

REEXAMINATION OF RADIOTOXICITY

OF IODINE-129

Oktaý I. Oztunali, Kim D. Petschek
Dames & Moore
20 Haarlem Avenue, White Plains, NY 10603

ABSTRACT

During the comment period following the publication of the proposed rule 10 CFR Part 61, comments were received on the appropriateness and the validity of the limiting concentrations in the waste for the iodine-129. In the past, iodine-129 was believed to be present in very small concentrations in the generated low-level radioactive wastes. Consequently, it was thought that no special procedures would likely need to be implemented to the waste form or disposal facility design in order to safely dispose of waste containing iodine-129. This paper presents an analysis and findings resulting from the reexamination of radiotoxicity of iodine-129.

INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) proposed Part 61 to the rules in Title 10 of the Code of Federal Regulations (10 CFR Part 61) with the intention of limiting human exposures to radionuclides from land disposed radioactive wastes (Ref. 1). Part 61 provides licensing procedures, performance objectives and technical requirements for the issuance of licenses for the land disposal of "low-level" radioactive waste (LLW). Included in the technical requirements is the specification of maximum concentrations of various short and long lived radionuclides which are allowed in wastes destined for near surface disposal. One of the radionuclides for which a maximum concentration is designated is iodine-129.

During the comment period following the publication of the proposed rule 10 CFR Part 61 and the accompanying draft Environmental Impact Statement (EIS) on 10 CFR 61: Licensing Requirements for Land Disposal of Radioactive Waste (NUREG-0782) (Ref.2), comments were received on the appropriateness and the validity of the limiting concentrations in the waste for the iodine-129 (I-129). In the past, I-129 was believed to be present in very small concentrations in the generated low-level radioactive wastes. Consequently, it was thought that no special procedures would likely need to be implemented to the waste form or disposal facility design in order to safely dispose of waste containing I-129. In addition, it was believed by some that, as a result of competition between the natural non-radioactive iodine and the radioactive nuclides, I-129 would not be present in biota in sufficiently large concentrations (as a result of natural dilution) to result in appreciable exposures. This paper presents an analysis and findings resulting from the reexamination of radiotoxicity of I-129.

Presented below is a brief summary of the concentrations of I-129 found in the U.S. generated low-level radioactive waste and its generation rate, and the pathway analyses methodologies utilized in calculating the radiation exposures resulting from disposal of this radionuclide. Following this background, an analysis of the dilution potential for I-129 is performed through an examination of the environmental concentrations of I-129, its chemistry

and uptake, and its dilution potential. Finally, the conclusions resulting from this reexamination are detailed.

Waste Concentrations and Generation Rates

Estimated concentrations of I-129 in radioactive waste expected to be routinely generated between the years 1980 to 2000 has been analyzed in the data base for radioactive waste management (Ref. 3) prepared for the draft EIS. In reference 3, low-level radioactive waste was divided into 36 separate waste streams and each waste stream was characterized in terms of its physical, chemical and radiological properties.

The concentrations of I-129 in the waste streams utilized in the radiological impact assessments performed for the draft EIS were calculated using the methodologies presented in reference 3. Since the publication of reference 3, however, additional information has been compiled on the total radioactivity content distribution of a number of light water reactor (LWR) power plant process waste streams (Ref.4). This new information does not alter the comparative concentration ratios of the radionuclides considered in each LWR waste stream (i.e., the fraction of the total waste stream activity provided by a given radionuclide is assumed to be constant). However, the new information indicates that the average radioactive concentrations calculated in reference 3 should be adjusted upward for most of the LWR process waste streams. Both the previous and the updated concentrations for I-129 are summarized below.

Iodine-129 is produced by fission. It decays by beta emission to xenon-129 with a half-life of 1.7×10^7 years. The emitted beta particles have a maximum energy of 0.150 MeV. The beta decay is accompanied by the emission of xenon x-rays and conversion electrons with energies of 0.005 MeV and 0.034 MeV, respectively (Ref.3). Fission of U-238, U-235, and Pu-239 (produced inside the reactor core through neutron absorption by U-238) is the principal means through which I-129 is generated. Consequently, only waste streams generated by light-water reactors and by medical isotope production facilities are expected to contain significant amounts of I-129. These concentrations and expected generation rates are presented in Table I (Refs. 3 and 4).

TABLE I . Estimated I-129 Generation Rates

Waste Stream	Activities (Ci/m ³) (Ref. 3)	Activities (Ci/m ³) (Ref. 4)	Vqlumes (m ³ per Gw(e)-yr)	Total Activity (Ci per Gw(e)-yr)
P-IXRESIN	2.44E-06	5.60E-04	17.6	9.85E-03
P-CONCLIQ	3.16E-06	2.43E-05	123.0	2.99E-03
P-FSLUDGE	2.37E-06	1.72E-05	2.2	3.79E-05
P-FCARTRG	1.06E-06	NC*	11.0	1.17E-05
P-COTRASH	2.78E-07	NC	215.0	6.00E-05
P-NCTRASH	6.41E-06	NC	110.0	6.75E-04
Totals			478.8	1.36E-02
B-IXRESIN	2.04E-04	2.47E-04	80.7	1.99E-02
B-CONCLIQ	6.65E-06	2.00E-05	223.0	4.47E-03
B-FSLUDGE	1.33E-04	1.42E-04	179.0	2.54E-02
B-COTRASH	7.14E-07	NC	221.0	1.58E-04
B-NCTRASH	1.15E-04	NC	105.0	1.20E-02
Totals			808.7	5.37E-02
Waste Stream	Activities (Ci/m ³) (Ref. 3)	Activities (Ci/m ³) (Ref. 4)	Vqlumes** (m ³ per year)	Total Activity (Ci/year)
L-DECONRS	3.34E-05	NC	1666	5.56E-02
N-ISOPROD	2.72E-06	NC	148	4.03E-04
Totals			1814	5.60E-02

Source : References 3 and 4.

(*) NC : No Change

(**) Volumes are for the year 1980.

Utilizing the information in Table I and the specific activity of I-129 of 1.63×10^{-4} Ci/g, expected I-129 generation rates may be estimated. These rates are about 83.44 grams of I-129 per GW(e)-yr for PWRs, 379.75 grams of I-129 per GW(e)-yr for BWRs, and 343.56 grams of I-129 per year from other sources.

Pathways and Dose Conversion Factors

As discussed in the draft EIS and in "Data Base for Radioactive Waste Management, Volume 3, Impact Analysis Methodology Report" (Ref. 5), eight sets of pathway dose conversion factors (PDCF's) are used to determine potential radiological dose equivalents based upon a unit concentration of a radionuclide at a biota access location. That is, assuming that there exists a unit concentration of a radionuclide at a biota access location (e.g., 1 Ci/m³ in water obtained from a well), there may be a number of pathways through which radiological exposures to an individual could occur. These could include direct consumption of the water or consumption of food which has been irrigated by the contaminated well water. Airborne resuspension of the contaminated irrigated soil is another potential pathway. PDCF's are used to reduce to a single set of numbers all of the potential pathways from a biota access location and the transfer of radionuclides through these pathways. This is preferable to repetitively calculating all of the pathways and transfer mechanisms through each stage of the impact analysis methodology.

The eight basic groups of uptake pathways leading to human exposures, and the PDCF's corresponding to these pathways, are as follows:

- PDCF-1 : Accident
- PDCF-2 : Intruder-construction-air
- PDCF-3 : Intruder-agriculture-air
- PDCF-4 : Food
- PDCF-5 : Direct gamma
- PDCF-6 : Well water
- PDCF-7 : Open water
- PDCF-8 : Atmospheric transport

In order to classify a particular waste stream or to determine individual radionuclide concentration limitations, two radionuclide release events corresponding to the intruder-construction and intruder-agriculture scenarios are considered. Detailed discussion of these inadvertent intruder scenarios and the classification methodology is presented in reference 5.

Through calculations of the dose to the intruder, it is evident that the "food" pathway represented by PDCF-4 is about 10 times more significant than the other pathways for I-129. As a consequence of the dominance of the "food" pathway parameters which affect the calculation of PDCF-4 are directly relevant. The soil-to-plant concentration (uptake) factor (usually called B_{iv} in the literature) is directly proportional to PDCF-4 and was examined in this analysis.

ANALYSIS

There are two major interrelated questions that must be addressed in order to resolve the concern over limiting concentrations of I-129 in the waste. These questions are:

- (1) Whether natural iodine will provide a means of limiting exposures (especially thyroid exposures) which may result from the near-surface disposal of waste containing I-129; and
- (2) Whether it is possible to provide artificial dilution by disposing certain wastes together with material containing high concentrations of natural iodine.

In addition to these two major questions, there are two peripheral questions that have a bearing on the issue of concern. These two questions are:

- (3) Whether natural and/or artificially introduced stable iodine will behave chemically in a manner similar to radioiodine in the pathways of concern; and
- (4) Assuming that stable and radioactive iodine chemically behave identically, whether the atom ratio I-129/I-127 resulting from either natural or artificially introduced stable iodine will remain approximately constant along the pathways of concern and thereby provide dilution.

In addressing these questions, two factors should be considered. First of all, it should be pointed out that the thyroid exposures are the main area of concern. Thyroid PDCF's are approximately 1000 times the PDCF's for other human organs. Secondly, it should be pointed out that a primary question relating to the chemical behavior of iodine is its solubility in water. That is, both the "food" pathway, whose predominance within the intruder initiated scenarios was pointed out earlier, and the "ground water migration" scenarios start with the dissolution of iodine in water.

Within this framework, the areas considered include the environmental concentrations of natural, stable and radioactive iodine, the chemistry and uptake of iodine, and the concentrations of I-129 in waste in comparison with natural and/or artificially introduced iodine concentrations.

Environmental Concentrations

Although iodine is not a particularly abundant element (ranking as the forty-seventh most abundant element in the earth's crust, counting the rare earths as a single element), it is fairly widely distributed in nature (Ref. 6). The average concentration in the earth's crust is variable but has been estimated to average about 0.3 parts per million (ppm) (Ref. 7). Significantly higher iodine concentrations are found in certain sodium nitrate mining deposits in Chile, in which iodine occurs as calcium iodate in concentrations of about 0.1 weight percent of iodine (Ref. 7).

Other variations in the iodine content of natural soil and rock have also been reported. Concentrations reported include an average of 22 to 1900 parts per billion (ppb) in volcanic rocks (Ref. 8), 75 to 150 ppb in igneous rocks (Ref. 8), and 0.3 parts per million (ppm) in igneous rock (Ref. 9). The abundance of iodine in sedimentary rock is on the order of 1000 times that of igneous rock and marine sediments are richer in iodine than sedimentary rock (Ref. 8).

There appears to be a marked increase in the iodine content in soil compared to the rocks that the soil is derived from. Two estimates of the average iodine content in soil are 5 ppm (Ref. 8) and 1.2 ppm in the top twelve meters of soil in the United States (Ref. 10).

The iodine concentration within surface and ground waters is also variable. Concentrations reported include an average of 0.05 ppm (Refs. 6,7) to 0.06 ppm (Ref. 11) in sea water, 0.0033 to 0.042 ppm (Ref. 10) in the principal rivers of the USSR, 0.0007 to 0.015 ppm in New Zealand groundwater (Ref. 12), 13.6 to 85.9 ppm in ground water in Kerr County (Ref. 13), 0.02 to 2 ppm in the coastal plain of North Carolina in ground water associated with phosphorite deposits (Ref. 12), 48 ppm in the highly mineralized water in the Midland County Michigan, up to 77 ppm in the Vienna basin, 50-80 ppm at Tchusowkaja in the western Urals (Ref. 12), 10-35 ppm in California and Kentucky oil-field brines (Ref. 9), less than 0.1 ppm in volcanic hot springs (Ref. 9), 0.7 to 39 ppm in thermal waters believed to contain water of connate or metamorphic origin, and 0.2 to 1.0 ppm in New Zealand volcanic thermal waters (Ref. 14).

Another relevant value is the ratio of radioiodine (I-129) to stable iodine (I-127). These reported values include measurements of pre-atomic age materials showing I-129/I-127 ratios of about 2×10^{-15} for a very old iodine rich ores, 3×10^{-12} for chemicals and 1×10^{-10} for biological materials. A nominal base-figure value of 3×10^{-12} for pre-1945 potassium iodide is used by many investigators (Ref. 15).

More recent ratios have been reported at 3×10^{-12} to 1×10^{-6} in the biosphere during the early 1950's, 1×10^{-10} to 1×10^{-8} in biological material samples in the late 1950's and early 1960's (Ref. 15),

4.8×10^{-10} to 3.1×10^{-9} in bovine thyroid samples taken in 1962 (Ref. 16), 3×10^{-7} in bovine thyroid samples taken recently in Vermont and New Hampshire (Ref. 17), up to 3.9×10^{-5} in thyroid tissues of other than bovine animals around existing nuclear facilities, up to 1.7×10^{-6} in bovine thyroid in around northeastern Oregon (Ref. 18) and 4.5×10^{-7} around the Savannah River Plant (Ref. 19).

These experimental data (and calculations based on these data), have led some investigators in the past to suggest the total body dose to humans should be used as a better indicator of the limiting exposure due to I-129 than the thyroid dose (Ref. 20). The selection of the total body dose instead of the thyroid dose results in a significant difference in limiting exposures since the fundamental dose conversion factors for thyroid are about 1000 times that of total body. This is not believed to be justifiable, however. Reference 20 quotes a calculation stating that if the ratio of I-129 to I-127 in the thyroid is 2 percent or less, it is not possible to exceed 1500 mrem/year for thyroid exposures (Ref. 21).

Iodine Chemistry and Uptake

As was pointed out earlier, ingestion of iodine through the "food" pathway is a function of the rate of iodine transfer between the soil and plant roots (the soil-to-plant uptake factor, B_{1v}), and the dissolution of iodine in water. These are of importance in a reexamination of I-129 radiotoxicity, since the food pathway is the major contributor of exposures to potential inadvertent intruders and is also of importance in determining exposures due to ground water migration. The major contributor to ground water exposures is through water to human pathways which are again a function of the dissolution rate of iodine in water.

Iodine is a nonmetallic element belonging to the halogen family. There are 24 known isotopes of iodine with 18 of these isotopes having half-lives of less than 1 day. The only stable isotope is I-127. Although iodine is known in the -1, +1, +3, +5, and +7 oxidation states, its usual occurrence is as the -1 (iodide, I^-) state in fresh waters and as an iodate (IO_3^-) in marine or similar aqueous environments (Refs. 6, 8). Iodine, like the other halogens, is very active chemically, but is usually less violent in its action. Iodine is also a volatile element, subliming at atmospheric pressures without melting.

A considerable proportion of iodine occurs in organic forms which are much less reactive than elemental iodine (Ref. 22). Most compounds of iodine are very soluble. Iodine in aqueous solutions free from oxidizing agents generally exists as iodide (Ref. 8).

Soil-to-plant concentration factors (uptake factors) are obtained from experiments on plants grown in the laboratory or in the field and are also estimated from the statistical correlation between the concentration in a crop and the cumulative ground deposition. In general, ions of any element present in the soil will pass into the root system whether or not they are essential for plant growth (Ref. 23). Plant roots absorb only the soluble species of metals (Ref. 23). The major factor governing the availability of radionuclides to plants in soils is the solubility of the nuclides in the soil matrix.

Iodine is not concentrated by vegetation and is classified by Menzel as in the "not concentrated" class (Ref. 24). It has been shown with stable iodine however that uptake increases with increasing concentration in the substrate and that uptake increases when the soil pH was reduced down to about 4. Elevated levels of soil iodine have been shown to be toxic to plants. The most sensitive species studied was lettuce which was drastically affected at all levels of applied iodine above 10 ppm.

Another important factor is the limits on iodine concentration in the thyroid. Normally the adult thyroid has an iodine content of 7 to 8 milligrams (mg) although this varies greatly in individuals (Refs. 25-27). The normal adult thyroid takes up approximately 80-100 micrograms of iodide per day (Ref. 28). It is known that insufficient thyroid iodine content leads to goiters (Ref. 28). The inverse of this condition (i.e., administration of large amounts of iodine) may also have an upper bound. The National Council on Radiation Protection and Measurements (NCRP) has published reports on the function of stable iodine as a blocking mechanism for persons potentially exposed to high levels of radioiodine. The report states that "toxic reactions from a brief course of iodide treatment should be rare. A few individuals, however, are sensitive and may develop angioedema. Chronic iodide poisoning, or iodism, can also occur but only after ingesting iodides for several weeks or longer. Symptoms and signs include sialadenitis, rhinitis, conjunctivitis, headache, drug fever and skin rashes. In either acute or chronic toxicity reactions, withdrawal of a medication and supportive care is all that is necessary and symptoms disappear within a few days" (Ref. 28). The NCRP also states that it has been determined that toxic effects of iodide are not noted with doses of 100 mg (about 130 mg of KI) per day given to children over a course of years and that iodide goiter will result only after daily doses of several hundred milligrams of iodide administered for years.

Iodine Dilution Potential

According to Soldat (Ref. 27) an I-129/I-127 atom ratio of 1:48 is required to limit thyroid exposures to 1500 mrem/year.^a This case appears to be the "worst case" scenario and the value of 1:48 is in agreement with other calculations (Ref. 21). This results in a concentration of 3.6 uCi of I-129 per gram of total iodine. Utilizing the specific activity of I-129 of 1.63×10^{-4} Ci/g, this yields a ratio of about 22 mg of I-129 per gram of total iodine. It would be reasonable to assume that if this ratio were 1:960, the thyroid exposures would be limited to 75 mrem/year.

This relationship determined by Soldat can be used to determine the potential for natural dilution of stable iodine to reduce I-129 exposures either from direct contact by inadvertent intruders or from water to human pathways resulting from consumption of ground water contaminated by radionuclides migrating from the disposed wastes.

To estimate the I-129 concentrations in disposed waste, the expected generation rates of I-129 in routine radioactive waste determined previously can be utilized. These rates were calculated to be about 83.44 grams per GW(e)-yr for PWRs, 379.75 grams per GW(e)-yr for BWRs, and 343.56 grams per year from other sources.

Based upon an estimated average PWR capacity during the years 1980 to 2000 of 87,798 MW(e), a BWR capacity of 41,612 MW(e), and accounting for the contributions of other waste sources (a factor of 1.72 is incorporated to account for the linear increase in the generation rate of waste from other sources) (Ref. 5), an average total generation rate of about 23,718 grams of I-129 per year can be calculated. This value corresponds to an activity of about 3.87 Ci/year. Normalizing these generation rates to the waste volumes assumed in the draft EIS for the reference disposal facility (50,000 m³/year of waste disposed) results in an I-129 value of 6552 g/year (1.07 Ci/year).

These values can be used to arrive at average I-129 concentrations in disposed waste. Assuming that the wastes containing iodine are disposed together, and considering the average annual waste volumes of 42,038 m³/year from all PWRs, 33,652 m³/year from all BWRs, and an average of 3120 m³/year (1814x1.72) from all other sources (totaling 78,810 m³/year), one may calculate an average I-129 concentration of about 0.30 g/m³ (4.91×10^{-5} Ci/m³). This value is about 150 times less than the concentration limit of 8 mCi/m³ for Class A wastes given in Table I of reference 1. However, if the average annual generation rate of all wastes (including those that are not expected to contain I-129) is considered (about 1.72×10^5 m³/year), this would yield an average I-129 concentration of 0.14 g/m³ (2.24×10^{-5} Ci/m³).

For purposes of illustration and comparison with the Soldat relationship, assume that the average concentration of total iodine in the soil/waste mixture ranges from 1 to 5 ppm, and that soil/waste mixture density is about 1.6 g/cm³. The waste usually contains very little stable iodine; consequently, this implies an assumption of almost 2 to 10 ppm of total iodine in the soil assuming that the waste is disposed randomly. These assumptions yield a concentration of total iodine ranging from 1.6 to 8 g/m³. These values, when used in conjunction with the values previously calculated for I-129 of 0.30 g(I-129)/m³ for wastes expected to contain I-129 and the value of 0.14 g(I-129)/m³ averaged over all wastes results in the following I-129/I-127 ratios:

Soil/Waste Iodine (ppm)	Waste averaging considered	I-129/I-127 ratio
1	all waste	1:11 (.088)
1	waste containing I-129	1:5 (.19)
5	all waste	1:57 (.018)
5	waste containing I-129	1:27 (.038)

Further assuming that the I-127 in the soil behaves in a chemically similar manner as the I-129 in the waste, this calculation implies that natural dilution of I-129 by stable iodine will not limit exposures to thyroid to levels below 1500 mrem/year if I-129 is assumed to be distributed throughout the wastes expected to contain I-129. (This analysis conservatively assumes that a person's total iodine input is from the disposal site; in reality considerable stable iodine, which would tend to dilute to ingested radioiodine, would probably be received from other sources). However, it will limit exposures to below 1500 mrem/year if it is assumed to be distributed throughout all the wastes expected to be

^a Soldat calculates that undiluted I-129 could result in a dose to the thyroid of 73 rem/yr.

generated, which is a questionable premise, and if the average iodine concentration in the soil/waste mixture is as high as 5 ppm. Moreover, the assumption that the average concentration of natural iodine in the soil/waste mixture will be as high as 5 ppm is not believed to be conservative. The previous discussion of the environmental iodine concentrations indicates a relatively wide variation in the stable iodine content of soil and further implies that the iodine concentration may be less than 1 ppm.

Discussion

An earlier work (Ref. 21) also performed a calculation similar to the above, assuming an iodine soil concentration of 1 ppm. This work concluded that I-129 exposures were inherently limited to levels less than 1500 mrem/year and has been used as a basis by some for stating that I-129 need never be considered a problem in low-level waste disposal. This work assumed that 175 grams of I-129 is shipped to a disposal site per year, based on the assumptions that a reactor produces 230 grams of I-129 per year, 0.1% escapes from the reactor fuel, and the disposal site receives waste from 25 reactors. This value of 175 grams/year is considerably different than the above calculated value of 6552 grams of I-129 per year shipped to the reference disposal site. The 6552 gm/yr value is based upon projections of waste concentrations and volumes which are based on experimental data. Given this difference, however, a series of vigorous measurement providing additional experimental data on the I-129 content of LWR waste streams would be most useful.

Another problem is that both the above analysis and the one in reference 21 assume that the I-127 in the soil/waste mixture behaves in a chemically similar manner to the I-129 in the waste. This is a questionable premise since neither the chemical form of the I-129 in the waste nor the chemical form of the I-127 in the waste and soil are known. Assuming that stable iodine is to dilute uptake of I-129, then the stable iodine must be in a form which will dissolve at the same rate as the I-129 in the waste and thus both be taken up by plant roots at the same rate. There is no experimental evidence to support this supposition. In the case of natural iodine in soil, it appears reasonable to assume that the natural iodine is mostly in an insoluble form, since if it was in a soluble form it would have been long ago leached out of soils. Experiments to leach natural iodine from volcanic rocks usually removed less than 20 percent of the total iodine in the rock, and only about 23 percent of the total iodine contained in marine sediments could be extracted with organic solvents (Ref. 7).

A final problem in both the above analyses is the dose criteria used for comparison, i.e., 1500 mrem/yr. While a thyroid dose criteria in the range of a few rems may be appropriate for potential inadvertent intrusion (which is a hypothetical event potentially involving only a few persons), a much lower dose criteria is appropriate for groundwater migration. This statement is based on proposed and existing federal standards for groundwater and drinking water contamination as water contamination as well as the real concern that most persons have regarding groundwater protection. For example, the proposed 10 CFR Part 61 Regulation for licensing requirements for land-disposal of radioactive waste sets a limit of 75 mrem/yr for potential human exposures as determined at the site boundary. In addition, the existing EPA interim primary drinking

water standard (40 CFR Part 191) sets a limit of 4 mrem/yr for exposures due to consumption of water from public water supplies.

The potential of diluting some of the wastes artificially with natural iodine as they are placed in the near-surface disposal facility also requires examination. In the case of groundwater impacts, for example, the stable iodine would have to leach at the same rate and pass through the soil matrix at the same speed as the radioactive iodine in order to arrive at the biota access location at the same time. Assuming that this is the case, about 15 grams of natural I-127 per m³ of waste would be required to reduce the estimated average I-129 concentrations (about 0.30 grams per m³ of waste expected to contain I-129) to an I-129/I-127 atom ratio dilution of 1:48 (i.e., a dose limit of 1500 mrem/year); about 300 grams of natural iodine per m³ of waste (an atom ratio of 1:960) would be required to reduce exposures to 75 mrem/yr; and about 5625 grams of natural iodine per m³ of waste would be needed to produce an atom ratio of 1:18,000 and thus reduce exposures to levels less than 4 mrem/yr.

However, the natural iodine thus employed would have to behave in a chemical manner similar to the I-129 contained in the waste. The chemical form of I-129 in the waste is not known at the present time. It appears that due to the complex behavior of iodine both in the plants and soil and the various organic and inorganic compounds it forms, a controlled series of experiments would be useful as a means of testing this approach.

CONCLUSION

It thus appears from the preceding discussion that natural iodine will not provide a means of limiting exposures which may result from the near surface disposal of waste containing I-129 for dose rates in the range of up to a few hundred millirem per yr (mrem/yr). Natural dilution of I-129 by stable iodine will probably limit exposure to levels less than several rems per year.

The question of whether it is possible to provide artificial dilution by disposing of certain wastes together with material containing high concentrations of natural iodine cannot be definitively determined given the information presently available. If it can be demonstrated that the I-127 in soil behaves in a chemical manner similar to the I-129 contained in the wastes (a questionable premise), and using a non-conservative background concentration value of 5 ppm of I-127 in the soil/waste mixture will not limit thyroid exposures to levels below 1500 mrem/yr. However, if the chemical form of I-129 in the waste is determined, and if a chemically comparable artificial iodine dilution material is employed, it may be possible to limit thyroid exposures from I-129 to levels consistent with the amount of stable iodine utilized.

With regard to the third and fourth questions posed earlier, it is unlikely that natural iodine in soils will behave in a chemical manner similar to I-129 in the waste (it would likely have been leached out of the soil long ago if it were easily soluble in water), and it may be possible to locate a compound of iodine that will behave in a manner chemically similar to I-129 in the waste. Clearly, the answer to the fourth question is positive; no evidence could be located to ascertain the opposite conclusion. As long as the solubility and chemical

behavior of iodine in the waste and outside the waste are compatible, it is reasonable to assume that they will be present in the pathways to biota (including groundwater) in the same proportion.

One more item requires examination. In the impact analyses methodologies utilized in the draft EIS, no credit was assumed due to the presence of stable iodine in the soil/waste mixture. As it is pointed out above, this credit can only be calculated after ascertaining the chemical form of I-129 in the waste and of I-127 in the soil. Consequently, this question can not be addressed and resolved in this report. However, if a fraction of natural stable iodine in the soil is demonstrated to be similar in solubility and chemical behavior to the I-129 in the waste, then this ratio may be utilized to reduce the I-129 pathway dose conversion factors.

REFERENCES

- U.S. Nuclear Regulatory Commission, Office of Nuclear Materials Safety and Safeguards, "10 CFR Parts 2, 19, 20, 21, 30, 40, 51, 61, 70, 73, and 170 : Licensing Requirements for Land Disposal of Radioactive Waste," Federal Register 46 FR 38081, July 24, 1981.
- U.S. Nuclear Regulatory Commission, Office of Nuclear Materials Safety and Safeguards, "Draft Environmental Impact Statement on 10 CFR Part 61 : Licensing Requirements for Land Disposal of Radioactive Waste," NUREG-0782, November 1981.
- Wild, R., et.al., Dames & Moore, "Data Base for Radioactive Waste Management. Volume 2. Waste Source Options Report," USNRC Report NUREG/CR-1759, November 1979.
- Personal Written Communication, G.Roles of USNRC to O. Oztunali, Dames & Moore, March 1982.
- Oztunali, O.I., et.al. Dames & Moore, "Data Base for Radioactive Waste Management. Volume 3. Impact Analyses Methodology Report," USNRC Report NUREG/CR-1759, November 1979.
- Kirk, Othmer, Encyclopedia of Chemical Technology, Volume II, John Wiley and Sons, Inc., 1966.
- McGraw-Hill, Encyclopedia of Science and Technology, Volume 7, McGraw-Hill Book Company, 1971.
- Ames, L.L. and D. Rai, "Radionuclide Interactions With Soil and Rock Media," Vol.1, EPA 520/6-78-007, 1978.
- White, D.E., "Magmatic, Connate, and Metamorphic Waters," Geochemistry of Water, Dowden, Hutchinson and Ross, Inc., 1982.
- Smith, C.F., J.J. Cohen, T.E. McKone, A Hazard Index for Underground Toxic Material, UCRL-52889, Lawrence Livermore Laboratory, June 1980.
- Hem, J.D., Study and Interpretation of the Chemical Characteristics of Natural Water, U.S. Geological Survey Water-Supply Paper 1473, 1971.
- Matthess, G., The Properties of Groundwater, John Wiley and Sons, 1982.
- Chave, K.E., "Evidence on History of Sea Water From Chemistry of Deeper Subsurface Waters of Ancient Basins," Geochemistry of Water, Dowden, Hutchinson and Ross, Inc., 1982.
- Ellis, A.J. and W.A.J. Mahon, "Natural Hydrothermal Systems and Experimental Hot-Water/Rock Interactions," Geochemistry of Water, Dowden, Hutchinson and Ross, Inc., 1982.
- Nuclear Fuel Services, Inc., "Environmental Report, NFS Reprocessing Plant," U.S. NRC Docket Number 50-201, 1973.
- NSEC-93, "Survey of Iodine-129 Concentrations in Thyroid Tissues," Nuclear Science and Engineering Corporation, May 1963.
- Magno, P.J., et.al., Office of Radiation Programs, Environmental Protection Agency, "Iodine-129 in the Environment Around a Nuclear Fuel Reprocessing Plant," 1972.
- Brauer, J.K., et.al. "National Iodine and Iodine-129 in Mammalian Thyroids and Environmental Samples Taken From Sites in the USA," Environmental Surveillance Around Nuclear Installations, Vol.II, Proceedings of a Symposium Warsaw 5-9 November 1973, IAEA Publication, IAEA-TM-180/34, 1974.
- Palms, J.M., and V.R. Veluri, "A Summary of the Analysis Associated with the Environmental Impact of ¹²⁹I Released by the Barnwell Nuclear Fuel Plant," Emory University Report EMP-122, July 1974.
- Adam, J.A. and V.L. Rogers, "A Classification System for Radioactive Waste Disposal - What Waste Goes Where?," NUREG-0456, FBDO-224-10, Prepared by Ford Bacon & Davis Utah for USNRC, June 1978.
- Leddicotte, G.W., et.al. "Suggested Quantity and Concentration Limits to be Applied to Key Isotopes in Shallow Land Burial," Management of Low-Level Radioactive Waste, Volume 2, Pergamon Press, New York, 1979.
- McKay, H.A.C., "Background Considerations in the Immobilization of Volatile Radionuclides," International Atomic Agency, IAEA-SM-245/8, pp. 59-78, 1980.
- Nishita, H. et.al., "Radionuclide Uptake by Plants," USNRC Report NUREG/CR-0336, 1978.
- Menzel, R.G., "Radioactivity in Plants," in Disposal of Residues on Land, Proceedings of the National Conference of Disposal of Residues on Land, EPA, 1976.
- Shapiro, J., "Radiation Protection A Guide for Scientists and Physicians," Harvard University Press, Cambridge Massachusetts, 1981.
- UNSCEAR, "Sources and Effects of Ionizing Radiation," United Nations Publication, Appendix E, 77.IX.1, 1977.
- Soldat, J.K., "Radiation Doses from Iodine-129 in the Environment," Health Physics, 30, 61, 1976.
- National Council on Radiation Protection and Measurements, Management of Persons Accidentally Contaminated with Radionuclides, NCRP Report No. 65, April 1980.