DISTRIBUTION OF ARSENIC IN THE ENVIRONMENT IN NEW JERSEY

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Abstract

Concentrations of arsenic have been measured in soils, streambed sediments, ground water, surface water, and drinking water in New Jersey over the past few decades as part of several U.S. Geological Survey (USGS) and other agency investigations with various objectives. Results of these studies indicate that arsenic concentrations vary spatially in all the sampled media and that both natural and human sources of arsenic in the environment may affect drinking-water quality. Arsenic concentrations in ground water, surface water, and drinking water rarely exceeded the previous Federal and State Maximum Contaminant Level (MCL) of 50 μg/L (micrograms per liter); however, the new Federal MCL of 10 μg/L will be exceeded in several public and many domestic drinking-water-supply wells in New Jersey. Arsenic-concentration data for environmental samples in some parts of New Jersey are scarce. Additional data as well as process-related studies will help to determine which human populations are most likely to be exposed to arsenic.

Introduction

Considerable data on arsenic concentrations in the environment have been collected during the past few decades as part of several investigations in New Jersey, but the spatial distribution of arsenic in relation to hydrogeologic and land-use factors has not been determined. Arsenic typically occurs naturally at low concentrations in the environment but occasionally may be present at concentrations greater than the Federal and State soil cleanup criterion of 20 mg/kg (milligrams per kilogram) and the new drinking-water MCL of 10 μg/L. Concentrations measured in environmental samples indicate that historical arsenic use has resulted in elevated concentrations of arsenic in soils, stream sediments, surface water, ground water, and drinking water. This paper presents some of the available information on the distribution of arsenic in New Jersey and indicates the need for additional studies that will enable investigators to determine the relation between the presence of arsenic in the environment and in drinking water.

Distribution of Arsenic in the Environment

Arsenic use

Arsenic was used in New Jersey as a pesticide on cropland, turf, and golf courses. From 1900 to 1980, about 49 million pounds of lead arsenate and 18 million pounds of calcium arsenate were applied to soils (Murphy and Aucott, 1998). Estimates of total arsenical pesticide applications for each county (fig. 1) indicate that the largest amounts of arsenic were applied in counties in the Coastal Plain, in the southern part of the State.

Soils and streambed sediments

Concentrations of arsenic and other trace elements in soils and streambed sediments (fig. 2) were measured as part of the National Uranium Resource Evaluation (NURE) program conducted by the U.S. Department of Energy in the late 1970's (Grosz and others, 2000). Some

concentrations exceeded 20 mg/kg, especially in samples from the northeastern part of the Coastal Plain. Stream-sediment and soil samples also were collected and analyzed for arsenic in a project conducted cooperatively by the USGS and NJDEP. Concentrations of arsenic in streambed sediments differed significantly among physiographic provinces. Results of logistic-regression analysis indicate that the presence of arsenic in streambed sediments is related to agricultural land use (O'Brien, 1997, p. 4). Results of chemical fingerprinting to determine the possible sources of arsenic in soils in an area in the east-central Coastal Plain indicate that arsenic concentrations greater than 20 mg/kg occurred naturally in clays, but that concentrations of this magnitude in sandy soils were a result of agricultural pesticide use or waste disposal from a nearby industrial site (Barringer and others, 1998).

Ground water

Concentrations of dissolved arsenic in water samples collected by the USGS from more than 2,000 wells (fig. 3) varied among four major aquifer types—unconfined Coastal Plain, confined Coastal Plain, bedrock, and glacial. Concentrations of arsenic in ground water typically are less than 2 μg/L, but arsenic may occur naturally at concentrations greater than 50 μg/L. Arsenic concentrations commonly exceeded 5 μg/L and in some instances exceeded 10 μg/L in water from wells open to the fractured bedrock aquifers in the Piedmont Physiographic Province, where arsenic is present naturally in the black shale (Szabo and others, 1997) (Surfes and others, 2000). Concentrations of arsenic greater than 50 μg/L in ground water typically are associated with known contamination sites. Water samples collected from wells along the industrial corridor adjacent to the Delaware River also contained arsenic at concentrations greater than 10 μg/L.

Surface water

Arsenic in surface-water samples may be derived from suspended sediments resulting from natural weathering of soils and sediments such as glauconitic sands and clays. Arsenic in surface water also may result from human activities, such as application of arsenical pesticides in agricultural areas. Concentrations of arsenic in whole-water samples collected by the USGS from streams varied among five major drainage basins (fig. 4). Arsenic concentrations in streamwater typically were less than 2 μg/L. The largest concentrations of arsenic were those detected in surface-water samples collected in the southern Coastal Plain downstream from a facility where arsenic was processed (D.E. Buxton, U.S. Geological Survey, written commun., 2001).

Drinking water

Concentrations of arsenic reported by purveyors in point-of-entry water samples collected from community water supply facilities typically are less than 2 μg/L (J.B. Louis, New Jersey Department of Environmental Protection, written commun., 2001). Of all the facilities that distribute water from ground-water sources, the average arsenic concentration in water from seven equaled or exceeded 10 μg/L and that in water from one equaled 50 μg/L. Most of the ground-water-supply facilities with water containing arsenic at concentrations greater than 10 μg/L obtain their water supply from bedrock aquifers in the Piedmont Physiographic Province. The average concentration of arsenic in water from all facilities that distribute water from surface-water sources was less than 10 μg/L.

Research Needs

In order to refine the knowledge of the distribution of arsenic in New Jersey and to determine the relation of arsenic in the environment to that observed in drinking water,

- methods need to be developed to relate the distribution of arsenic in surface and ground water to hydrogeologic and land-use factors;
- available data on arsenic concentrations in soils and streambed sediments need to be related to hydrogeology and land use, and additional samples need to be collected to ascertain whether arsenic concentrations are decreasing as a result of the reduction in use of arsenical pesticides;
- additional sampling and chemical and mineralogical analyses of various types of aquifer materials are needed to quantify the natural distribution of arsenic;
- methods of chemical fingerprinting of water-quality samples need to be developed to ascertain the source(s) of arsenic in water supplies;
- studies need to be developed to investigate the processes by which naturally occurring arsenic in soils and sediments and arsenic added to the environment as a result of human activities is mobilized; and
- information on arsenic in the environment needs to be shared with public health officials and epidemiologists who study the effects of arsenic exposure on human health.

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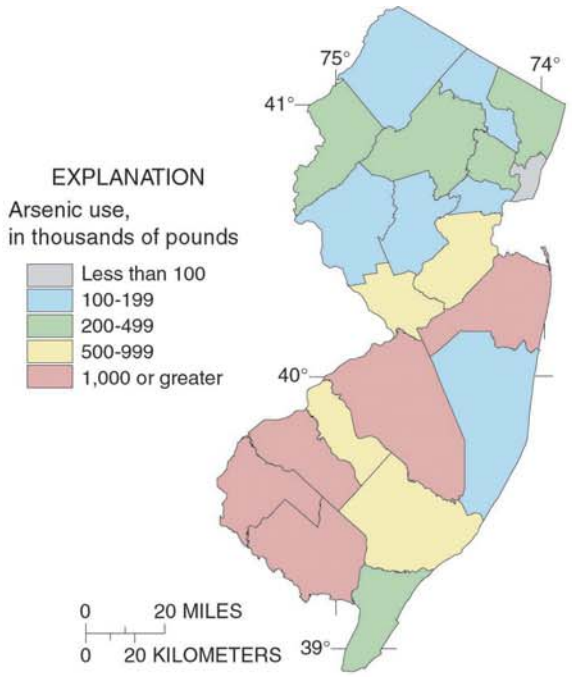

Figure 1. Estimated arsenic use in New Jersey, 1900-80. (Data from Murphy and Aucott, 1998)

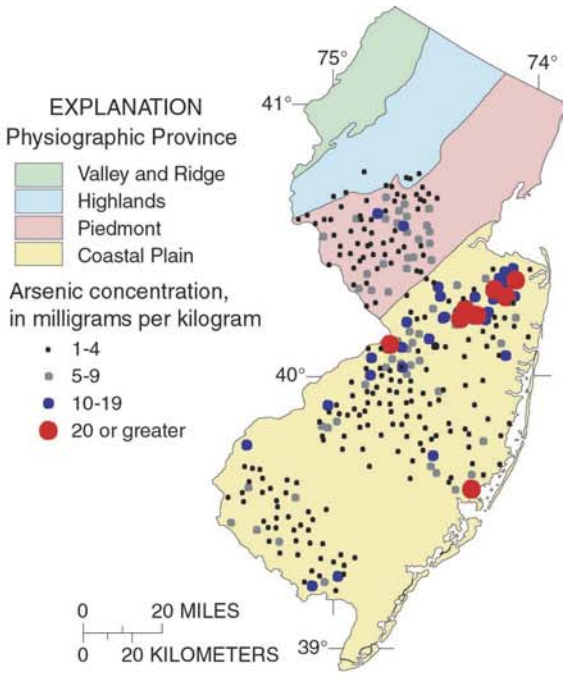

Figure 2. Distribution of arsenic in soils and streambed sediments in New Jersey, by physiographic province. (Data from National Uranium Resource Evaluation Program database (Grosz and others, 2000))

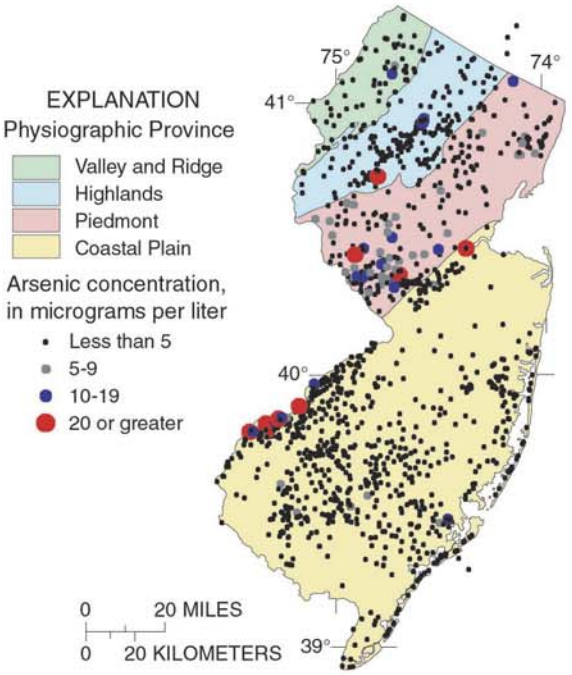

Figure 3. Distribution of concentrations of dissolved arsenic in ground water in New Jersey, by phsiographic province. (Data from U.S. Geological Survey National Water Information System database)

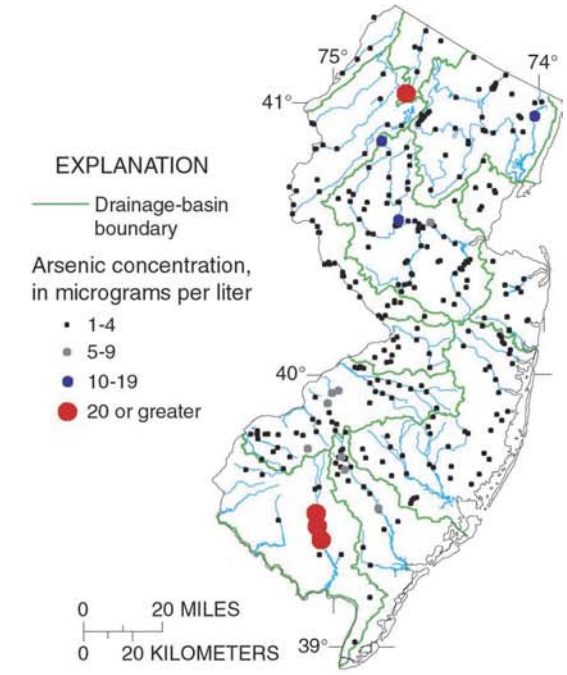

Figure 4. Distribution of concentrations of total arsenic in streams in New Jersey, by major drainage basin. (Data from U.S. Geological Survey National Water Information System database)