Expert Panel Recommends a Radical Reduction in Permissible Levels of Tritium in Drinking Water

by Gordon Edwards, June 12, 2009.

Proposed New Standard

At the request of the Ontario Minister of the Environment, an expert panel has concluded a 25-month study of the health dangers of radioactive tritium in drinking water. It has concluded that the current "permissible levels" in Ontario are hundreds of times too high – 350 times too high, in fact.

The final report of the Ontario Drinking Water Advisory Council (ODWAC), is entitled *Report and Advice on the Ontario Drinking Water Quality Standard for Tritium.* It recommends that the current permissible limit of 7,000 becquerels per litre be reduced to 20 becquerels per litre. This is regarded as a compromise between the needs of the Ontario nuclear industry – since man-made tritium is a byproduct of nuclear reactors – and the need to protect human health.

The report, dated May 21, 2009, was made public on June 9. It can now be downloaded: http://ccnr.org/ODWAC_tritium_2009.pdf

ODWAC's proposed numerical standard of 20 becquerels per litre is identical with a recommendation made 15 years ago by another Ontario expert group, the Advisory Committee on Environmental Standards (ACES). Back then, in 1994, the Government of Ontario did not accept the ACES recommendation, and there is no assurance that the present Ontario Government will accept ODWAC's recommendation either. Political considerations have now become paramount.

What is a becquerel?

A "becquerel" is a unit of radioactivity. One becquerel indicates that there is one radioactive disintegration happening every second. Thus a standard of 7,000 becquerels per litre means that in one litre of drinking water, it is permissible to have 7,000 radioactive disintegrations happening every second, or 420,000 disintegrations each minute, or 25.2 million disintegrations each hour, all within that single litre of water. If someone drinks from that litre of water, the disintegrations will continue to take place inside his or her body.

How does radioactivity cause cancer?

Like all radioactive materials, tritium is a cancer-causing agent. When a tritium atom disintegrates, it gives off a tiny electrically charged particle called a beta particle, moving at an enormous speed. Inside the body, the beta particle will damage any organic molecules in its path, including DNA molecules, killing and/or crippling one or more cells in the vicinity. Some of these crippled cells can develop into cancers many years later. There is no absolutely safe dose of atomic radiation since a single radioactive disintegration can cause the kind of damage that ultimately results in a cancer.

What is tritium?

Tritium is a radioactive form of hydrogen.

Hydrogen is the most abundant element in the universe. It is an essential ingredient in all organic molecules. About half of the atoms in the human body are hydrogen atoms. Every water molecule is made of two hydrogen atoms and one oxygen atom.

An atom of tritium is three times heavier than a normal hydrogen atom, and it is unstable – a tritium atom will spontaneously and suddenly disintegrate, giving off a high-velocity beta particle. Beta radiation (as it is called) is dangerous to living things because of the damage it can do at the cellular level.

When tritium atoms are combined with oxygen, the resulting water molecules are radioactive. This radioactive water (also called "tritiated water") is indistinguishable from ordinary water except for the fact that it is radioactive. The tritium cannot be filtered out or otherwise removed from drinking water by any readily available technology – you can't filter water from water!

What is the "natural background" of tritium?

Cosmic radiation from outer space bombards nitrogen atoms in the upper atmosphere and produces radioactive tritium as a byproduct. As a result, there exists a "natural background" of tritium in lakes and rivers around the world; the background level is between one and two becquerels per litre of water. (ODWAC, page 12)

What is "fallout tritium" from nuclear explosions?

When nuclear weapons are exploded, radioactive materials – including tritium – are released. Following the atmospheric testing of nuclear weapons, global levels of tritium in surface waters increased dramatically to about 25 bequerels per litre; however, since the atmospheric test ban treaty (ATBT), levels of this "fallout tritium" have dropped to about one becquerel per litre. (ODWAC, page 12)

Where else does tritium come from?

The combination of "natural tritium" and "fallout tritium" has resulted in a tritium level of about 2 to 3 becquerels of tritium per litre of surface water in the northern hemisphere. "Any levels above this range imply [other] man-made sources." (ODWAC, page 3)

The only other major source of tritium is nuclear reactors. Every nuclear power plant produces large amounts of tritium and releases some of it into the environment. Since tritium has a 12 year half-life, it builds up in the environment year after year. Most of the tritium released from reactors is in the form of radioactive water – water molecules that incorporate radioactive tritium atoms instead of ordinary non-radioactive hydrogen atoms. This radioactive water is also called "tritiated water".

The Canadian-designed CANDU reactors produce and release far more tritium than other designs of nuclear reactors, because, for technical reasons, they need to use large volumes of "heavy water". Heavy water is not radioactive, but the hydrogen atoms in the water molecules are twice as heavy as ordinary hydrogen atoms. When the reactor is running, these heavy hydrogen atoms are gradually transmuted into radioactive tritium atoms. Year after year, more and more tritium is created in this way. Tritium is notoriously difficult to contain, so a lot of it ends up in the effluent water or in the atmospheric emissions from the nuclear reactor.

Ontario is also home to two manufacturing plants in Peterborough and Pembroke that mass-produce tritium-filled glow-in-the-dark signs. These plants release large quantities of tritium to the environment, but that tritium originates in Ontario's CANDU reactors. There is a Tritium Removal Facility at Darlington Ontario that periodically extracts tritium from the contaminated heavy water in Ontario's nuclear reactors, in order to make the working environment safer for atomic workers in those nuclear power plants. Once extracted, some of this tritium is then sent to the tritium light factories in Peterborough and Pembroke, causing extensive local contamination to occur at sites far removed from the CANDU reactors.

What is ODWAC's rationale for the proposed standard?

ODWAC's proposed standard for tritium in drinking water is based on how many extra cancers develop if people drink tritium-contaminated water for 70 years. By applying the same logic that is used for other cancer-causing substances, ODWAC reasoned that the standard for an acceptable level of tritium in drinking water should not allow more than one additional cancer per million persons exposed.

Using this cancer rate as a goal, ODWAC calculated the permissible level of tritium in drinking water seven different times, using a variety of assumptions, ending up with answers ranging from 109 becquerels per litre to 7 becquerels per litre. Any one of these figures could be correct – but there is too much uncertainty to know which one is most accurate. ODWAC selected the figure of 20 becquerels per litre

from this range of possibilities, in part because they received indications that the nuclear industry could meet this standard as long as the figure could be averaged out over the period of a year. Accordingly, ODWAC recommends that the proposed standard be based on annual averages.

So ODWAC concluded that if a million people are drinking water containing 20 becquerels per litre for 70 years, one would expect about one extra cancer in the population as a result. If 7 becquerels per litre is a more correct figure, then a lifetime exposure to 20 becquerels of tritium per litre would actually produce about 3 extra cancers in a population of a million.

How did the ODWAC process get started?

The ODWAC process was precipitated by a unanimous resolution from Toronto City Council asking the Province of Ontario to re-examine the standard for permissible levels of tritium in drinking water and urging the province to adopt a standard more protective of human health than the current standard of 7,000 becquerels per litre. It made a pointed suggestion that the ACES proposal of 1994 be reconsidered.

There is a population of about 5.5 million in the Greater Toronto Area (GTA). The city's drinking water comes from Lake Ontario, which already has levels of tritium of about 7 becquerels per litre. Most of this tritium comes from nuclear reactors – especially the CANDU reactors at Pickering and Darlington. So if ODWAC's lower calculation is the correct one, about 5 or 6 extra cancers in the GTA population are being caused by tritium in drinking water taken from the Lake.

Reasons for an even more stringent standard

ODWAC's proposed standard is based on limiting the number of cancers caused by drinking tritium-contaminated water. However, ODWAC lists a number of other health concerns that might be used to argue for an even more stringent standard. They are listed on pages 35 and 36 of the ODWAC report:

- There is no safe level of exposure to radiation, and even the smallest doses (e.g., background) can cause cancer and other heath effects. Tritium can also promote and accelerate cancer.
- Women are more vulnerable to tritium and are affected differently than men, particularly with respect to their reproductive systems [research has shown that a woman is likely to store twice as much "organically bound tritium" in her body than a man of comparable weight] ;
- Rapidly growing cells such as fetal tissue and young girls' developing breasts, genetic materials, and blood forming organs, are especially sensitive to tritium;

- Tritium can damage DNA, causing a mutagenic effect resulting in cancers, as well as miscarriages, birth defects, sterility, and hypothyroidism, among others. The effects from exposure to tritium can harm offspring and last for generations;
- Female human infants are at risk from elevated tritium levels due to genetic damage to ova exposed to tritiated hydrogen [a woman's eggs are laid down early in infancy and stay with her throughout her life];
- Certain groups are especially vulnerable to environmental carcinogens, such as women (especially when pregnant), the unborn, the elderly, those with compromised immune systems, children, teenagers and Aboriginal people;
- Serious concerns exist about how risk and dose measurements are calculated, because (1) calculations based on "standard man" may not reflect dosages experienced by women and children; (2) Canadian and International standard-setting agencies use an RBE factor* for tritium of "one" (RBE = 1), whereas an RBE factor* of at least "two" (RBE ≥ 2) should be used (ODWAC page 38);
- Exposure studies based on animal testing are not accurate because of the lower body fat levels found in animals;
- Many of the non-lethal cancer effects of tritium are not currently considered in the model upon which the current [7,000 becquerels per litre] standard is based. These effects include non-fatal cancers, miscarriages, still births, birth defects, sterility, hypothyroidism, genetic mutation, respiratory failure, kidney failure, nervous system disorders, cardiovascular disease, among others;
- The current standard does not consider organically-bound tritium [tritium atoms that are incorporated into organic molecules within the body], thus under-estimating the true dose;
- Cumulative exposure and combined effects are not being considered;
- The current standard considers 340 excess fatal cancers per million as an "acceptable risk", which is equivalent to 1 in 3,000;
- Anthropogenic emissions of tritium directly impact the drinking water supplies of approximately one-quarter of the Canadian population, thereby resulting in a large population being exposed involuntarily;
- Levels of tritium are 2 to 5 times higher in Lake Ontario than in other water bodies in the Great Lakes and across Canada, and Lake Ontario is a major source of drinking water for Ontarians;
- It was felt that the precautionary approach is not being applied with respect to tritium in drinking water and that, because there is still uncertainty over the impacts of tritium (such as synergistic effects with other substances), the precautionary principle should be applied and the standard should be lowered.

* *The RBE factor is intended to reflect the Relative Biological Effectiveness of tritium in causing cancers and other illnesses. Doubling the RBE factor has the effect of doubling the estimated biomedical harm from a given tritium exposure, in line with existing evidence.*

Conclusion

Progress on health and environmental matters often depends upon a well-informed and politically active citizenry. Leadership on such issues generally comes from the bottom up, rather than from the top down.

Twenty years ago, when Irene Kock first alerted the citizens of Pickering to the fact that their drinking water was a dumping ground for tritium from Ontario Hydro's nearby reactors, the standard for permissible levels of tritium in drinking water was 40,000 becquerels per litre. Her courageous leadership and persistence at that time led to an Ontario Environmental Assessment Panel recommending to the Government of Ontario that the tritium standard for drinking water be re-examined. In 1994 , the government-appointed ACES committee recommended that the permissible level be dropped immediately to 100 becquerels per litre, and then further reduced to 20 becquerels per litre over a period of five years. Instead, the government lowered the existing standard from 40,000 to 7,000 becquerels.

Fifteen years later, a small group of citizen advocates worked with the Toronto Public Health Department to get the tritium issue onto the city council agenda. This led to the ODWAC investigation. It is now the job of citizens in Ontario and throughout Canada to carry this fight to their provincial legislatures and get the permissible levels for tritium in drinking water tightened across Canada.

Change happens where the political will exists to make it happen. Collective awareness is just the beginning; it must be followed by a collective will to bring about real change.

I believe that the permissible level for any known carcinogen should be zero. This was the formal conclusion of a report entitled "Poisons and Policies" published in the 1980's by the Science Council of Canada. I was a consultant to this task force, which was chaired by Dr. David V. Bates of the McGill Medical School (subqeuently Dean of Medicine at UBC) – one of Canada's foremost experts on lung diseases.

If we must accept some degree of tritium pollution, I believe that no more man-made tritium should be allowed into drinking water than what nature already provides: that is, 1 - 2 becquerels per litre in addition to the background levels already there. This would bring the standard down to about 3 – 5 becquerels per litre – a level already surpassed by the waters in Lake Huron, Lake Ontario, and the Ottawa River as a result of activities from the Canadian nuclear industry.

The Sequel: Tritium in Air

Once the new drinking water standard has been accepted and implemented, it will be time to concentrate on reducing atmospheric emissions of tritium. There is no standard for tritium in air, and the release limits are exceedingly permissive. Yet more tritium is given off by our nuclear reactors as radioactive steam, than as liquid radioactive water. This steam comes back to earth as rain, snow, and dew, depositing tritium fallout over a wide area. It is readily incorporated into fruits, vegetables, fish, and animals, including humans.