New Jersey Geological Survey — Information Circular




Arsenic in New Jersey Ground Water

***A**rsenic (As) is a toxic element that is known to pose a risk of adverse health effects in people who consume water containing it. These impacts include, but are not limited to, cancer of the skin, bladder, lung, kidney, nasal passages, liver and prostate (USEPA, 2001). Because of these health concerns, the United States Environmental Protection Agency (USEPA) has lowered the drinking water standard for arsenic in public water supplies from 50 mircrograms per liter (ug/l) to 10 ug/l effective January 23, 2006. The New Jersey Department of Environmental Protection (NJDEP) has adopteded a lower standard of 5 ug/l to protect the public health. The statewide standard will apply to both public and non-public water systems and also become effective January 23, 2006.*

Introduction

Ground-water-quality data from the New Jersey Ambient Ground-Water Quality Network, Public Water Supplies and other studies in New Jersey reveal that arsenic concentrations in ground water are highest in the Piedmont Physiographic Province (fig. 1). In New Jersey, the Piedmont mostly includes a 195- to 225-million-year-old sediment-filled tectonic depression called the Newark Basin. This basin consists mainly of 3 water-bearing sedimentary bedrock formations that are gently folded and generally dip 5 to 15 degrees to the northwest. These rocks are locally faulted and interlayered with younger basaltic igneous rocks. From oldest to youngest the three major sedimentary formations are: (1) the Stockton, mainly comprised of arkosic sandstone, (2) the Lockatong, mostly black (organic rich) with some red, argillitic mudstone, siltstone and shale containing lenses of pyrite, and (3) the Passaic, mainly red hematitic mudstone, siltstone and sandstone interlayered with beds of black shale containing pyrite (fig. 2). Note: the term shale is used here for fine-grained sedimentary rock of the Passaic and Lockatong Formations. Detailed stratigraphic relationships, including the identification of specific members of the three principle formations in the Newark Basin, have been determined as part of the Newark Basin Coring Project (Olsen and others, 1996).

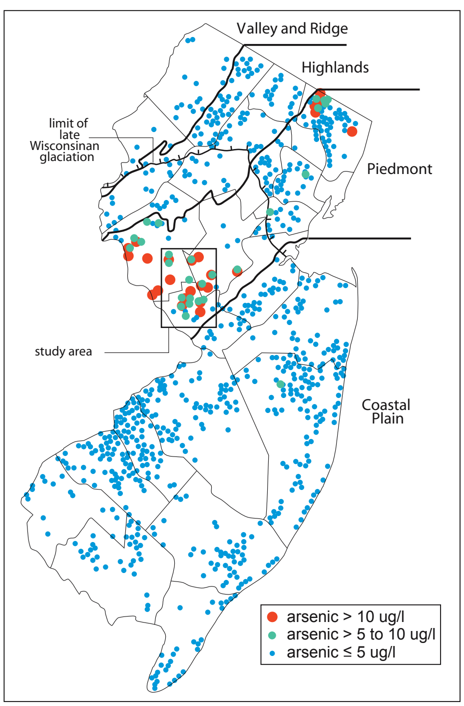

***Figure 1.** Location of study area and distribution of public community supply wells (shown by colored circles) in New Jersey.*

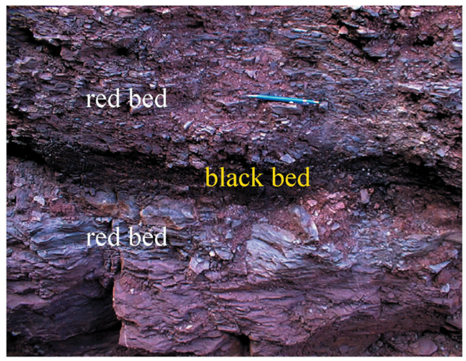

***Figure 2.** Outcrop showing metal-rich black shale between red beds in the Passaic Formation near Flemington, NJ. Blue pencil shown for scale.*

Domestic wells were randomly sampled in 2000 and 2001 in a 200-square-mile study area in the central part of the Newark Basin in western New Jersey. As shown on figures 1 and 3, arsenic concentrations in ground-water ranged from < 1 to 57 ug/l. For the purposes of water quality analysis, micrograms per leter (ug/l) is the same as parts per billion (ppb). Of the 94 wells sampled, 15 percent had arsenic concentrations exceeding 10 ug/l and 30 percent were greater than 5 ug/l (fig. 3 and 4). Water from the Passaic and Lockatong Formations had the highest arsenic concentrations and frequency of occurrence. Ground water with arsenic concentrations exceeding 10 ug/l generally had low dissolved oxygen (DO) concentrations (DO < 3 mg/L) and pH values range from 7.5 to 8.0 (fig. 5). Arsenic

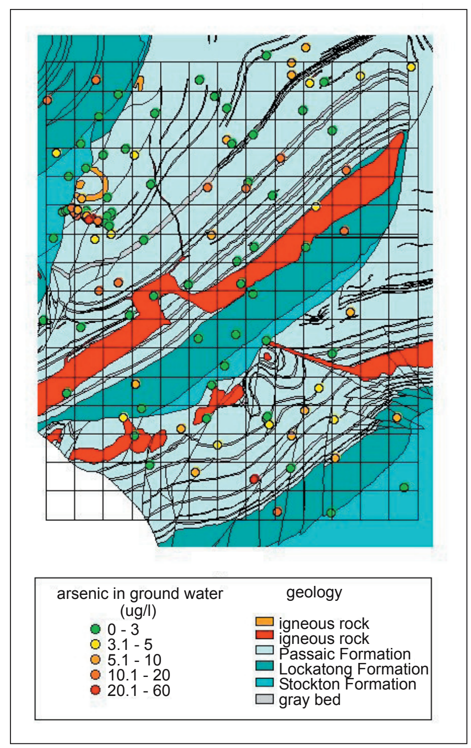

***Figure 3.** Geologic map of study area showing arsenic concentration ranges in water from domestic wells sampled on a 1-square-mile grid.*

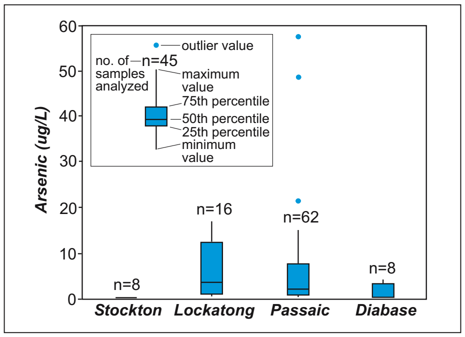

Figure 4. *Box and pin diagram showing arsenic concentration of geologic formations in study area.*

concentrations in water greater than 40 ug/l are associated with suboxic (DO < 1.0 mg/L) or nearly suboxic ground water. Subsequent analyses have identified 3 localized areas of ground water with as much as 90, 120 and 215 ug/l arsenic in each.

Potential Arsenic Source(s)

Potential sources for the regional occurrence of arsenic in ground water in the Newark Basin are arsenical pesticides and natural minerals in bedrock. Arsenical pesticides were widely used in this country, including New Jersey, from the late 1800's until the middle to late 1900's (Murphy and Aucott, 1998). The greatest use in New Jersey was in fruit orchards (NJDEP, 1999). Arsenical pesticides are not very water soluble and bind tightly to soil particles. Studies in North Dakota, South Dakota, Wisconsin and Minnesota all conclude that ground water is largely unaffected by past arsenical pesticide use (Welch and others, 2000). Therefore, arsenic from arsenical pesticides is generally not very mobile in soils and not a major source in ground water.

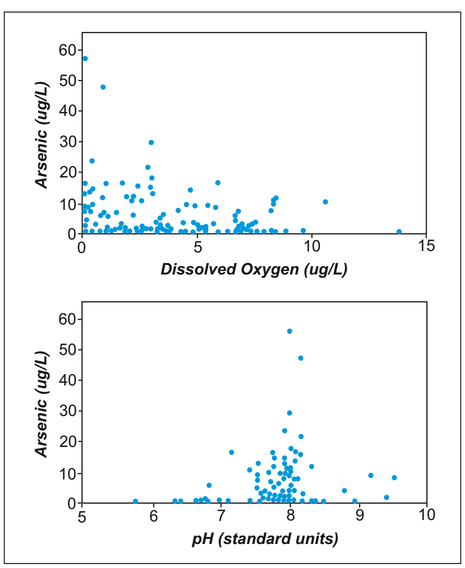

Figure 5. *Arsenic concentration versus dissolved oxygen and pH in ground water from study area. Based on data from all the formations sampled.*

Whole rock geochemical analyses conducted by the New Jersey Geological Survey (NJGS) showed that arsenic concentrations decreased from black to gray to red shale. Maximum concentrations found were 130, 50 and 13 parts per million (ppm) in the black, gray and red shale, respectively. Electron microprobe analysis of the black shale identified the mineral pyrite (FeS_2) as the major source of arsenic. Pyrite in two different black shale members of the Passaic Formation was shown to have maximum arsenic concentrations of 40,000 and 3000 ppm (fig. 6). A spatial relationship between arsenic concentrations greater than 40 ug/l in well water and the local occurrence of black shale has been observed in the Lockatong and Passaic Formations.

Therefore, the regional occurrence of arsenic in ground water is natural. Pyrite is the most significant mineral source of arsenic; however, hematite (Fe_2O_3) and clay minerals in red shale may also be sources. Three mechanisms for arsenic mobilization are likely (1) oxidation of pyrite, (2) release of arsenic from hematite and clays by desorption, and (3) dissolution of hematite. Pyrite oxidation is expected to be most significant in the shallow subsurface system in the unsaturated zone and at the water table where DO is generally readily available. Here, mobilized arsenic would follow the local ground water flow path, potentially recharging the deeper ground-water system via water-bearing zones. Arsenic may be mobilized from hematite and clay minerals under chemically alkaline and reducing conditions and during competitive adsorption with other ions. An alkaline pH and low DO (more reducing) aqueous environment is associated with high arsenic concentrations in water in the Newark Basin (fig. 5). NJGS continues to investigate this problem to determine vulnerable areas.

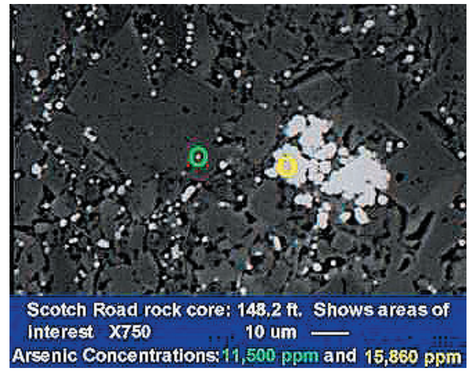

Figure 6. *Electron micrograph at 750 times magnification showing pyrite (light) and calcite (dark). Green and yellow circles show pyrite grains with 11,500 ppm 15,860 ppm arsenic respectively. Rock has 130 ppm As. (Core sample courtesy Zoltan Szabo, USGS).*

Sources of Information

EPA, 2001, Technical Fact Sheet: Final Rule for Arsenic in Drinking Water: EPA 815-F-00-016: www.epa.gov/safewater/ars/ars_rule_techfactsheet.html, 1 p.

Murphy, E.A. and Aucott, M., 1998, An assessment of the amounts of arsenical pesticides used historically in a geographical area: The Science of the Total Environment: v. 218, p 89-101.

Olsen, P.E., Kent, D.V., Cornet, B., Witte W.K., and Schlishe, R.W, 1996, High–resolution stratigraphy of the Newark rift basin (early Mesozoic, eastern North America), GSA Bulletin, January 1996 v. 108, p. 40-77.

NJDEP, 1999: Findings and recommendations for the remediation of historic pesticide contamination: Final Report March 1999, 43 p.

Welch, A.H., Westjohn, D.B., Helsel, D. R., Wanty, R. B., 2000, Arsenic in ground water in the United States: Occurrence and Geochemistry: Ground Water v. 38.no. 4, p. 589-604

STATE OF NEW JERSEY

Richard J. Codey, *Acting Governor*

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Bradley M. Campbell, *Commissioner*

Land Use Management

Ernest P. Hahn, *Assistant Commissioner*

New Jersey Geological Survey

Karl Muessig, *State Geologist*

Prepared by Michael Serfes - 2004

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Indicators Research

Comments or requests for information are welcome.
Write: NJGS, P.O. Box 427, Trenton, NJ 08625
Phone: 609-292-2576, Fax: 609-633-1004
Visit the NJGS web site @ www.njgeology.org

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