Uranium mining and health

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The energy needs of our society are becoming a challenge. One energy source, nuclear power, is entirely dependent on uranium. Increasingly, physicians are opposing the mining of uranium. In the 1980s, family physician Dr Robert Woollard led a task force that resulted in a provincial moratorium on uranium mining in British Columbia.[1] In autumn 2009 in Sept-Îles, Que, more than 20 physicians threatened to leave if a uranium mine was opened 13 km upstream from the community in which they practised.[2] In 2010, the International Physicians for Prevention of Nuclear War passed a motion opposing the mining of uranium.[3] Why would physicians oppose uranium mining?

Toxic profile

Uranium is a heavy metal with the potential to cause a spectrum of adverse health effects ranging from renal failure and diminished bone growth to damage to the DNA.[4,5] Because uranium possesses both chemical toxicity and radioactivity, assessing the relative contributions of each to its toxic profile is difficult. The effects of low-level radioactivity include cancer, shortening of life, and subtle changes in fertility or viability of offspring, as determined from both animal studies and data on Hiroshima and Chernobyl survivors.[6,7] These effects can be delayed for decades or for generations and are not detected in short-term toxicologic studies.

Uranium is chemically toxic to the proximal tubules of the kidney, although the damage is reversible, at least in the early stages.[8] Increased glucose levels in the urine and high blood pressure have been reported.[9] One study concluded that "uranium exposure is weakly associated with altered proximal tubulus function without a clear threshold, which suggests that even low uranium concentrations in drinking water can cause nephrotoxic effects."[10]

Uranium is widespread in the earth's crust, and wherever aquifer and bedrock interface, there might be some uranium in the water. Exploratory drilling or mining increases exposure of water to potential contamination.[11]

Radioactivity of uranium

Uranium is an α-particle emitter, as are many of its radioactive decay products, including radon. α-Particles are bulky (2 protons and 2 neutrons) and cannot penetrate human skin. However, when particulate matter containing α-emitters is inhaled or ingested, it results in internal exposure to radiation. The carcinogenicity of inhaled α-emitters is not in dispute. Radon gas is responsible for up to 20% of cases of lung cancer in Canada. Health Canada recently lowered the allowable limit in Canadian homes.[12]

A study of Czech and French uranium miners concluded:

> [A] substantial excess of lung cancer, reduced pulmonary function and emphysema … has been reported. The excess has been attributed primarily to irradiation of the tracheobronchial epithelium by alpha particles emitted during the radioactive decay of radon and its daughter products.[13]

Canadian studies have linked lung cancer in uranium miners to exposure to radiation.[14] Radon is a radioactive decay product of uranium and occurs wherever uranium does. Despite better management than in the past, it remains a hazard in both mines and homes.

In addition to α-particles, the radioactive decay products of uranium might emit β-particles or γ-rays, both of which also have adverse effects on biological systems.

Uranium mining

Methods employed for mining uranium in Canada are open-cast (pit) mining and conventional underground mining.

Milling typically occurs close to the mine, and involves crushing the ore to a fine sandlike consistency. Alkali and acid washes isolate the uranium, now called *yellowcake*. The remaining 80% to 99.6% of the ore is referred to as *tailings*, and is stored in tailings ponds or containment fields to prevent wind and water erosion.

Besides chemicals used in washes, the toxic tailings contain sulfide ores, molybdenum, selenium, arsenic, and mercury, and approximately 85% of the radioactivity of the original ore.

The Canadian Nuclear Safety Commission (CNSC) has accepted plans to permanently and safely manage waste by contouring the tailings, covering them with an impervious layer of claylike material and a topsoil layer, and planting them with trees and grasses.[15]

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Discussion

Health and environmental concerns about uranium mining can be categorized as

- health and safety of miners and mine sites;
- health and safety of people in the immediate vicinity who might be affected by spread of radioactivity from the tailings or tailings ponds; and
- global health and environmental effects of increasing background radiation and water contamination.

The health of miners and the effects on the immediate environment around the mine site are monitored by the companies involved, with oversight from the CNSC. Concerns about the freedom of the CNSC to act independently of government and industry were highlighted by the firing of the Commission's Chief Executive Officer by the federal government when she applied safety guidelines to shut down the Chalk River reactor in Ontario.[16] It is concerning that health standards are set by physicists and industries, based on financial and technological convenience, rather than by those educated in and committed to public health and safety.

Political issues have hampered decommissioning and tailings management. Near Bancroft and Haliburton in Ontario, approximately 5 million tonnes of uranium mine tailings were left in jurisdictional limbo when uranium became a federal concern in 1977.[17] Only through relentless prompting by citizens' groups has some of this remedial work begun. For older mines, neither governments nor companies have set aside sufficient funds for long-term management.

The hazards of uranium mining to surrounding populations have not been studied, in part because mines have typically been located in remote areas with sparse populations. As richer ore bodies are exhausted, companies are now exploring marginal deposits, often in more populated regions (such as in the Ottawa Valley near Sharbot Lake in Ontario or upstream from Sept-Îles).

It is concerning that there is currently no plan in Canada to monitor uranium in drinking water near exploration and mining sites. There is no plan to deal with the effect of mining activity on agriculture or residential populations. Uranium binds to soil and can be taken up by garden produce and forage crops.[18] There are surprisingly few studies on long-term effects of uranium ingestion in humans.

Contamination from uranium mining activity will persist for generations. The dust that blows away from the sites and the copious amounts of water used for dust control and uranium extraction all contain long-lived radioisotopes that are being disseminated into the environment. In the tailings, thorium 230 decays to produce radon gas. With a half-life of 76 000 years, it will produce radon for millennia. In the atmosphere, radon decays into the radioactive solids polonium, bismuth, and lead, which enter water, crops, trees, soil, and animals, including humans.

In intact rock formations, radon gas is largely trapped within the rock during its decay process. In finely ground tailings, it has multiple access routes to the surface and the atmosphere. Planting over the tailings will result in the uptake of radioactive substances by vegetation which, in the usual cycle of growth and decay, will be deposited on the surface.

The effects of all these sources of contamination on human health will be subtle and widespread, and therefore difficult to detect both clinically and epidemiologically. Incidences of cancers, fertility problems, and inheritable defects can be expected to rise with the increasing background radiation.

Genetic effects in humans have been clearly documented. A cohort study on a population in India exposed to higher levels of natural background radiation has shown increased incidences of Down syndrome and autosomal dominant congenital anomalies.[19] Transgenerational effects have been shown in nonhuman species with which humans share many biochemical pathways.[7,20] We ask whether our increasing burden of cancer, intellectual disabilities, and metabolic diseases has any relationship with an increasingly radioactive environment.

Finally, the end uses of uranium in both nuclear weapons and nuclear power generation pose ethical questions. By-products of the nuclear power industry—enriched and depleted uranium and plutonium—are used in weapons, raising the issue of proliferation. Nuclear weapons are uniformly destructive and illegal according to the International Court of Justice.[21] In nuclear power generation, fuel rods produce up to 18 months of power but leave waste far more radioactive and toxic than natural uranium and remain radioactive and toxic for millennia.

Conclusion

Uranium mining has widespread effects, contaminating the environment with radioactive dust, radon gas, water-borne toxins, and increased levels of background radiation.

Uranium mining is the first step in the generation of both nuclear power and nuclear weapons. Nuclear power plants produce routine radioactive emissions in air and water, produce nuclear waste, and create conditions for disasters similar to Chernobyl and Fukushima.

Physicians should be concerned about the health effects of the uranium continuum. As advocates for the health of our patients, we have a duty to advocate for an environment free of radioactive waste and to insist on representation in environmental and policy decision making in cases in which health might be

affected. We should press for baseline health studies at future uranium mining sites. We should be demanding independently funded research on the effects of uranium—and the effects of all radionuclides—on health.

There are no boundaries for air and water; the addition of long-lived radioisotopes anywhere in the environment eventually affects the health of everyone.

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Competing interests

Dr Dewar prepared a brief on behalf of the Saskatchewan Medical Association for the Uranium Development Partnership panel in 2008. She has funds invested in the uranium mining industry through her retirement plans, and she is Executive Director of Physicians for Global Survival.

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References

1. Young ER, Woollard RF. The health dangers of uranium mining and jurisdictional questions: a summary of material before the British Columbia Royal Commission of Inquiry. Vancouver, BC: British Columbia Medical Association; 1980.
2. Séguin R. Protesters seek debate on uranium mining. *The Globe and Mail* 2009 Dec 9. Available from: **www.theglobeandmail.com/report-on-business/industry-news/energy-and-resources/protesters-seek-debate-on-uranium-mining/article1393708/**. Accessed 2013 Mar 20.
3. International Physicians for the Prevention of Nuclear War [website]. *Global call to action for a ban on uranium mining*. Basel, Switz: International Physicians for the Prevention of Nuclear War; 2010. Available from: **www.ippnw.org/pdf/2011-resolution-uranium-ban.pdf**. Accessed 2013 Mar 20.
4. Brugge D, de Lemos JL, Oldmixon B. Exposure pathways and health effects associated with chemical and radiological toxicity of natural uranium: a review. *Rev Environ Health* 2005;20(3):177-93.
5. Craft E, Abu-Qare A, Flaherty M, Garofolo M, Rincavage H, Abou-Donia M. Depleted and natural uranium: chemistry and toxicological effects. *J Toxicol Environ Health B Crit Rev* 2004;7(4):297-317.
6. Nesterenko AB, Nesterenko VB, Yablokov AV. Chapter II. Consequences of the Chernobyl catastrophe for public health. *Ann N Y Acad Sci* 2009;1181:31-220.
7. Nesterenko AB, Nesterenko VB, Yablokov AV. Chapter III. Consequences of the Chernobyl catastrophe for the environment. *Ann N Y Acad Sci* 2009;1181:221-86.
8. Zamora ML, Tracy BL, Zielinski JM, Meyerhof DP, Moss MA. Chronic ingestion of uranium in drinking water: a study of kidney bioeffects in humans. *Toxicol Sci* 1998;43(1):68-77.
9. Kurttio P, Harmoinen A, Saha H, Salonen L, Karpas Z, Komulainen H, et al. Kidney toxicity of ingested uranium from drinking water. *Am J Kidney Dis* 2006;47(6):972-82.
10. Kurttio P, Auvinen A, Salonen L, Saha H, Pekkanen J, Mäkeläinen I, et al. Renal effects of uranium in drinking water. *Environ Health Perspect* 2002;110(4):337-42.
11. Health Canada. *Canadian Health Measures Survey: summary of the biomonitoring results and government actions.* Ottawa, ON: Health Canada; 2010.
12. Health Canada [website]. *Radon*. Ottawa, ON: Health Canada; 2012. Available from: **http://hc-sc.gc.ca/hl-vs/iyh-vsv/environ/radon-eng.php**. Accessed 2013 Mar 20.
13. Tomasek L, Rogel A, Tirmarche M, Mitton N, Laurie D. Lung cancer in French and Czech uranium miners: radon-associated risk at low exposure rates and modifying effects of time since exposure and age at exposure. *Radiat Res* 2008;169(2):125-37.
14. Howe D, Geoffrey R. *Updated analysis of the Eldorado Uranium Miners' Cohort: part I of the Saskatchewan Uranium Miners' Cohort Study (RSP-0205).* Ottawa, ON: Canadian Nuclear Safety Commission; 2006. Available from: **http://nuclearsafety.gc.ca/eng/readingroom/healthstudies/eldorado/**. Accessed 2013 Mar 20.
15. Canadian Nuclear Safety Commission [website]. *Uranium mining and milling: the facts on a well-regulated industry*. Ottawa, ON: Canadian Nuclear Safety Commission; 2012. Available from: **http://nuclearsafety.gc.ca/eng/readingroom/factsheets/uranium-mining-milling.cfm**. Accessed 2013 Mar 20.
16. O'Neill J. Harper government fires Linda Keen over isotope crisis. *Ottawa Citizen* 2008 Jan 16. Available from: **www.canada.com/topics/news/national/story.html?id=c70b1f37-7efe-46c1-a165-8b0efd4dfcaa**. Accessed 2013 Mar 20.
17. Canadian Institute for Radiation Safety. *Radioactive and toxic wastes from the Bancroft uranium mines. Where are we going? Who is in charge? CAIRS Report Stage II.* Toronto, ON: Radiation Safety Institute of Canada; 1987. Available from: **www.radiationsafety.ca/wp-content/uploads/2012/01/Bancroft.pdf**. Accessed 2013 Mar 20.
18. Hakonson-Hayes AC, Fresquez PR, Whicker FW. Assessing potential risks from exposure to natural uranium in well water. *J Environ Radioact* 2002;59(1):29-40.
19. Padmanabhan VT, Sugunan AP, Brahmaputhran CK, Nandini K, Pavithran K. Heritable anomalies among the inhabitants of regions of normal and high background radiation in Kerala: results of a cohort study, 1988-1994. *Int J Health Serv* 2004;34(3):483-515.
20. Hesse-Honegger C. *Heteroptera. The beautiful and the other, or images of a mutating world.* New York, NY: Scalo; 2001.
21. International Court of Justice [website]. *Legality of the threat or use of nuclear weapons.* The Hague, Netherlands: International Court of Justice; 1996. Available from: **www.icj-cij.org/docket/index.php?sum=498&code=unan&p1=3&p2=4&case=95&k=e1&p3=5**. Accessed 2013 Mar 21.