ASSESSMENT OF RADIONUCLIDES UNDER THE *CANADIAN ENVIRONMENTAL PROTECTION ACT*

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ÉVALUATION DE RADIONUCLÉIDES CONFORMÉMENT À LA *LOI CANADIENNE SUR LA PROTECTION DE L'ENVIRONNEMENT*

RÉSUMÉ

Les radionucléides dégagés par les installations nucléaires sont une des vingt-cinq substances de la deuxième Liste de substances prioritaires. Ces rejets doivent par conséquent être évalués afin de déterminer s'ils correspondent à la définition de substance toxique de la *Loi canadienne sur la protection de l'environnement*. Le présent exposé effectuera un survol de la méthode d'évaluation du risque écologique utilisée pour l'étude des substances prioritaires, et fait un bref résumé des conséquences potentielles de l'évaluation. La méthode d'évaluation du risque écologique sera illustrée par l'exemple de l'évaluation des installations de production d'uranium, l'un des secteurs étudiés lors de la présente évaluation, et les résultats potentiels de l'évaluation ainsi que les lacunes dans les données disponibles seront présentés.

ABSTRACT

"Releases of radionuclides from nuclear facilities (impact on non-human species)" is one of the twenty-five substances included in the second Priority Substances List. Therefore, releases of radionuclides from nuclear facilities must be assessed to determine whether they are toxic as defined in the *Canadian Environmental Protection Act*. The presentation will provide a general overview of the ecological risk assessment (ERA) framework used for the assessment of priority substances as well as a brief discussion of potential assessment outcomes. An example of the application of the ERA framework to releases of radionuclides from uranium facilities (one of the sectors covered in the scope of the assessment) will be presented, including potential assessment endpoints and data gaps.

1.0 INTRODUCTION

1.1 What is a PSL Assessment?

Under the *Canadian Environmental Protection Act* (CEPA), substances that are placed on the Priority Substances List (PSL) must be assessed to determine whether they are toxic as defined in the Act. Under Section 11 of the Act, a substance "is toxic if it is entering or may enter the environment in a quantity or concentration or under

conditions.

a) having or that may have an immediate or long-term harmful effect on the environment;
b) constituting or that may constitute a danger to the environment on which human life depends;
c) constituting or that may constitute a danger in Canada to human life or health."

In October 1995, the Ministers' Expert Advisory Panel recommended 25 substances for inclusion on the second PSL (i.e. PSL2). "Releases of radionuclides from nuclear facilities (impact on non-human species) " was included on PSL2 based on the following rationale: "The Panel notes that while the Atomic Energy Control Board (AECB) already assesses the risks to human health of radionuclides released from nuclear facilities, there are gaps in the assessment of the risks to non-human species...[1]."

Substances on the PSL usually undergo both an ecological risk assessment (ERA) and a human health risk assessment. In the case of "releases of radionuclides," however, only an ERA will be carried out under CEPA.

1.2 Scope of the Assessment

As recommended by the Panel, the assessment will include releases from nuclear facilities as defined by the AECB-power and research reactors, uranium mines and mills, uranium refining and conversion facilities, particle accelerators and radioactive waste management facilities.

In order to reduce the complexity of the ERA to be performed and to facilitate the identification of control/management options should they be needed, sectorial ERAs will be carried out. The three sectors are:

i) uranium facilities,
ii) power and research reactors,
iii) waste management facilities.

An ERA for each of these sectors will be carried out and where appropriate effects of radiation and of the chemical toxicity of uranium will be assessed. Operational, decommissioned and abandoned facilities/sites will be included in the assessment.

1.3 Potential Assessment Outcomes

One of two possible conclusions will emerge from the assessment. "Releases of radionuclides from nuclear facilities" can either be found "toxic" or "not toxic" under CEPA. If the ERAs indicate that radionuclides are not toxic under CEPA, then no further action would be needed. On the other hand, if the conclusion is that radionuclides are toxic as defined in the Act, then "release of radionuclides from nuclear facilities" would be managed under the federal government's Toxic Substances Management Policy (TSMP). The TSMP will apply to areas of federal jurisdiction and is intended to guide the development and implementation of regulatory and non-regulatory management programs to reduce the levels of substances found to be CEPA-toxic. In accordance with the Policy, Environment Canada will provide technical and scientific advice to other departments such as the Atomic Energy Control Board while public accountability for implementation of the Policy will be ensured through the Commissioner of the Environment and Sustainable Development in the Office of the Auditor General [2].

It is at the management phase that socio-economic factors are considered in developing and implementing management strategies. Socio-economic factors are not taken into account in the ERA. Rather, the objective of an ERA under CEPA is to describe and estimate risks to exposed receptors, whatever their perceived value to society [3].

2.0 ECOLOGICAL RISK ASSESSMENT OF PRIORITY SUBSTANCES

2.1 General Framework

The framework for ecological risk assessment of priority substances described in the Environment Canada (1996) Guidance Manual [3] will be used in the assessment of radionuclides. The ERA involves 3 major steps: problem formulation (scoping and planning), analysis (entry, exposure and effects characterization), and risk characterization.

The assessment will be carried out in a tiered approach. The objective of Tiers 1 and 2 which use, respectively, hyperconservative and conservative point estimates of exposure and effects, will be to determine if radionuclides (radiation dose or U chemical toxicity) have the potential to cause harm in the environment. The assessment would proceed to Tier 3 if a potential for harm is identified. Tier 3 is a more realistic assessment that compares distributions of exposure and effects values rather than point estimates. For naturally occurring radionuclides, their natural background concentrations, in each area of concern, will be used in the course of Tiers 2 and 3 of the assessment.

The ERA focuses on characterization of risk to selected assessment endpoints, for example, risk of reduction in fish production from exposure to radionuclides released to surface waters. As is also often the case with chemicals, direct information on radiation effects may not always be available for assessment endpoints and consequently, measurement endpoints need to be used to estimate effects on assessment endpoints. Examples of relevant measurement endpoints for "reduction in fish production" are: effects on survival and reproduction (fecundity, embryotoxicity, teratogenicity).

2.2 Potential Endpoints for the Assessment of Radionuclides and Characterization of Risks

As indicated in the Guidance Manual [3], a pathways analysis will be used to identify the environmental compartments of concern. A preliminary pathways analysis for releases of radionuclides from uranium facilities (e.g. U mines and mills, U refining and conversion, fuel fabrication) was carried out using some of the available environmental chemistry data and bioaccumulation factors. This information indicates that the environmental compartments of concern are water, sediment, soil, air and biota. From this information, assessment and measurement endpoints were identified to correspond to maximally exposed organisms. Examples are provided in Table 1.

The information presented in Table 1 is preliminary and will be refined as the assessment progresses through further review of the literature and from input from the members of the Environmental Resource Group (experts actively involved in the assessment) and from the Review Group (experts, and various stakeholders).

The available data on selected measurement endpoints will be used to derive a critical toxicity value (CTV) for each assessment endpoint. An estimated no effect value (ENEV) is then calculated by dividing the CTV by an appropriate application factor.

Risk is characterized by comparing expected exposure values (EEV), for example total radiation dose or U concentration in sediments, with the ENEV. In Tier 1 a hyperconservative quotient (EEV/ENEV) is calculated with the ENEV representing the maximum expected or predicted total dose or exposure concentration (e.g. end-of-pipe scenario). Tiers 2 and 3 are progressively made less conservative by considering, for example, a range of measured or predicted exposure concentrations. A determination of "CEPA Toxic" would only be possible if a Tier 3 analysis indicates that adverse effects are likely.

All relevant information, including data on other endpoints such as doses associated with genetic effects, occurrence of cancers or tumors, could be used in a weight of evidence approach to support the conclusion (i.e. CEPA-toxic or not CEPA-toxic) of the assessment.

Table 1. Examples of potential assessment and measurement endpoints for the ERA of releases of radionuclides from uranium facilities

ASSESSMENT ENDPOINT	MEASUREMENT ENDPOINT
Reduction in Fish Production	Effects of Radiation on Survival Effects of Radiation on Reproduction (fecundity, teratogenicity, embryotoxicity) Effects of Uranium on Growth and Survival
Reduction in the Number of Benthic Invertebrates	Effects of Uranium on Growth, Survival and Reproduction Effects of Radiation on Survival and Reproduction (fecundity, teratogenicity, embryotoxicity)
Reduction in Aquatic Primary Production	Effects of Uranium on phytoplankton growth and photosynthesis
Impairment in the Reproduction of Muskrat Alteration of Kidney Morphology and Function of Wildlife	Effects of Radiation on Fecundity, Embryotoxicity and Teratogenicity in Mice Effects of Uranium on the Survival of Mice Effects of Uranium on Kidney of Laboratory and Domesticated Animals
Damage to Terrestrial Plants	Effects of Uranium on Germination and Growth Effects of Radiation on Annual Stem growth, Reproduction and Survival of Conifers

2.3 Data Gaps and Uncertainties

At this point some data gaps and areas of uncertainties have been identified. For example, in contrast to the extensive database on the toxicity of uranium to mammals, few studies have been carried out to assess the toxicity of uranium to aquatic species. No studies dealing with the effects of uranium on benthic invertebrates, macrophytes or phytoplankton have been found. Likewise, no studies on the effects of radiation on aquatic macrophytes and phytoplankton have been found.

Concerning the effects of radiation, two areas of uncertainty are noted:

i) the scarcity of data on the effects of internally deposited radionuclides (e.g. alpha and beta emitters) in comparison to the effects of external gamma-emitters;

ii) the most appropriate factors to account for the relative biological effectiveness (RBE) of alpha (and beta?) emitters.

Additional areas of uncertainty are the significance at a population level of the occurrence of genetic damage (e.g. DNA strand breaks) in individuals of that population and the pertinence of using threshold vs. non-threshold dose-response curves for genetic endpoints.

One of the objectives of the problem formulation is the identification of major data gaps that would need to be filled through research before the assessment can proceed.

3.0 CONCLUSIONS

It is expected that the ERA of "Releases of Radionuclides from Nuclear Facilities" under CEPA will be carried out over a period of about two years. It is anticipated that a problem formulation for all three sectorial ERAs would be ready towards the end of January 1997.

The successful completion of the assessment will be ensured by its scientific quality and by the transparency of the process. The scientific quality of the assessment will be attained through the active participation of members of the ERG and input from the Review Group, and publication of pertinent material in peer-reviewed journals. Transparency of the process will be attained by making assessment documents available for stakeholder review during the process. Information sessions can also be held upon request by industry, government regulatory agencies, and non-governmental environmental groups.

4.0 DISCUSSION

Question No. 1: ***Is the assessment for whether radionuclide releases are "CEPA toxic" or not, to non-human biota, to be performed at existing emission levels or at artificially high levels.***

Dr. Thompson replied that CEPA assessment is based on entry levels or at actual release levels. However if no data are available they would model the data.

Discussion of the concept of "adverse effects" followed. Dr. Thompson indicated that although the definition is specified as "potential adverse effects," the assessment needs to be based on science where actual observable effect would be used. Existence of an adverse effect at a given exposure level would be based on statistical variation from normal response — for example if, say, 25% of individuals exhibited the effect.

Question No. 2: ***Isn't the use of the terminology "toxic substance" somewhat inaccurate in this context? That is, it is the dose received that is toxic, not simply the presence of a substance [inherent toxicity].***

Dr. Thompson agreed that toxic substances are defined in the *Canadian Environmental Protection Act* (CEPA) in terms of the quantity or concentration (in effect the dose) that may have adverse effects.

Question No. 3: ***How wide is the scope of assessments? Might the effects of other forms of generation (e.g., data from the U.S. suggests that with decreasing nuclear electricity generation and increasing reliance on coal, the emissions of acid gases and natural radioactive emissions is increasing) be considered in this assessment?***

Dr. Thompson indicated that other forms of electricity generation would not be assessed. The objective of the CEPA PSL2 study is to assess the effects of radioactive releases from nuclear facilities in Canada. Assessment of comparative risks of alternative energy forms is outside the scope, and would basically be a societal judgment.

Question No. 4: Would you please expand on Environment Canada's Toxic Substances Management Policy (TSMP)?

Dr. Thompson replied that the TSMP specifies that depending on certain criteria (e.g. bioaccumulation, environmental half life), a CEPA toxic substance would be managed under either of two tracks: Track 1, managed toward virtual elimination; and Track 2, managed to control of toxic discharges.

Karen Lloyd (Environment Canada) provided additional details on the specific criteria for Track 1 substances:

1. It is designated as "CEPA Toxic," or has equivalent designation under some other legislation.
2. It is persistent in the environment with an environmental half-life in a given medium exceeding specified values (ranging from 2 days in air to 1 year in sediments).
3. It is bioaccumulative, with a BAF [bioaccumulation factor] or BCF [bioconcentration factor] equal to or greater than 5000.
4. It is predominantly anthropogenic (i.e. concentrations in the environment are largely due to human activities).

She noted that naturally occurring substances like metals could not be placed on Track 1 as they could not be virtually eliminated. Natural background concentration would be considered in any assessment. Consideration of concentrations would be factored into the assessment.

5.0 REFERENCES

[1] Report of the Ministers' Expert Advisory Panel on the Second Priority Substances List Under the *Canadian Environmental Protection Act* (CEPA). October, 1995.

[2] Government of Canada, Environment Canada. 1995. Toxic Substances Management Policy. June 1995.

[3] Environment Canada. 1996. Ecological Risk Assessments of Priority Substances Under the *Canadian Environmental Protection Act*. Guidance Manual — Interim. September 1996. Chemicals Evaluation Division, Commercial Chemicals Evaluation Branch, Environment Canada.