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Radionuclide and chemical concentrations in mineral waters at Saratoga Springs, New York

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Abstract

A project to characterize the radionuclide and chemical components in natural spring waters in the vicinity of Saratoga Springs, New York (USA) has been completed. As a result of the measured radionuclide and chemical content, eight springs were labeled as mineral waters, whereas three springs contained very low concentrations of these components. The mineral waters were highly enriched in alkaline and alkaline-earth elements, as well as chloride ions. Three isotopes of radium (^{224}Ra, ^{226}Ra, ^{228}Ra) were detected in the mineral waters and reached concentrations of 1, 20, and 2 Bq/L, respectively. Overall, the ^{226}Ra isotope constituted about 80% of the total radioactivity measured in the water samples. Dissolved uranium concentrations in the mineral waters were very low (mean ~50 mBq/L).

Keywords: Radioactivity; Radium; Mineral water; Chemical; Alkaline

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1. Introduction

It is well known that naturally occurring mineral waters contain elevated concentrations of dissolved radium. While the dissolved radionuclides and minerals allegedly instill medicinal benefits in persons who drink and bathe in the water, consumption contributes to the body burden of these constituents. Mineral waters exist throughout the world, are typically consumed by the local residents, and may be bottled for commercial distribution. The principal health effect associated with ingestion of radium is sarcoma of bone and soft tissue, the sites [in the body] where radium predominantly accumulates. As a result, radium is a Group A carcinogen, a known human cancer-causing agent. Radium exists naturally as four isotopes (^{223}Ra, ^{224}Ra, ^{226}Ra, and ^{228}Ra), although only the latter two are of primary concern in public water supplies, due to their longer half lives and greater likelihood of occurrence. Of the two latter isotopes, ^{228}Ra has been reported to be over twice as likely to cause bone sarcoma (Rowland et al., 1978; ICRP, 1996). Radon (^{222}Rn), a radioactive gas produced by ^{226}Ra decay, dissolved in water poses a health risk both from ingestion and, following its emanation from the water, inhalation. The risk associated with inhalation of radon released from water is considerably greater than the risk from the ingestion pathway; waterborne radon may thereby be responsible for ~170 deaths annually in the United States (NRC, 1999). The concentrations of uranium isotopes (^{234}U and ^{238}U) in mineral waters, while rarely reported, are typically low (e.g., Labidi et al., 2002). While ingested uranium may induce radiological effects in organs, nephrotoxic effects from ingested uranium are more likely due to its chemical, as opposed to radiological, properties. The risk associated with ingestion of water containing uranium is significantly less than that from a similar concentration of ^{226}Ra (Cothern et al., 1983; ICRP, 1996).

While no regulations exist regarding natural radionuclide levels in private water supplies, the current Environmental Protection Agency (EPA) Safe Drinking Water Standard, or maximum contaminant level (MCL), which applies only to public drinking water supplies, is 556 mBq/L for gross alpha (GA) activity and 185 mBq/L for combined radium (^{226}Ra and ^{228}Ra). The MCL for uranium is 1.1 Bq/L. There is no MCL for radon, although a value near 11 Bq/L is pending (FR, 2000). MCLs exist for several chemical constituents; however, among the regulated elements, only Ba, Na, and Cl are commonly present in mineral waters.

Studies of mineral waters at Saratoga Springs, New York (NY), have characterized their radiological and chemical constituents for nearly a century. Moore and Whittemore (1914) measured radium concentrations in 14 springs at the site, several of which still operate today. They reported a hydrologic revitalization of the springs following the cessation of pumping for commercial purposes (i.e., bottling and bathing). In 1925, several inorganic compounds measured in the water supplies were used to differentiate between "sweet" spring water and the mineralized waters. Ba and Ra concentrations in water collected from eight of the springs in 1935 revealed a doubling of Ra levels over the 21-yr period since the original determinations (Baudisch and Brewer, 1939). Studies in 1960 and 1971 (Aulenbach and Davis, 1976) resulted in the most comprehensive listing of the radium content of