Workshop Report: Potential Impacts and Significance of Elevated ^{131}I on Drinking Water Sources [Project #4486]

ORDER NUMBER: 4486

DATE AVAILABLE: October 2013

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The US Environmental Protection Agency (EPA) and its partners responded to radionuclide releases from the Fukushima Dai-ichi Nuclear Power Plant in Japan with enhanced monitoring of drinking waters, air, and other potential radionuclide exposure routes and a review of EPA's historical RadNet database. During enhanced monitoring, elevated iodine-131 (^{131}I) concentrations were detected in surface waters used as source waters for two of the Philadelphia Water Department's (PWD) drinking water plants. Careful review of RadNet data identified episodes of detectable ^{131}I in finished drinking water at the PWD's three drinking water treatment plants since the late 1990s. The PWD, the Pennsylvania Department of Environmental Protection (PADEP), and the EPA initiated a robust monitoring program to determine the source of the ^{131}I and to develop a better characterization of the concentrations and temporal variability ^{131}I in drinking water sources.

Findings from the monitoring program, a review of published studies, and discussions with regulators suggested that the likely source for PWD's radioiodine observations was ^{131}I used in medical treatments. Since PWD has not exceeded the maximum contaminant level (MCL) for drinking water distributed to customers (the finished water is regulated, not the source water) no action has been required but a potential emerging contaminant has been identified. After a year of sampling and analysis, from April 2011 to April 2012, PWD approached the research community with a proposal to hold an experts workshop to collect information that would inform strategies for determining the significance of source water ^{131}I, filling knowledge gaps and managing the contaminant. This report documents the workshop, presents the major findings, and suggests activities for assessing ^{131}I in drinking water sources.

OBJECTIVES

The workshop was convened to establish the state of knowledge with respect to ^{131}I in drinking and wastewaters, to assess the significance of PWD's elevated source water ^{131}I, and to identify key data gaps. Specific objectives for the workshop were as follows:

- Identify the possible sources for elevated ^{131}I concentrations in drinking source waters and those most likely responsible for elevated ^{131}I activity observed in PWD's source waters.
- Evaluate the importance of elevated ^{131}I in drinking source waters in the United States.
- Define options for managing drinking source water ^{131}I.
- Propose research that could improve the understanding or management of ^{131}I in drinking water sources.

These objectives led to discussion of the occurrence, regulations, human health effects, potential economic impacts, and fate and transport of ^{131}I in surface waters and treatment in drinking water treatment plants. Outcomes of the workshop include this report and future presentation of workshop results at key conferences and in the technical literature.

BACKGROUND

Iodine-131 is a radioactive isotope of iodine with a half-life of approximately eight days. There is evidence to support that it can cause thyroid cancer and other thyroid diseases. However, large (as high as 5 GBq) doses of ^{131}I are also used in treatment of thyroid cancer and smaller (around 0.4 GBq) doses are used in medical diagnostic procedures. Though there appears to be a potential for medical use of ^{131}I to pose a health hazard, epidemiological studies have not specifically demonstrated a link between medical use of ^{131}I and thyroid cancer or other thyroid diseases. Epidemiological studies following nuclear power plant accidents and nuclear weapons uses indicate that children may be at greater risk from exposure to ^{131}I than adults. Dietary iodine deficiency is also associated with increased cancer risk. Non-drinking water exposures to ^{131}I are regulated by the Nuclear Regulatory Commission, and the EPA has established that an ^{131}I concentration of 3 pCi/L in finished drinking water is consistent with the MCL for beta emitting radionuclides[1].

Possible sources of ^{131}I in surface waters are medical treatments, unplanned nuclear power plant releases, releases from other activities related to nuclear power production (e.g., from laundries washing clothes used in nuclear power facilities), veterinary treatments, nuclear weapons tests, nuclear weapons production, and ^{131}I intentionally introduced into the environment as a tracer. It is believed that ^{131}I used in medical treatments reaches drinking source waters by patient excretion into sewage collection systems and passage through wastewater treatment plants. During collection and treatment, some level of removal occurs. The ^{131}I is then introduced to surface waters in pulses (or perhaps in continuous elevated concentrations if recycle or other plant processes promote mixing) via wastewater treatment plant effluent discharges. A simple model of this process and reports from the literature indicate that excretion from a single medical treatment with ^{131}I has the potential to generate the elevated surface water concentrations observed by PWD in its drinking source waters.

[1] The EPA maximum contaminant level (MCL) in finished drinking water for all beta emitters combined is 4 mrem/year. The ^{131}I activity at which a sample would exceed 4 mrem/yr is 3 pCi/L.

The extent of drinking source and finished waters with detectable concentrations of ^{131}I is currently unknown. RadNet, the only current national radionuclides monitoring program, was not designed to provide drinking water occurrence data. Drinking water utilities participating in the RadNet program sample infrequently and at different locations (source water, finished water, and tap) that correspond to different "ages" of water and therefore different levels of dilution and decay of ^{131}I. Also, RadNet sites are not necessarily the sites with the greatest potential for the occurrence of ^{131}I in source waters. Furthermore, high analytical reporting limits relative to the regulated level of ^{131}I and the possibility that some analytical methods don't recover total ^{131}I (radioiodine in all the chemical forms present in environmental samples) may also contribute to the difficulty in evaluating the extent of ^{131}I occurrence for drinking water plants in the United States.

APPROACH

The Water Research Foundation and its co-sponsors (The Water Environment Research Federation, The American Water Works Association and the PWD) determined that an expert workshop was the best means for establishing the current state of knowledge and formulating a response to PWD's elevated source water ^{131}I. Experts were drawn from the drinking water sector, the wastewater sector, regulatory agencies, academia, and public health organizations.

The first day of the workshop featured presentations from experts on the sources, occurrence, and treatment of ^{131}I and discussion of the material presented. The second day included structured discussions for two breakout groups and integration of the materials in plenary sessions. The second day also included discussion of the likely cause of PWD's elevated source water ^{131}I, the likelihood that there is undetected elevated ^{131}I in the other source waters, and the significance of elevated ^{131}I.

RESULTS/CONCLUSIONS

Workshop participants concluded that the likely source of ^{131}I in Philadelphia's source waters is residual ^{131}I excreted from patients following medical treatments and that more intensive, targeted monitoring would likely identify other areas with detectable ^{131}I in drinking source water. The latter conclusion was supported by data presented by experts on the first day of the workshop and by published studies in the literature.

Over the course of the workshop many data gaps regarding the occurrence, fate, transport, treatment, and management of ^{131}I were identified. The key data gaps include:

- the number and geographic distribution of drinking water plants that have measurable activities of ^{131}I in source water, and the concentrations of ^{131}I in the source waters;
- the removal of ^{131}I by the unit processes in typical water and wastewater treatment plants. Note that removal may differ for influent waters with high versus low concentrations of ^{131}I;
- the frequency of ^{131}I treatments in the catchments (including sewers) of individual water treatment plant source waters and the locations where patients may be expected to discharge ^{131}I to sewers (Because this information is probably known by hospitals

and facilities conducting treatments with ^{131}I, this is only a data gap from the perspective of water and wastewater utilities);

- the potential contributions of sources other than medical use (e.g., veterinary treatments, contributions from septic systems [diffuse pollution], Sanitary Sewer Overflows [SSOs] and Combined Sewer Overflows [CSOs], hydro-fracturing) to occurrence of ^{131}I in wastewaters and drinking water treatment plant source waters); and
- the significance of elevated ^{131}I to the ecology of receiving waters.

APPLICATIONS/RECOMMENDATIONS

Experts were uncertain about the significance of elevated ^{131}I in Philadelphia's source water and suggested a staged response. First, a targeted monitoring program at sites other than Philadelphia was suggested to confirm that ^{131}I occurrence in drinking water is not specific to Philadelphia and to develop a clearer understanding of the potential importance of ^{131}I occurrence in its source waters in light of the trend toward increasing use of ^{131}I in medical treatments. Other sites such as drinking water treatment plants involved in water reuse might merit additional consideration in targeted monitoring since ^{131}I in the plant process water is not diluted. A second response is outreach to the public health/medical and environmental communities to develop a coalition capable of developing approaches for addressing this concern effectively and economically. Other steps that could be taken if source water ^{131}I proves to be prevalent and at concentrations of real concern would include development of analytical techniques for more sensitive and less expensive measurement of ^{131}I in environmental waters, research on removal of ^{131}I in drinking water and wastewater treatment processes, and development of communication strategies for utilities facing public inquiries about radioiodine (^{131}I).

The drinking source water targeted monitoring activity would help establish the number of systems that are potentially impacted by ^{131}I and the geographic distribution of those plants and would address two major questions: (1) Are detectable levels of ^{131}I observed at other locations in the United States? If so, what is the spatial and temporal distribution of these elevated occurrences? (2) Are the levels observed sufficiently high that some mitigation may be required? If monitoring suggests that ^{131}I is an emerging contaminant of concern, the impacts could be costly and may require extensive research into treatment. A follow-up technical workshop was recommended for designing this monitoring program. The expert workshop would draw from experiences PWD has gained in its monitoring and mapping activities and outcomes from the workshop would be a monitoring plan and cost estimates.

A second follow-on activity suggested by the experts was constructive engagement of all of the stakeholders in the assessment of ^{131}I as a drinking water, wastewater, and surface water emerging contaminant. Some of the key additional partners identified for inclusion in a larger group addressing ^{131}I are the medical community involved in thyroid treatment, the Centers for Disease Control (CDC), the Joint Commission for Accreditation of Hospital Organizations, the American Thyroid Association, and environmental groups. Outreach to the medical community needs to be done with a realization that medical practitioners are working within their regulations and

that they face economic and resource constraints that limit their ability to manage ^{131}I releases to the environment. Outreach to environmental groups is also essential to enlist their support in determining ecological impacts of medical ^{131}I discharges to surface waters and because they can play a constructive role in working with all of the groups connected with ^{131}I in the environment.

There are no off-the-shelf drinking water treatment options available at this time and few research studies provide a basis for developing treatment options. Further, PWD's experience has shown that the media can react strongly and perhaps irrationally to reports of radioactive contaminants in drinking waters. Given the potential costs associated with monitoring and treatment and the potential for the public to be strongly interested in ^{131}I, WRF subscribers would be well served to engage in investigations and support the drinking water community's response to this concern. That response could produce hard data that will help utilities assess and manage their risks, and communication tools that could be shared among utilities facing public questions over ^{131}I in drinking source waters.

RESEACH PARTNERS

We gratefully acknowledge The Water Environment Research Federation, The American Water Works Association, and The PWD as co-funders of this project and for the energetic participation of their staff in planning for and participating in the experts workshop.