Arsenic and Diabetes: Significance of Drinking Water Exposures

By Kelly A. Reynolds, MSPH, Ph.D.

Drinking water, including both groundwater and surface water supplies, is considered a primary exposure route of arsenic. Based on evidence of increased cancer rates from arsenic exposures, the US EPA implemented a more stringent arsenic rule in 2001, reducing the maximum contaminant level (MCL) from 50 ppb to 10 ppb in drinking water.

The public health benefit from the lowered MCL is estimated to be an avoidance of 21-30 fatal bladder and lung cancers per year. Recently, additional reports have linked even low levels of arsenic exposures to type 2 diabetes, a predominant illness in the US.

Approximately 13 million people in the US are still exposed to tap water with arsenic concentrations above the US EPA standard. As arsenic in food, especially marine-related foods, is generally organic in form and not considered a human health threat, tap water creates the primary exposure for inorganic, toxic arsenic.

What is diabetes?

Nearly eight percent (23.6 million) of Americans and 2.8 percent (171 million) of people worldwide are thought to have diabetes. Globally, the numbers are predicted to double by 2030.

Diabetes is a condition where the body does not produce the necessary amount of the hormone, insulin. Insulin is a vital hormone in the body, converting sugars, starches and other foods into energy for essential metabolic functions.

Type 1 and type 2 diabetes differ in that, with the former, the body does not produce insulin where as with the latter, the body does not properly utilize insulin. Type 1 is sometimes referred to as early onset, type 2 as adult or late onset. About 90-95 percent of people diagnosed with diabetes in North America are type 2 diabetics.[1]

Numerous factors have been associated with diabetes, including genetics, age and obesity. As obesity rates have increased in America, type 2 diabetes has also increased. The odds of developing diabetes have doubled over the last three decades. Disease rates are significantly increasing in children.

Approximately 55 percent of patients with type 2 diabetes are also diagnosed as obese. Elderly populations are at an increased risk with 20 percent of those over the age of 65 diagnosed with diabetes and 40 percent having either diabetes or impaired glucose tolerance (a precursor condition to diabetes).[2]

Diabetes is a treatable illness, via diet and exercise, medications or insulin shots. However, if not properly controlled, it can lead to acute and chronic health effects.

Nearly a quarter of persons in the US with diabetes do not even know it, as the symptoms may be mild and unnoticed for years. Long-term complications include cardiovascular disease, liver failure, blindness and poor wound healing, particularly in the feet, often leading to amputation.

Drinking water exposure

In January, 2001, the US EPA changed the arsenic MCL from 50 ppb to 10 ppb, requiring increased monitoring for both groundwater and surface water supplies. In addition, the maximum contaminant level goal (MCLG) for arsenic is now zero, meaning that exposure at any level is suspected to cause adverse health effects. The rule became effective in January 2006, allowing up to five years for all community water systems and non-community water systems to comply.

Arsenic levels in drinking water in the US vary widely by region but the West and parts of the Midwest and New England have a high number of utilities that test positive for the hazard at levels exceeding the MCL. Baseline monitoring of new systems is necessary to identify geographical regions of greatest concern. More than four thousand utilities around the country were expected to install treatment to comply with the new standard.[3]

Bangladesh has been a region of targeted arsenic studies due to high exposure potentials from contaminated groundwater supplies. Arsenic-rich sediments contribute to groundwater contamination levels as high as 1,000 ppb. In 2003, more than 50 million people in Bangladesh were estimated to be consuming arsenic-contaminated drinking water at levels more than five times the US EPA MCL.

Epidemiological evidence

In 1994, researchers presented evidence that arsenic exposure was a risk factor for diabetes.[4] A follow-up study in 1998 concluded the same.[5] In the latter study, long-term sampling of the water supply was not done, making it difficult to know what level of arsenic individuals were actually exposed to from the environment.

This 1994 study in the American Journal of Epidemiology identified the potential for many confounding factors (sex, age, diet, other environmental exposures, etc.) that cloud the true association of arsenic with diabetes. These previous studies established a link between high levels of exposure to arsenic and diabetes but low-level exposure effects remained unknown.

A review of the experimental and epidemiological evidence of chronic arsenic exposures and the link to diabetes was published in 2006.[6] To date there were 19 laboratory studies on arsenic and glucose metabolism with speculation of the specific biological mechanism but none was consistently identified. Studies in populations exposed to high arsenic levels generally indicate a consistent association to diabetes but lack the information needed to determine if the link is causal.

Exposure to different arsenic species (some forms of arsenic in the environment are more toxic than others) and exposures to other sources of arsenic (occupational settings or foods) complicate extrapolation of effects across different populations.

Studies outside of Bangladesh, for example, do not always show a consistent correlation.

A more recent (2008) study provides evidence that even low-level exposures to inorganic arsenic in drinking water are associated with type 2 diabetes. The study examined medical records of 788 adults who previously submitted to a urine test, finding that 7.7 percent had type 2 diabetes and a 26 percent increase of arsenic in their urine, compared to those without diabetes.[7] Persons with the highest levels of arsenic (16.5 ppb) in their urine were 3.6 times more likely to have diabetes than persons with very low levels (3.0 ppb).

The authors concluded, "given widespread exposure to inorganic arsenic from drinking water worldwide, elucidating the contribution of arsenic to the diabetes epidemic is a public health research priority with potential implications for the prevention and control of diabetes." Therefore, environmental factors may play a bigger role in diabetes prevention than previously recognized.

Protecting the public

How arsenic contributes to diabetes is not currently known but studies show that pancreas cells secrete abnormal insulin levels following treatment with arsenic. Whether or not arsenic exposures cause diabetes or if there is just an association, remains the topic for future research. For example, it is possible that people with diabetes excrete more arsenic in their urine, providing an association but not a causal relationship.

Most published laboratory studies with animals or cell cultures, evaluate arsenic exposures at levels hundreds to thousands of times greater than the US EPA MCL of 10 ppb in order to evaluate acute effects. Future studies looking at more targeted, low-dose arsenic exposures in human populations—with specific analysis of exposure routes, ingested dose and biological markers—are warranted.

Arsenic is particularly a problem with groundwater supplies. Underground mineral deposits naturally contaminate the water table where arsenic is leached from weathering rocks and eroding materials.

Industrial applications, such as discharge from semiconductor manufacturing, petroleum refining and glass manufacturing, as well as products used as wood preservatives, animal feed additives, herbicides and lead or copper based alloys also contribute to environmental arsenic. Federal standards require public utilities to provide drinking water with arsenic levels below the 10 ppb MCL, but for the 15 percent of Americans who have private well water sources, these safeguards may not be implemented.

Private water supplies can be tested periodically by a state-certified laboratory (lists are available from state extension offices) for a fee of around $30 (USD). Many affordable and reliable treatment devices are available for installation at the residential point of use or point of entry.

Technology is available to treat arsenic in drinking water ranging from adsorbent resins to counter-top distillers. Reverse osmosis is also an option for household purification. Until the metabolic consequences of arsenic exposures are fully understood, a precautionary approach to minimize exposure is recommended.

References

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