HONG KONG RADIATION PROTECTION SOCIETY

Professor NG Ching-fai
Chairman
LegCo Panel on Environmental Affairs

Dear Professor NG,

Thank you very much for inviting us to submit our opinion on the subject of "Removal of radioactive wastes" to the Legco. In the following pages, I have included a brief review of the biological effect of radiation, health risks for low doses of radiation as well as recommendation for radioactive wastes disposal.

The toxicity of radioactive wastes is one of the best understood amongst the various harmful pollutants. Such wastes require careful management to ensure adequate protection of humans and the environment. Policies for radioactive wastes management should integrate both technical and ethical considerations to maximise the benefits and limit the potential adverse effects to the public and the environment. A balanced and objective understanding of environmental or health impacts for such policies (and in fact any environmental policy) should be approached with an open mind and involve a broad spectrum of public representatives in order to create the conditions for a sound analysis of all the relevant aspects.

We hope our opinion can assist in the analysis of the subject. Thank you very much for your attention.

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1. Biological Effects of Radiation

When ionizing radiations, such as X- and gamma rays, interact with living tissue, it is the absorption of radiation energy in th tissues which causes damage. Whenever radiationis absorbed, chemical changes are produced virtually immediately, and subsequent molecular damage follows in a short space of time (seconds to minutes). It is after this, during a much longer time span of hours to decades, that the biological damage becomes evident.

During radiation exposures, the ionization process causes the majority of immediate chemical changes in tissue. The critical molecules of radiation damage are believed to be the proteins and nuclei acid. The damage occurs in two basic ways: by producing lesions in solute molecules directly, or by an indirect action between the solute molecules and the free radicals produced during the ionization of water.

Indirect damage arises more commonly because living tissue is about 70-90% water. If a pure water molecule is irradiated, it emits a free electron and produces a positively charged water ion, which immediately decomposes:

$$H_2O \ + \ \text{radiation} \ \rightarrow H_2O^+ + e^-$$

$$H_2O^+ \overset{\text{decomposes}}{\rightarrow} H^+ + OH\bullet$$

The hydroxyl free radical $OH\bullet$ is a highly reactive and powerful oxidizing agent which produces chemical modifications in solute organic molecules. These interactions, which occur in microseconds or less after exposure, are one way in which a sequence of complex chemical events can be started, but the free radical species formed can lead to many biologically harmful products and can produce damage chain reactions in tissue.

At the molecular level, these chain reactions will cause damage to macromolecules such as DNA, RNA, and enzymes. At the subcellular level, cell membranes, nuclei, chromosomes, etc. are affected. And at the cellular level, cell death can result or transformation of the cell to a malignant state could be induced. However, it is also important to realize that cell repair can also occur, and is an important mechanism when there is sufficient time for recovery between irradiation events.

2. Radiation Related Health Risks

At low radiation doses, the stochastic effects (or probabilistic effects) of carcinogenesis and genetic damage are of primary importance. For the stochastic effects, the probability of an effect occurring (rather than its severity) increases with dose. The existence of any threshold doses for stochastic effects is unknown and controversial, and for radiation protection purposes, stochastic effects are assumed to have no threshold.

It is difficult to assess the genetic risk in humans, as even the descendants of those exposed at Hiroshima and Nagasaki have shown no additional genetic or cytogenetic effects. The frequency of congenital defects, fecundity, and life expectancy appear to be no different than for the children of nonirradiated parents. Similarly, surveys of descendants of radiotherapy patients show no increase in congenital defects. However, a safety margin is included in all risk estimates. The risk of hereditary ill-health in subsequent children or grandchildren is estimated to be at worst 10 extra cases from a million individual parents exposed to 1 mGy, whereas the normal incidence, without irradiation, is about 70,000 cases.

In ICRP Publication 26 (1977)[1], the fatal cancer radiation risk was estimated to be 1.25% per sievert for whole-body exposure. Recent revisions (by BEIR, UNSCEAR and ICRP[2]) increased the radiation-induced fatal cancer risk by a factor of between 2 and 3 (4% per sievert depending on the exposed population). This data can be interpreted as 4 fatal cancer cases in a population of 100 individuals each receiving 1 Sv whole-body exposure.

However, it should be emphasized that these probability coefficients for organs are very approximate, containing a large number of uncertainties, among those the uncertainties in extrapolation from observed high dose, high dose rate effects necessary to estimate the effects at low doses.

3. Natural and Artificial Sources of Radiation to Population Dose

The background radiation contributes a major portion of the radiation dose to each individual. Everyone is exposed to natural background radiation to a greater or lesser extent depending on where they live and the food intake. Artificial or man-made sources of radiation also contribute to individual overall exposure.

The largest contributor from natural background is exposure to radon gas, which permeates through the ground and into buildings. The radiation dose from radion ranges widely from negligible to over 50 mSv, depending on the geology. Hong Kong being situated on a granite rich geological region, and with dwellings mostly of concrete, the Kong Kong population has a higher than world average radiation dose from radon exposure. There is also intake of natural long-lived radionuclides in our food and drink. Cosmic radiation is another source of natural background radiation and frequent air travelers could receive a much higher overall dose as the cosmic ray dose increases considerable with altitude.

Of the total radiation exposure, a certain proportion comes from artificial sources, with diagnostic medical radiation being the largest artificial source.

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For example chest x-ray has a effective dose of 0.2 mSv[3], while other exams can result in a whole body dose of 10 mSv or more.

4. Recommendations for Management of Radioactive Wastes

Any activity that produce or make use of radioactive material generates radioactive wastes. Majority of the radioactive waste generated in Hong Kong is from medicine and industry. The waste can be in solid, liquid or gas form and the waste can remain radioactive and be a potential health hazard for a long time. And the health risk resulting from radioactive wastes, however small, jeopardizes the well being of the public. Proper disposal is essential to ensure protection of the health and safety of the public. It also safeguards the quality of the environment including air, soil, and water supplies.

In the management of long-lived radioactive substances, as for other hazardous substances, there are essentially three options. The first is to dilute and disperse, the second is to store and monitor, and the third is to dispose by containment and isolation.

The dilution and dispersal of wastes in the air and water of the biosphere is now approached with great caution and is subject to strict regulatory control and is usually inapplicable to radioactive wastes with long half-lives.

The objective of disposal by containment and isolation is to isolate the wastes from the biosphere for extremely long periods of time, ensure that residual radioactive substances reaching the biosphere will be at concentrations that are insignificant compared, for example, with the natural background levels of radioactivity. Today there is a broad international consensus on the technical merits of the disposal of long-lived radioactive wastes in containment and isolation. Proper management of the facility will render the risk from inadvertent human intrusion acceptably small. Most importantly, proper siting of the waste facility is of utmost importance for minimizing the health risks to the public[4].

References:

1. International Commission on Radiation Protection Publication 26, 1977.
2. International Commission on Radiation Protection Publication 60, 1991.
3. RF Farr and PJ Allisy-Roberts, *Physics of Medical Imaging*, Saunders 1997.
4. http://www.ag.ohio-state.edu/~rer/rerhtml/rer_42.html