

## Occurrence of $^{210}\text{Po}$ and Biological Effects of Low-Level Exposure: The Need for Research

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**BACKGROUND:** Polonium-210 ( $^{210}\text{Po}$ ) concentrations that exceed 1 Bq/L in drinking-water supplies have been reported from four widely separated U.S. states where exposure to it went unnoticed for decades. The radionuclide grandparents of  $^{210}\text{Po}$  are common in sediments, and segments of the public may be chronically exposed to low levels of  $^{210}\text{Po}$  in drinking water or in food products from animals raised in contaminated areas.

**OBJECTIVES:** We summarized information on the environmental behavior, biokinetics, and toxicology of  $^{210}\text{Po}$  and identified the need for future research.

**METHODS:** Potential linkages between environmental exposure to  $^{210}\text{Po}$  and human health effects were identified in a literature review.

**DISCUSSION:**  $^{210}\text{Po}$  accumulates in the ovaries when it kills primary oocytes at low doses. Because of its radioactivity and tendency to concentrate  $^{210}\text{Po}$ , the ovary may be the critical organ in determining the lowest injurious dose for  $^{210}\text{Po}$ .  $^{210}\text{Po}$  also accumulates in the yolk sac of the embryo and in the fetal and placental tissues. Low-level exposure to  $^{210}\text{Po}$  may have subtle, long-term biological effects because of its toxicity towards reproductive and embryonic and fetal tissues where exposure to a single alpha particle may kill or damage critical cells.  $^{210}\text{Po}$  is present in cigarettes and maternal smoking has several effects that appear consistent with the toxicology of  $^{210}\text{Po}$ .

**CONCLUSIONS:** Much of the important biological and toxicological research on  $^{210}\text{Po}$  is more than four decades old. New research is needed to evaluate environmental exposure to  $^{210}\text{Po}$  and the biological effects of low-dose exposure to it so that public health officials can develop appropriate mitigation measures where necessary.

**KEY WORDS:** cigarettes, drinking water, Fallon, human health, lead-210, leukemia, ovary, polonium-210. *Environ Health Perspect* 120:1230–1237 (2012). <http://dx.doi.org/10.1289/ehp.1104607> [Online 26 April 2012]

In 2007, very high levels of the naturally occurring radioisotope polonium-210 ( $^{210}\text{Po}$ ) were discovered in drinking water from numerous private wells in Lahontan Valley, Churchill County, in northern Nevada. Of the 60 private wells and 3 public supply wells sampled in the valley (Seiler 2011), more than one-third of the private wells had  $^{210}\text{Po}$  levels exceeding 0.55 Bq/L, and 10% had levels that exceeded 2 Bq/L. This level is extremely unusual—fewer than 100 wells in the United States have reported  $^{210}\text{Po}$  activities that exceed 0.55 Bq/L, and the maximum value measured in Lahontan Valley, 6.59 Bq/L, is the fourth highest value reported in the United States (Seiler 2012).

$^{210}\text{Po}$  is one of the most toxic substances known because of its intense radioactivity, with 1  $\mu\text{g}$  of  $^{210}\text{Po}$  having an activity of  $1.66 \times 10^6$  Bq. After the death of Alexander Litvinenko from  $^{210}\text{Po}$  poisoning in 2006, several papers were published that addressed the diagnosis, treatment, and toxicity of acute  $^{210}\text{Po}$  poisoning (Harrison et al. 2007; Jefferson et al. 2009; Scott 2007) and the need for medical toxicology expertise about  $^{210}\text{Po}$  because of its potential use in radiation terrorism events (Nienhauser 2008). The estimated acute lethal dose from oral ingestion for an adult if unabsorbed is 10–30  $\mu\text{g}$  (Jefferson et al. 2009), and as little as 1  $\mu\text{g}$

might be lethal to the most radio-sensitive members of the population (Scott 2007).

As an alpha-particle-emitting decay product of radium-226 ( $^{226}\text{Ra}$ ),  $^{210}\text{Po}$  is classified as a Group 1 human carcinogen [International Agency for Research on Cancer (IARC) 2001]. Numerous epidemiological studies, which were reviewed by Camu et al. (2011), have investigated associations between exposure to members of the uranium-238 ( $^{238}\text{U}$ ) decay series in drinking water and cancers such as leukemia (e.g., Hoffmann et al. 1993; Lyman et al. 1985; Raabohn-Nielsen et al. 2008). Because  $^{210}\text{Po}$  is the last radioactive member of the  $^{238}\text{U}$  decay series, a common feature of all these studies is the presence of  $^{210}\text{Po}$  in the environment, even if it was not measured. Because  $^{210}\text{Po}$  is a human carcinogen and because information on environmental exposure to it is poorly known, we reviewed the literature on  $^{210}\text{Po}$ .

In this paper, we summarize relatively unknown and disparate information on the environmental behavior, biokinetics, and toxicology of  $^{210}\text{Po}$  and suggest supportive research that could help guide future investigations.

### Environmental Behavior of $^{210}\text{Po}$

$^{210}\text{Po}$  has a relatively short half-life of 138.4 days and decays to lead-206 ( $^{206}\text{Pb}$ ) by emitting an alpha particle. It is the last unstable

isotope in the  $^{238}\text{U}$  decay series and is present in the environment whenever  $^{238}\text{U}$  or any other members of the  $^{238}\text{U}$  decay series, such as  $^{226}\text{Ra}$ , radon, or  $^{210}\text{Pb}$ , are present. The average crustal U concentration is approximately 2.7 mg/kg (Siegel and Bryan 2003), and > 99% of natural U is  $^{238}\text{U}$  (Bondarjenco 2002). Large areas in the United States have surficial uranium concentrations exceeding 2.7 mg/kg (Figure 1). The specific activity of  $^{238}\text{U}$  is 12.4 Bq/mg, and in old sediments where radon is not lost to the atmosphere, the activity of  $^{210}\text{Po}$  in secular equilibrium with 2.7 mg/kg of  $^{238}\text{U}$  would be about 33.5 Bq/kg.

The main source of  $^{210}\text{Po}$  in the atmosphere and oceans is from the emanation of radon gas from surficial sediments to the atmosphere where it is spread by diffusion and winds (Parfenov 1974; Persson and Holm 2010). In addition, high  $^{210}\text{Po}$  can be introduced into the atmosphere in volcanic eruptions because of the high volatility of  $^{210}\text{Po}$  compared with  $^{210}\text{Pb}$  (Kim et al. 2011). Radon's decay products,  $^{210}\text{Pb}$  and  $^{210}\text{Po}$ , have strong affinities for particles and become widely distributed on the earth's surface as the  $^{210}\text{Pb}$  and  $^{210}\text{Po}$  that are formed from decay of radon in the atmosphere adsorb to aerosol particles and fall onto the land or sea.

$^{210}\text{Po}$  activities exceeding 1 Bq/L have been found in private wells in Florida and Nevada and public supply wells in Louisiana and Maryland (Seiler et al. 2011).  $^{210}\text{Po}$  in groundwater is normally < 30 mBq/L because

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R.L.S. is retired from the USGS, and the views expressed in this paper are those of the authors and do not reflect the position of the U.S. government or the USGS.

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# Biological Effects Of Low Level Exposure

**JA Banks**



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## **Biological Effects Of Low Level Exposure** Book Review: Unveiling the Power of Words

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