RESULTS OF GEORGIA DOMESTIC WELL WATER TESTING PROGRAM

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Abstract. Beginning in 1989, the University of Georgia Cooperative Extension Service began compiling a database to determine the extent and distribution of nitrate contamination of domestic wells in Georgia. From 1989-1996 approximately 7000 wells with a known depth were sampled and analyzed for 15 mineral elements plus pH, hardness and nitrate-nitrogen (NO_3-N). Water quality problems in decreasing frequency of occurrence were: iron and manganese, sodium, lead and copper, nitrate-nitrogen, phosphorus, chromium, cadmium and nickel.

INTRODUCTION

The University of Georgia Cooperative Extension Service, through its Agricultural Services Laboratories, has offered a water testing program since the early 1980's. In 1989 the University received funding from the USDA Extension Service Water Quality Initiative to test all water samples for nitrate-nitrogen and to begin building a database to document nitrate contamination of private domestic wells.

The data addressed in this paper includes 4,593 samples collected from 1992-1996 for which the well depth was specified on the water analysis submission form. Any well less than 100 ft deep was considered a shallow well. These wells were presumed to be drawing water from the surficial, water table aquifers. All wells that were 100 ft deep or deeper were categorized as deep wells.

The University of Georgia water testing program is offered primarily as a service to private well owners to insure safe drinking water. The routine analysis includes 15 mineral elements plus pH and hardness.

Water samples are generally collected by the client in a sample bottle available in each County Extension office. Along with the bottle, the client receives instructions for collection of the sample and a water sample submission form. Sampling instructions indicate that water samples are to be collected at the wellhead. In some cases, however, it appears that the water samples were collected inside the home. The submission form includes information about the location of the well, well depth (if known) and a description of any problems. The sampling usually represents a worst case situation. Since samples are submitted by homeowners suspecting a problem, they may not be truly representative of statewide water resources.

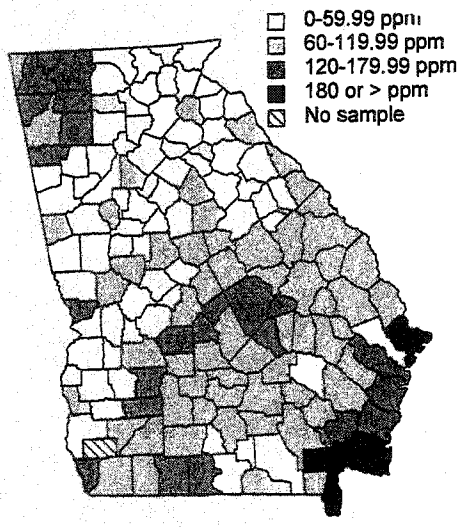

Figure 1. Summary of water hardness by category. Calculated hardness levels for all wells sampled were averaged by county.

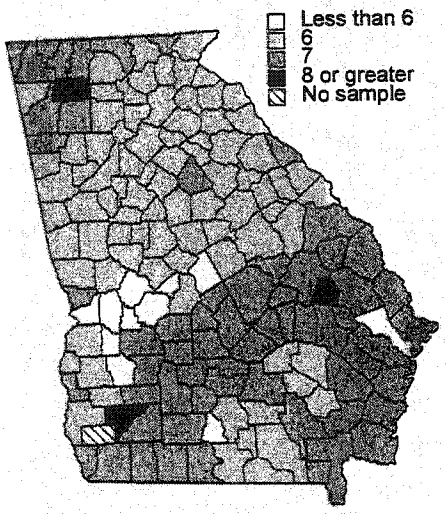

Figure 2. Average well water pH for all wells tested by county.

Table 1. pH of selected wells near the fall line.

Well	County	pH
Kaolin County	Wilkinson	4.6-5.1
City of Buena Vista	Marion	4.6-5.9
City of Perry	Houston	3.9-4.4
City of Irwinton	Wilkinson	4.5-5.2
Richmond County Water	Richmond	4.7-6.5
Packaging Corp. of America	Bibb	5.0-6.0

Data from John Donahue, Georgia Geologic Survey, Atlanta, GA, November, 1994.

RESULTS

Hardness

In general, well water in the state is soft to moderately soft (Figure 1). Samples collected in the Limestone Valley counties of Northwestern Georgia and coastal counties have hard water, >120 ppm $CaCO_3$ equivalent (Figure 1). The shallow wells of the Piedmont and Coastal Plain have relatively soft water (<60 ppm), while deep wells of the Coastal Plain fall into the moderately hard category.

Acidity

A summary of well pH is presented in Figure 2. Piedmont and Mountain counties have pH in the range of 6-7. West Central counties below the fall line have acidic water and, in general, the shallow wells of the Coastal Plain tended to be somewhat acidic (<6.0) (data not presented). Deep Coastal Plain wells tended to be neutral (pH 7-8) or slightly alkaline.

The acidity occurs naturally and results from the inability of the sandy aquifer sediments to buffer acidic rainwater and acid-producing reactions between infiltrating water and soil or sediment. The Georgia Geologic Survey indicated that the pH of municipal wells drawing water from the Cretaceous sands (oldest sediments deposited in the Coastal Plain region approximately 90 million years ago) in or near the outcrop area is also acidic (Table 1). Water from these municipal wells must be neutralized during the treatment process and prior to distribution.

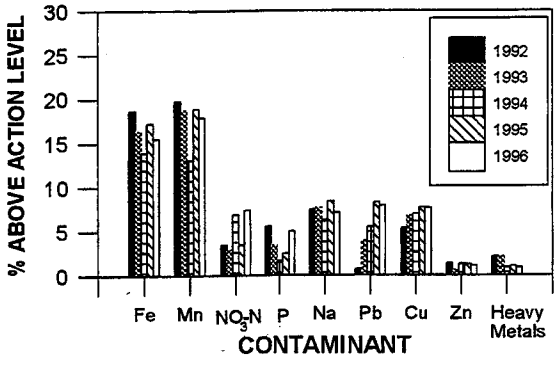

Figure 3. Incidence of occurrence of various water quality problems for all wells analyzed during 1992-1996. Action levels were: NO_3-N = 10 ppm; total P = 0.3 ppm; Pb = 0.015 ppm; Cu = 1 ppm; Zn = 5 ppm; Fe = 0.3 ppm; Mn = 0.05 ppm; Cd = 0.01 ppm; Cr = 0.05 ppm; Ni = 0.10 ppm; Na = 20 ppm.

Most frequent problems

Results of the 1992-1996 well water monitoring presented in Figure 3 highlight some water quality problems in decreasing order of occurrence, namely: iron and manganese, sodium, lead and copper, nitrate, phosphorus and the heavy metals (chromium, cadmium and nickel).

The five-year summary shows that elevated iron/manganese levels occurred in 13.9-18.7% for iron and manganese, respectively (Figure 3). These elements generally do not pose a health risk but can cause objectionable taste and odor problems. The incidence of elevated iron/manganese levels is more prevalent in deep than shallow wells (Figure 4).

Sodium in excess of the 20 ppm guidance level was found in 6.3-8.4% of the well samples (Figure 3). It was more prevalent in deep wells than shallow wells (Figure 4) and may reflect the presence of a water softener in some systems. Sampling instructions indicate that water samples are to be collected at the wellhead. In some cases, however, it appears that the water samples were collected inside the home.

Excessive lead and copper concentrations in well water were found in 0.7-8.4%. EPA reviews have suggested that excessive lead levels may retard mental and physical development. One major source of lead and copper is the result of acidic water corroding metal pipes and other plumbing components installed prior to 1986. The first symptoms of acidic water usually appear in the form of stains in toilets, sinks and other fixtures. The color of the stains will depend on the kind of metal being attacked -- green or blue stains from copper and red or brown stains from iron. If the corrosion is allowed to continue, the metal will slowly be eaten away, and the system will ultimately fail.

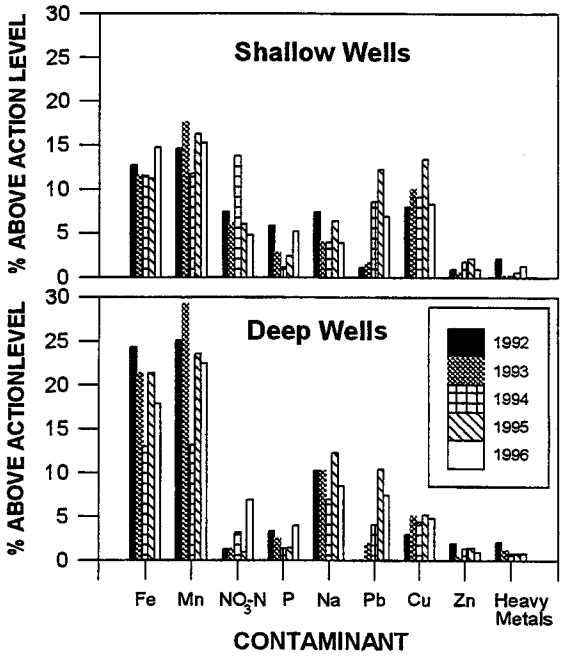

Figure 4. Incidence of occurrence of water quality problems (1992-1996) as a function of well depth (deep = > 100 ft, shallow = < 100 ft).

The increased incidence of lead and copper from 1992-1994 (Figures 3 & 4) reflects increased public awareness and the increased proportion of samples collected in acidic water regions near the Georgia fall line (Table 1, Figure 4).

Nitrate-Nitrogen

Well water monitoring results indicate that 2.9-7.4% of all wells tested contained elevated levels (>10 ppm) of nitrate-nitrogen, with greater occurrence in shallow wells than in deep wells (Figures 3 & 4). The most common sources of groundwater nitrates are septic systems and animal wastes. Follow-up investigations of heavily contaminated wells usually revealed a source near the well.

Nitrate levels in wells from an intensive 15-county survey from various areas of the state revealed that the majority (>60%) of all wells contained <3 ppm nitrate-nitrogen. In general, sampling from Coastal Plain counties (Marion, Mitchell, Sumter, Taylor, Coffee) showed low nitrate-nitrogen levels in both shallow and deep wells. The Piedmont counties, characterized by long-term confinement animal agriculture, tended to have a higher incidence of nitrate-nitrogen above 3 ppm and greater average values than the Coastal Plain counties.

Results of the 15-county survey (Table 2) show that intensive agriculture may have an impact on shallow groundwater resources. Confinement livestock operations such as swine, dairy, beef and poultry operations may produce elevated nitrate-nitrogen levels (> 3 ppm) on the farm. This points out the need for nutrient management plans to minimize the potential for off-site nutrient movement. The farm's nutrient management plan should be re-evaluated and adjusted when results of well water analysis reveal the presence of nitrate approaching or greater than 10 ppm.

Phosphorus and Heavy Metals

Total phosphorus levels were above 0.3 ppm levels in 1.7-5.6% of the samples. Total phosphorus levels of >0.3 ppm were taken as indicative of surface water or septic tank drainage contamination. Elevated phosphorus levels were equally distributed between shallow and deep wells and follow-up site visits usually indicated that the primary source of elevated phosphorus was poor wellhead protection or deteriorating well casings. Trace quantities of heavy metals (chromium, cadmium and nickel) were found in occasional samples (0.9-2.1%) from around the state and were attributable to local point sources of contamination (heavy industry and landfills).

Table 2. Mean Nitrate Levels by Use*

Use	No. of Samples	Mean Nitrate (ppm)
Swine	68	5.36
Other[1]	155	4.13
Dairy	20	4.12
Poultry	257	3.69
Beef	197	2.54
Unknown[2]	8	2.43
Irrigation	40	2.21
Household	309	1.44

* Includes only those counties which participated in the 15-county survey by submitting at least 25 samples. Database uses "Household" as a single use only and includes data for all uses (including "unknown" and "other").
[1]Other = Uses listed as "Horses", "Goats", "Fill Spray Tanks", "Farm Use", "Store", "Nursery", "Dog Kennels", "General Farm", "Lambs", "Other".
[2]Unknown = No "USE" listed on the paperwork received with the sample.
This data is a summary of the 15-county survey and does not reflect all analyses conducted by the Agricultural Services Laboratories.

Table 3. Summary of detection limits and action levels for well water sample analysis.

Parameter	ND Level (ppm)	Action Level (ppm)	Water Quality Standard
Nitrate-nitrogen	≤ 0.20	≥ 10.0	Primary
Phosphorus	≤ 0.05	≥ 0.30	*
Lead	≤ 0.002	≥ 0.015	Action Level
Aluminum	≤ 0.025	≥ 200.0	Secondary
Zinc	≤ 0.005	≥ 5.00	Secondary
Copper	≤ 0.005	≥ 1.00	Secondary
Iron	≤ 0.005	≥ 0.30	Secondary
Manganese	≤ 0.005	≥ 0.05	Secondary
Cadmium	≤ 0.005	≥ 0.01	**
Nickel	≤ 0.015	≥ 0.10	Primary
Chromium	≤ 0.023	≥ 0.05	**
Chloride	≤ 0.10	≥ 250.0	Secondary
Fluoride	≤ 0.50	≥ 1.00	**
Sulfate	≤ 0.20	≥ 250.0	Secondary
Sodium	≤ 1.00	≥ 20.0	Secondary

* Water quality parameter but no limit is given. A value of 0.3 was used based on analytical experience.
**Values for cadmium, chromium and fluoride have been changed to 0.005, 0.1, and 2.00 ppm, respectively. Values presented in the table were used in this summary.

CONCLUSIONS AND RECOMMENDATIONS

Farm wells should be routinely tested for nitrates. Shallow wells drawing water from water table aquifers (< 100 ft) should be tested at least once a year. Deeper wells tapping confined aquifers should be checked at least every three years.

ACKNOWLEDGMENTS

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