WATER QUALITY IN GEORGIA'S PRIVATE DRINKING WATER WELLS

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Abstract. The University of Georgia's Agricultural and Environmental Services Laboratories (AESL) conduct a water-testing program for private drinking water wells. In a review of over 27,000 tests done during the ten years from 1993 through 2004, the most common problems were low pH (data not shown), and high levels of manganese and iron. Approximately 15 and 18% of the household wells tested had iron and manganese levels above the EPA's secondary drinking water standards of 0.3 and 0.05 ppm, respectively. As primarily a consequence of pipe and fixture corrosion caused by low pH, alkalinity, and ionic strength waters, 4 and 6% of the samples had copper and lead levels above 1.3 ppm and 15 ppb, the EPA maximum contaminant levels (MCL) for copper and lead, respectively. Four percent of the samples tested had nitrate-N levels above the EPA's MCL of 10 ppm. High nitrate levels appear more often in shallow groundwater and may be a result of poor wellhead protection. Bacterial tests on 1413 well water samples submitted from 2002 to 2004 indicated about 41 and 7% of the wells had positive detections for total coliform bacteria and *E. coli*, respectively.

INTRODUCTION

Groundwater is important to the life, health, and economy of Georgia. Extension education programs for protecting private drinking water supplies need to be focused on the most significant problems encountered with Georgia groundwater. The University of Georgia Agricultural and Environmental Services Laboratories (AESL) provide analytical services to the public through the Cooperative Extension Service. One of the many services provided is testing the quality of the water from private household wells used for drinking.

In 1997, Bush et al. published a review of the water testing done by the University of Georgia's Agricultural and Environmental Services Laboratories. In that report, they identified water quality problems in decreasing frequency of occurrence: iron and manganese, sodium, lead and copper, nitrate-nitrogen, phosphorus, chromium, cadmium, and nickel. Vendrell et al. (2001) published a report on the relationship between iron and nitrate. They suggested that iron and nitrate-N are mutually exclusive in the ground waters of Georgia.

The present report summarizes the water quality chemical parameters of well water samples submitted by clients to AESL during the period 1993-2004. This serves as an update to the summary presented by Bush et al. (1997) along with additional information on the microbiology of Georgia groundwaters.

METHODS

Well water samples, submitted through the County Extension offices, were from the major land resource areas or provinces of Georgia that include Blue Ridge, Limestone Valley, Southern Piedmont, Atlantic Coast Flatwoods, Southern Coastal Plain and Sand Hills (Figure 1). There were a total of 27,047 well water samples for chemical and about 66% of the samples originated from the Southern Piedmont province (Tables 1 and 2). Well water samples were tested for chemical parameters that include both the primary and secondary inorganic contaminants. The Environmental Protection Agency (EPA) classified primary contaminants as those that may cause acute disease or long-term health effects: cadmium (Cd), chromium (Cr), copper (Cu), fluoride (F), lead (Pb), and nitrate (NO_3) are examples of primary contaminants determined at AESL. The secondary contaminants are defined as those chemicals that cause objectionable odors, tastes, staining, corrosion, or other aesthetic problems that do not generally pose a health risk, e.g., aluminum (Al), chloride (Cl), iron (Fe), manganese (Mn), sulfate (SO_4), and zinc (Zn). Lead was measured using the atomic absorption graphite furnace (Perkin-Elmer 4100 ZL) and nitrate was measured in a Dionex DX-100 ion chromatograph. All other elements were quantified using an inductively coupled plasma emission spectrophotometer (ICPES, Thermo Jarrel-Ash 61E). Bacterial enumeration was conducted on water samples obtained within 24 hours following collection. The samples were collected in sterile containers provided to the clients by AESL. References for the methodologies

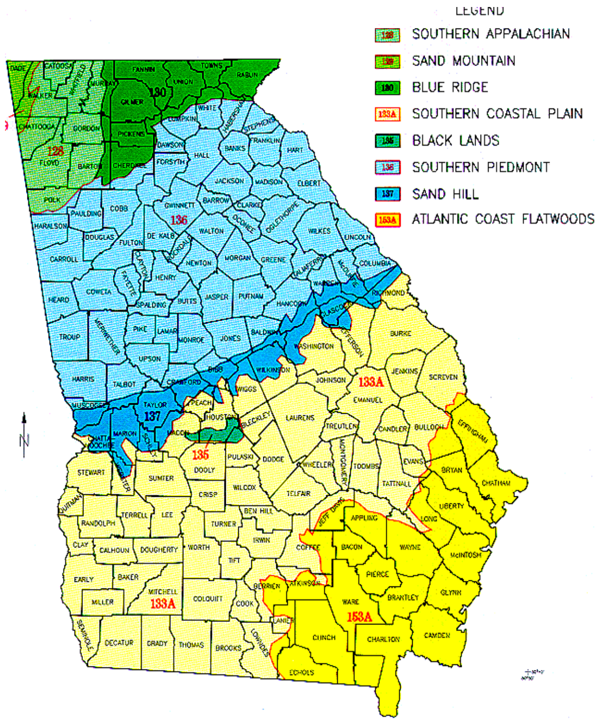

Figure 1. Major land resource areas or provinces of Georgia (source: U.S. Department of Agriculture).

Table 1. Number of well samples from the major land resource areas of Georgia for primary chemical contaminants.

Province*	Contaminants tested for				
	Cr	Cu	Pb	NO_3	F
SP	17710	17710	4861	3571	1177
SCP	4567	4568	1307	1432	412
BR	2481	2481	478	257	146
ACF	1237	1237	327	139	91
LV	514	514	234	121	43
SH	537	537	137	117	37
Total	27046	27047	7344	5637	1906

* SP = Southern Piedmont; SCP = Southern Coastal Plain; BR = Blue Ridge; ACF = Atlantic Coast Flatwoods; LV = Limestone Valley; SH = Sand Hills.

Table 2. Number of well samples from major land resource areas of Georgia for secondary chemical contaminants.

Province*	Contaminants tested for					
	Al	Fe	Mn	Zn	SO_4	Cl
SP	16944	17710	17710	17710	2300	2281
SCP	4415	4568	4568	4568	641	617
BR	2391	2481	2481	2481	263	250
ACF	1199	1237	1237	1237	133	130
LV	497	514	514	514	78	68
SH	511	537	537	537	67	61
Total	25957	27047	27047	27047	3482	3407

* SP = Southern Piedmont; SCP = Southern Coastal Plain; BR = Blue Ridge; ACF = Atlantic Coast Flatwoods; LV = Limestone Valley; SH = Sand Hills.

used by the AESL can be found on the web at *http://aesl.ces.uga.edu/methods/stl-water.html*

RESULTS AND DISCUSSION

Primary Contaminants

Results of a ten-year (1993-2004) well water chemical analysis indicate that nitrate, lead, and copper were the important primary contaminants found in Georgia well waters (Fig. 2-A). Nitrate-N in excess of MCL (10 ppm) was found in 1-8% of the well samples, with greater occurrence in the provinces of Limestone Valley and Sand Hills. The Sand Hills region occurs along the Coastal Plain - Piedmont boundary underlain by Cretaceous and Tertiary deposits with abundant sand. The predominance of sand makes the latter province vulnerable to pollution from various sources including from adjacent Piedmont counties where long-term animal confinement agriculture exists. Some other potential sources of well water nitrate include leakage or leaching from septic tanks, sewage, and runoff from fertilizer use.

About 2 to 8% of well water samples had lead and copper concentrations above MCL, with greater occurrence in water samples originating from Southern Piedmont and Sand Hills. Elevated levels of lead and copper could be due to corroded household plumbing and/or from erosion of natural deposits. Corrosion of pipes results when water is acidic. Although some water samples tested positive for chromium and fluoride, all values were below the MCL.

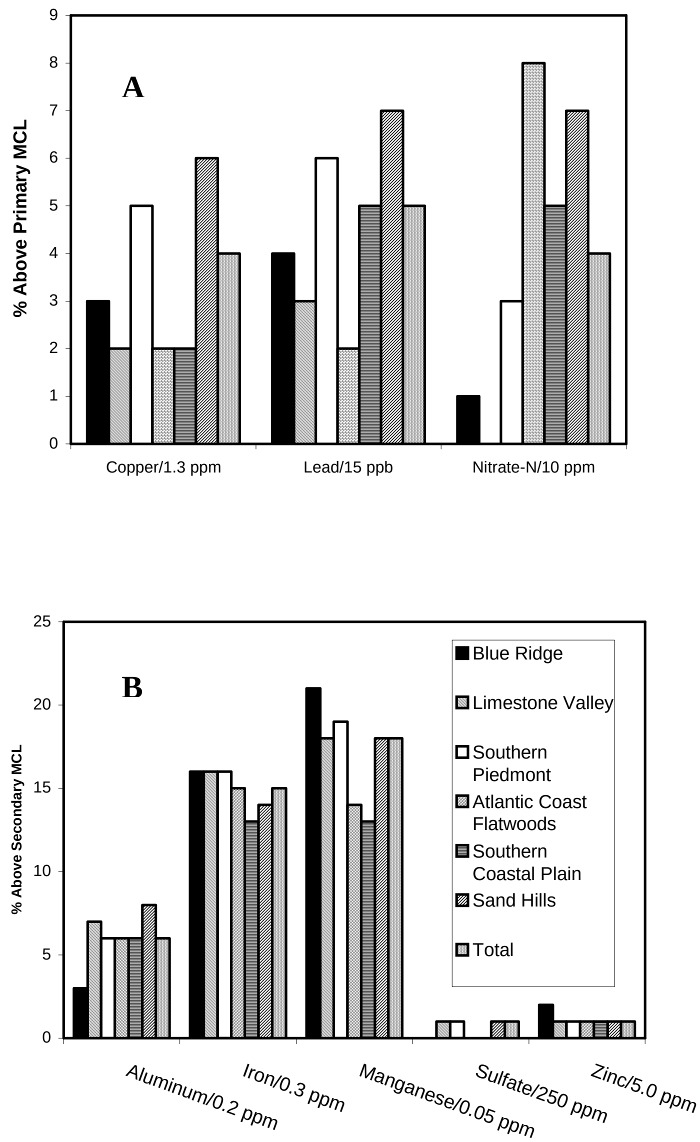

Figure 2. Primary (A) and secondary (B) water quality parameters that tested above MCLs. Maximum contaminant levels for primary and secondary contaminants follow EPA's primary and secondary water quality standards, respectively. MCLs are given opposite each contaminant.

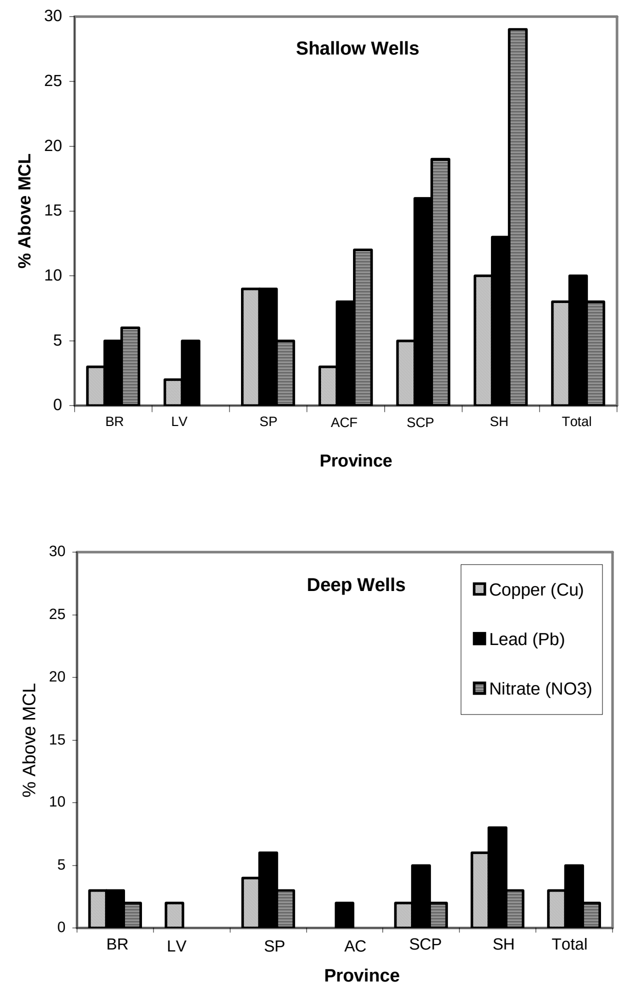

Figure 3. Occurrence of primary contaminants above MCLs in water samples collected from shallow (<100 ft.) and deep (>100 ft.) wells in various hydrogeologic provinces of Georgia. Provinces are: BR = Blue Ridge; LV = Limestone Valley; SP = Southern Piedmont; AC = Atlantic Coast; SCP = Southern Coastal Plain; SH = Sand Hills.

Secondary Contaminants

The ten-year summary indicates that manganese and iron proved to be the most common secondary water quality problems in groundwaters of Georgia (Fig. 2-B). Elevated manganese concentrations (>0.05 ppm) were detected in some well water samples from all Georgia provinces, with greater occurrence in Blue Ridge province. About 15% of the total wells tested showed iron at levels higher than the secondary MCL (0.30 ppm). Both iron and manganese do not pose a health risk but can cause reddish to brownish stains on objects. Aluminum was also detected in about 6% of the well water tested. According to Donahue (1998), iron, manganese, and aluminum are the three naturally occurring substances responsible for the greatest incidence of groundwater quality problem in Georgia.

Contaminants vs. Well Depth

Figure 3 shows that the occurrence of primary contaminants in groundwater was greater in shallow wells

(<100 ft.) compared to deep wells (>100 ft.). About 5 to 15% of the shallow wells tested showed copper levels above the MCL. High levels of nitrate were also noted in shallow wells particularly in the provinces of Southern Coastal Plain and Sand Hills, with 28% of the samples from Sand Hills containing nitrate greater than the 10 ppm NO_3-N MCL. A study by Bush et al. (1997) showed that nitrate-N above MCL occurred more frequently in Piedmont province with wells less than 100 ft deep, and this was attributed to confined animal agriculture in the area. Since most nitrate sources are or near the land surface, it is likely that shallow aquifers are more prone to contamination than deep aquifers. In sandy areas, the shallow wells are susceptible to rapid infiltration of potential pollutants from the ground surface.

Total Coliform and *Escherichia coli* in Water

Total coliform bacteria are commonly found in the environment (e.g., soil or vegetation) and are a natural part of the microbiology of the intestinal tract of warm blooded mammals, including man. The presence of total coliform bacteria is not a health threat in itself but it is used to indicate whether other potentially harmful bacteria may be present. When ***Escherichia coli*** *(E. coli)* is present in water, there is a strong indication of recent sewage or animal waste contamination and therefore, the threat of water-born organisms that cause illness increases appreciably.

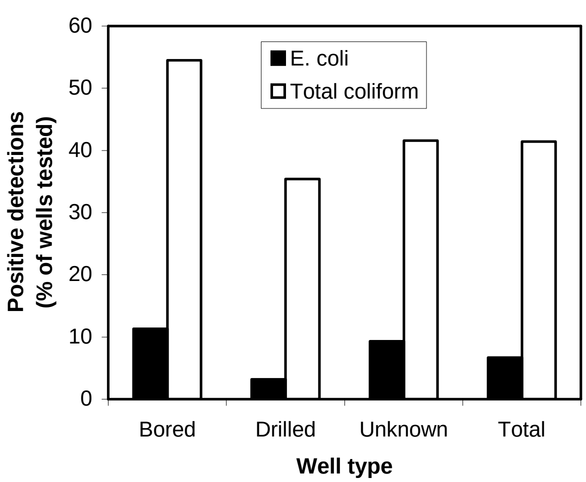

Figure 4. Occurrence of bacteria in different types of wells. Water samples from unidentified well type are categorized as unknown.

Summary of well water bacterial analysis from 2002 to 2004 showed that total coliform bacteria was positively detected in about 41% of the wells tested while 7% of the wells tested positive for *E. coli*. Total coliform was higher in bored (~55%) compared to drilled (~38%) wells (Fig. 4). Bored wells are usually shallow (less than 50-75 ft deep) and, thus prone to contamination by surface activities.

SUMMARY AND CONCLUSIONS

A ten-year well water quality analysis indicates that nitrate, lead, and copper, are the important primary contaminants found in Georgia well waters, which are attributed to factors like animal agriculture (for nitrate), and corrosion due to low pH, alkalinity, and ionic strength waters (for lead and copper). Among the secondary contaminants, iron and manganese occurrence in well water samples is prevalent. Total coliform and E. coli were detected in some wells tested, and bored wells appeared to be more vulnerable to contamination than drilled wells. Presence of bacteria in wells may be biased low due to a client testing the same well repeatedly, initially and again after disinfection.

The presence of inorganic and bacterial contaminants in well waters tested warrants a continuing effort on water testing of private household wells. Bush et al. (1997) recommends yearly testing for nitrate in shallow wells (<100 ft.). It is imperative to increase public awareness of water quality conditions and provide opportunities for participation and involvement. It is only through a concerted and coordinated effort by all entities (general public and government/private agencies) that ground water resources may be properly protected and preserved.

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