



# Mercury in ground water, septage, leach-field effluent, and soils in residential areas, New Jersey coastal plain

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Received 6 January 2005; accepted 25 May 2005

Available online 5 July 2005

## Abstract

Water samples were collected from domestic wells at an unsewered residential area in Gloucester County, New Jersey where mercury (Hg) concentrations in well water were known to exceed the USEPA maximum contaminant level (MCL) of 2000 ng/L. This residential area (the CSL site) is representative of more than 70 such areas in southern New Jersey where about 600 domestic wells, sampled previously by State and county agencies, yielded water containing Hg at concentrations that exceed the MCL. Recent studies indicate that background concentrations of Hg in water from this unconfined sand and gravel aquifer system are <10 ng/L. Additional sampling was conducted at the CSL site in order to better understand sources of Hg and potential Hg transport mechanisms in the areas with Hg-contaminated ground water.

At the CSL site, concentrations of Hg were substantially lower (although still exceeding the MCL in some cases) in filtered water samples than in the unfiltered water samples collected previously from the same wells. Surfactants and elevated concentrations of sodium, chloride, nitrate, ammonium, and phosphate in water from domestic and observation wells indicated septic-system effects on water quality; detections of sulfide indicated localized reducing conditions. Hg concentrations in septage and leach-field effluent sampled at several other households in the region were low relative to the contaminant-level Hg concentrations in water from domestic wells. Relations of Hg concentrations in leach-field effluent to iron concentrations indicate that reductive dissolution of iron hydroxides in soils may release Hg to the percolating effluent.

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**Keywords:** Mercury (Hg); Ground water; Septage; Leach-field effluent; Chloride (Cl); Dissolved organic carbon (DOC); Iron (Fe); Nitrate (NO<sub>3</sub>); Sodium (Na)

## 1. Introduction

Mercury (Hg) concentrations have been measured extensively in a variety of environmental media. Stud-

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ies have focused on both inorganic Hg and the more toxic methyl mercury (MeHg) in the atmosphere, in surface water (the recipient of atmospherically deposited Hg), and in various biota—particularly fish, which are considered the major source of Hg (as MeHg) to humans (USEPA, 1997).

Recent studies of Hg in soils, streams, lakes, and wetlands have advanced the understanding of the mobility and transformations of Hg in natural systems where aqueous concentrations of Hg commonly are <30 ng/L (e.g. Babiarz et al., 2000, 2003). Although Hg (II) is strongly complexed by Cl, it is preferentially complexed by dissolved organic matter (DOM), with hydrophobic S-bearing compounds providing strong binding sites (Ravichandran et al., 1998; Skyllberg et al., 2000, 2003; Drexel et al., 2002; Haitzer et al., 2002, 2003; Lamborg et al., 2003). In an anoxic environment, sulfide may control Hg behavior (Hurley et al., 1994; Wang and Driscoll, 1995; Benoit et al., 2001), although there are recent indications that Hg could complex more strongly with S-rich DOM than with sulfide (Ravichandran, 2004). The methylation of Hg by sulfate-reducing bacteria in various environmental settings can be inhibited by high concentrations of DOM and sulfide, or promoted by sulfate inputs (Gilmour et al., 1992; Barkay et al., 1997; Benoit et al., 1999; Jay et al., 2000; Hammerschmidt and Fitzgerald, 2004). MeHg in freshwater settings is taken up by organisms and biomagnified up the food chain to large predator fish that can become part of the human diet.

Human exposure to Hg in drinking water is estimated to be substantially less than exposure through fish consumption (USEPA, 2001). Ground water, an important source of drinking water, typically contains concentrations of Hg <10 ng/L (Krabbenhoft and Babiarz, 1992; Krabbenhoft et al., 1999; Reimann et al., 1999). Elevated concentrations of Hg in ground water have been linked to industrial contamination or mining activities (e.g. Srinanth et al., 1993; Somasundaram et al., 1993; Rytuba, 2000) and, rarely, to natural sources (e.g. Barber and Steele, 1980; Sidle, 1993).

Reports of concentrations of Hg in ground water in non-industrial developed areas are few. Hg concentrations in ground water underlying agricultural tile drainage systems in Sweden were generally <70 ng/L (two instances of 210 ng/L), with no apparent rela-

tion between Hg levels and soil texture or origin (Wiklander, 1969). Several ground-water samples from a developed area of Kansas were found to contain Hg concentrations that exceeded the MCL (Macfarlane et al., 1990). Incidences of high Hg concentrations in ground water from a large number of residentially developed areas have only been reported for southern New Jersey (Murphy et al., 1994; Barringer et al., 1997), to the authors' knowledge.

### 1.1. Previous studies of Hg in New Jersey

Concentrations of Hg in unfiltered water samples ( $Hg_u$ ) from about 600 domestic wells in at least 72 residential areas in southern New Jersey have been found by State and county agencies to exceed the USEPA and New Jersey maximum contaminant level (MCL) of 2000 ng/L (2  $\mu$ g/L) (Fig. 1). These contaminant-level concentrations, commonly between 2000 and 10,000 ng/L, have ranged as high as 72,000 ng/L. All instances of Hg contamination since discovery in the early 1980s to the present (2005) have been in water from the areally extensive (7770 km<sup>2</sup>) unconfined Kirkwood–Cohansey aquifer system of southern New Jersey's coastal plain. Aquifer materials were deemed unlikely to be the source of the Hg (Dooley, 1992). Resampling of selected affected wells with newly developed clean techniques (Murphy et al., 1994), and inter-laboratory comparisons of analytical results indicate that the high Hg concentrations were unlikely to have resulted from contamination during sample collection or analysis. Thus, these concentrations represent an environmental problem of unknown origin, as point sources of Hg could not be conclusively identified (Barringer et al., 1997). New instances of Hg contamination in samples collected by the US Geological Survey (USGS) from domestic and observation wells, using ultra-clean techniques, confirmed earlier indications that elevated Hg concentrations were present in water of degraded quality (typically high Cl and NO<sub>3</sub> concentrations) (Barringer et al., in press).

The Gloucester County Department of Health and Senior Services (GCHD), in a countywide investigation of Hg in drinking water, and the New Jersey Department of Environmental Protection (NJDEP), in a follow-up investigation, had sampled domestic wells at a 2.9-km<sup>2</sup> unsewered residential develop-

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