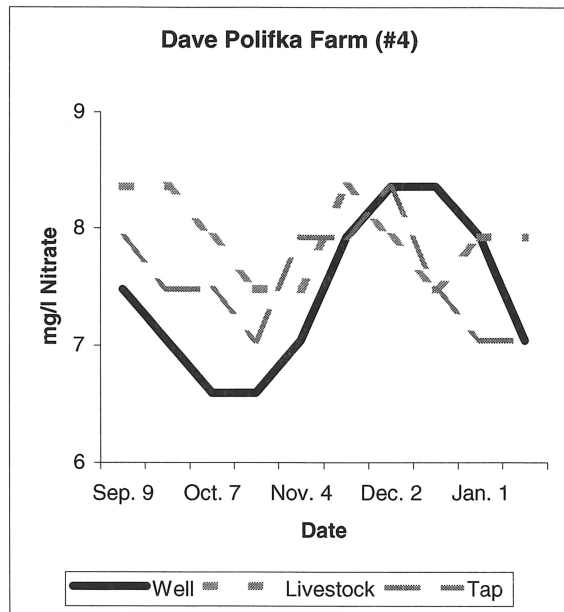


Figure 4. Date of sample collection as a function of mg/L nitrate concentration for Farm #4.

Dave Polifka Farm: (mg/L)

Sep. 9:	Well-7.48	Liv.-8.36	Tap-7.92
Sep.23:	Well-7.04	Liv.-8.36	Tap-7.48
Oct. 7:	Well-6.60	Liv.-7.92	Tap-7.48
Oct.21:	Well-6.60	Liv.-7.48	Tap-7.04
Nov. 4:	Well-7.04	Liv.-7.48	Tap-7.92
Nov.18:	Well-7.92	Liv.-8.36	Tap-7.92
Dec. 2:	Well-8.36	Liv.-7.92	Tap-8.36
Dec.16:	Well-8.36	Liv.-7.48	Tap-7.48
Jan. 1:	Well-7.92	Liv.-7.92	Tap-7.04
Jan.23:	Well-7.04	Liv.-7.92	Tap-7.04

Well-	x=7.35 s=0.671 6.60, 7.04, 7.26, 7.92, 8.36
Liv.-	x=7.92 s=0.359 7.48, 7.48, 7.92, 8.36, 8.36
Tap-	x=7.57 s=0.454 7.04, 7.04, 7.48, 7.92, 8.36

Tim Miller Farm: (mg/L)

Sep. 9:	Well-4.18	Liv.-4.84	Tap-4.40
Sep.23:	Well-4.84	Liv.-5.28	Tap-4.40
Oct. 7:	Well-4.40	Liv.-5.28	Tap-3.96
Oct.21:	Well-5.28	Liv.-4.84	Tap-4.84
Nov. 4:	Well-5.28	Liv.-5.72	Tap-5.28
Nov.18:	Well-4.84	Liv.-5.72	Tap-5.28
Dec. 2:	Well-5.28	Liv.-5.28	Tap-4.84
Dec.16:	Well-4.84	Liv.-6.16	Tap-4.84
Jan. 1:	Well-4.18	Liv.-5.72	Tap-4.40
Jan.23:	Well-3.96	Liv.-4.84	Tap-4.40

Well-	x=4.66 s=0.425 3.96, 4.40, 4.62, 4.84, 5.28
Liv.-	x=5.37 s=0.454 4.84, 4.84, 5.28, 5.72, 6.16
Tap-	x=4.71 s=0.500 3.96, 4.18, 4.84, 5.28, 5.28

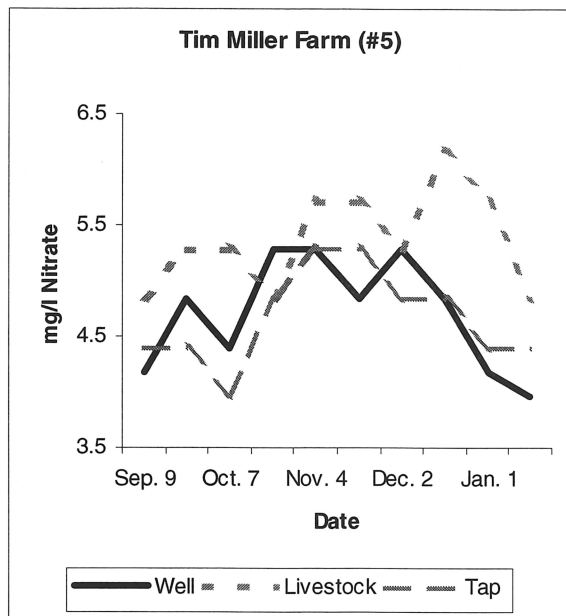


Figure 5. Date of sample collection as a function of mg/L nitrate concentration for Farm #5.

DISCUSSION

Nitrate concentration from a single source may reflect seasonal changes in moisture to plant growth. Therefore, "samples taken from January-March and in October are most likely to have the high values" (Christy and Smith, 1993). This particular study showed a slight drop in the mg/L nitrate concentrations in January instead of an increase.

Each of the farms showed similar trends in the mg/L nitrate concentration over the five-month period. The main trend was a gradual build to a peak in concentration in December, followed by a drop in the final samples taken in January. The livestock and tap samples followed this same trend for the most part, with exceptions in Farm #2 and Farm #4 (Fig. 2 and Fig. 4). Farm #1 had a decrease in the livestock and tap mg/L nitrate concentrations from Sep.23rd through Nov.4th. Farm #4 had a drop in concentration in the well, livestock and tap samples from Sep.9th through October 21st.

Analyzing the data from a statistical viewpoint, some significant variation is seen in the concentrations. The standard deviations and five-number summaries for the samples show that there is variation from the mean in the mg/L nitrate concentrations. The largest standard deviation seen was 0.815 for the well samples of Farm #2, where in particular the well showed a variation of nearly 3 mg/mL from the minimal to the maximal nitrate concentration.

Farms 2,3 and 4 all showed the highest mg/L nitrate concentrations of the group. These farms are within a 10-mile radius of each other along the Hackberry Creek. Farm 1 is 20 miles south of the three farms just mentioned. This farm had the lowest overall

concentrations of the group. Farm 5 is approximately 25 miles to the northeast of Farms 2,3 and 4. It had the second lowest overall concentrations of the five farms in this study. This suggests the possibility of location as a factor in the mg/L nitrate concentrations. Gove County is in a high-risk region for nitrate contamination according to a study carried out by the United States Geological Survey. The national risk map was "produced using an overlay analysis in a geographic information system" (Nolan 1996). Although the area where the samples were taken for this study is in a high-risk region, sampling and testing is required to depict actual nitrate contamination. Factors such as "land use, aquifer type, rainfall and irrigation amounts, and the timing of rainfall in relation to fertilizer and manure applications" will also have an effect on the actual contamination seen in a particular region (Nolan 1996).



Figure 7. Map of Northwest Kansas zoomed in to focus on Gove County and the three rivers south of Quinter. Farm 1 lies just off the Smoky Hill River. Farms 2 and 3 lie along the Hackberry River, and farm 4 lies near Big Creek. Farm number 5 is eight miles east of Quinter, on the outskirts of Collyer, KS.

The safe limit, as I stated in the introduction, has been set at 10mg/L. Farms 2 and 3 both contain numerous samples that exceeded the safe limit over the 5-month period. The highest concentration found was on Dec.16th in a sample taken directly from the well on the Farm #2 (Fig. 2).

In order to protect the tens of thousands of infants exposed to nitrate contaminated water every year the agricultural world has to make some changes. Farmers can continue to use nitrogen fertilizer, but they must stop overusing it. Farmers need to be educated on ways of improving the efficiency and consistency of nitrogen application. "Farmers can substantially reduce

nitrogen fertilizer use and better manage manure without reducing crop yield, and often while increasing profit" (Nolan, 1996).

ACKNOWLEDGEMENTS

The author wishes to thank Dr. Allan van Asselt and Dr. Tim Hubin for their help and guidance with this research. Thanks are also expressed to all of the science faculty who assisted in whatever means with the completion of this research. Lastly, a special thanks to the Stine Fund for providing the necessary funds to carry out this study.

LITERATURE CITED

- Christy, Marshall and George S. Smith. Nitrate and Water. Agricultural Publication. G9808. Oct. 1, 1993.
- Greater Risk Seen in Tainted Wellwater. Oct., 1996. Health. 10(6): 18.
- Jasa, Paul. 1998. Drinking Water: Nitrate-Nitrogen. Nebraska Cooperative Extension G96-1279-A (Revised November 1998).
- Nitrogen, Nitrate. 1973. DR-EL/2 Methods Manual. Hach Chemical Company.
- Nolan and others. 1996. Risk of Nitrates in Groundwaters of the U.S.- a National Perspective. Environmental Science and Technology. V31. N.8.
- Pouring It On: Nitrogen Use and Sources of Nitrate Contamination. Feb. 22, 1996. www.ewg.org.
- Powell, G.Morgan, Richard D. Black and John S. Hickman. Groundwater and Well Contamination. Water Quality. Aug., 1992.
- Water on Tap: A Consumer's Guide to the Nation's Drinking Water. 1997. United States Environmental Protection Agency Office of Water Publication Document No. EPA 815-K-97-002.