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Derived intervention levels for mostly consumed foodstuffs in Iran

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Background: Measures to protect the public following an accidental release of radionuclides to the environment will depend on the circumstances including the extent of the potential hazards. The projected levels of risk are an important precondition in emergency planning. The levels can be expressed in terms of concentration levels in the environment or in foodstuffs. These derived intervention levels (DILs) can be determined for the range of important radionuclides that could be released to the environment in the event of a nuclear accident. ***Materials and Methods:*** Derived intervention levels for ^{90}Sr, ^{131}I, ^{134}Cs + ^{137}Cs, ^{238}Pu + ^{239}Pu + ^{241}Am and ^{103}Ru + ^{106}Ru radionuclide groups were calculated for infants (<1 year) and adults (>17 years) for mostly consumed foodstuffs in Iran. Calculations of DILs were based on recommendations from international, national organizations and average food consumption rate data for Iran. ***Results:*** From our research it was found that DILs for foodstuffs consumed in Iran for above mentioned radionuclide groups except for Ruthenium group are equal to 387, 250, 1023 and 2.8 Bqkg^{-1} respectively. ***Conclusion:*** The comparison of DILs for foodstuffs consumed in Iran and DILs adopted in the new food and drug administration (FDA) Compliance Policy Guide (CPG) which are 160, 170, 1200, 2 Bq.kg^{-1} for ^{90}Sr, ^{131}I, $^{134/137}$Cs, $^{238/239}$Pu plus ^{241}Am radionuclide groups respectively, shows agreement with cesium and plutonium group and higher values for strontium and Iodine group. In the case of nuclear accident or radiological events that might affect our country calculated DILs can be used to prevent or reduce exposure due to consumption of foodstuffs. **Iran. J. Radiat. Res., 2006; 4 (2): 99-103**

Keywords: *Derived intervention levels, radionuclide groups, foodstuffs, Iran.*

INTRODUCTION

The use of nuclear energy and applications of its by-product, namely radiation and radiation substances, continue to increase around the world. Nuclear technologies are in growing use in industry, agriculture, medicine, and many other fields of research, benefiting hundreds of millions of people and giving employment to millions of people in this field [1]. The social acceptance of the risk associated with radiation depends on the benefits of radiation use. However, in some situation the source of radiation does not provide a net benefit. The aim of radiological protection in these circumstances is to reduce the exposure by taking some protective or remedial actions [2]. The common determinant in such situation is that radiation exposure can only be reduced by intervening in ways that require restriction or modification of people's action, or at least the redeployment of resources. These situations are defined as intervention [3].

In the event of nuclear accident or radiological emergency, the effectiveness of the measures taken to protect members of the public or workers will depend upon the adequacy of emergency plans prepared in advance. In these emergency plans, criteria are specified for taking particular prompt actions. After the immediate emergency, predefined criteria for longer-term actions provide a mean of minimizing the public health impact. Such criteria for intervention are based primarily on radiological protection principles. Intervention actions are implemented to introduce protective measures to restrict the exposure to individuals. Many parameters are involved in the derived intervention levels (DILs) such as the physical and chemical forms of the selected materials, its metabolism in the body, habits of the individuals and agriculture practice. In this respect (DILs) for foodstuffs are foreseen for accidental releases of radionclide from nuclear reactor, and for

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the radiological emergencies.

The types of nuclear facilities or activities and the principle radionuclides for which DILs were developed are:

Nuclear reactor (^{131}I, ^{134}Cs, ^{137}Cs, ^{103}Ru, ^{106}Ru)

Nuclear fuel processing plants (^{90}Sr, ^{137}Cs, ^{238}Pu + ^{239}Pu, ^{241}Am)

Nuclear storage facilities (^{90}Sr, ^{137}Cs, ^{238}Pu + ^{239}Pu, ^{241}Am)

Nuclear weapons (i,e. dispersal of nuclear weapons material without nuclear detonation) (^{239}Pu) and Radioisotope thermoelectric generators and radioisotope heater units used in space vehicles (^{238}Pu)

The DILs were calculated for nine radionuclides based on the recommendations of international and national organizations [4, 5] and the reported average food consumption rate data [6]. For each radionuclide, DILs were calculated for two age groups, using protective action guides (PAG), dose coefficients relevant to each radionuclide and age group [7], as well as dietary intakes relevant to each age group. The age groups included infants less than one year and adults over than seventeen years [8].

MATERIALS AND METHODS

The DILs for specific radionuclide is calculated as follows:

DILs (Bq kg^{-1}) = PAG (mSv) / [f × FI (kg) × DC (mSv Bq^{-1})]

Where:

DC: dose coefficient, the radiation dose received per unit of radionuclide activity ingested (mSv Bq$_{-1}$).

f: fraction of food intake assumed to be contaminated.

FI: food intake, quantity of food consumed.

The used PAGs are 5 mSv committed effective dose equivalent, or 50 mSv committed dose equivalent to individual tissues and organs, which ever is more limiting.

According to the Food and Drug Administration (FDA) recommendation the fraction of food intake presumed to be contaminated for adults (>17) was assumed to be 0.3 (i.e, thirty percent) where as this fraction was set equal to 1.0 (100%) for infant's diet (<1year).

Food intake included all dietary component, consumed in on year, with the exceptions in the period of time for ^{131}I ($T_{1/2}$ =8.04 days) and ^{103}Ru ($T_{1/2}$ =39.3 days). For these radionuclides, the quantities consumed were for a 60-day period and 280-day period, respectively.

RESULTS AND DISCUSSION

The radionuclides, age groups and dose coefficients used in the calculations are presented in table 1, food intake is given in table 2, and food intake in case of ^{103}Ru and ^{131}I are listed in table 3. Calculated DILs for ^{90}Sr, ^{131}I, $^{134/137}$Cs, $^{103/106}$Ru, $^{238/239}$Pu and ^{241}Am for infants and adults are presented in table 4.

The nine radionuclides studied can be considered as radionuclide groups having the same characteristics. The groups are: ^{90}Sr,

Table 1. Radionuclides, age groups and dose coefficients (mSv .Bq^{-1})*.

Radionuclide	<1 year	>17 year
^{90}Sr bone surface	1.0 ×10 $^{-3}$	3.8 × 10 $^{-4}$
^{90}Sr	1.3 ×10 $^{-4}$	3.5 × 10 $^{-5}$
^{131}I thyroid	3.7 ×10 $^{-3}$	4.4 × 10 $^{-4}$
^{131}I	1.1 ×10 $^{-4}$	1.3 × 10 $^{-5}$
^{134}Cs	2.5 ×10 $^{-5}$	1.9 × 10 $^{-5}$
^{137}Cs	2.0 ×10 $^{-5}$	1.3 × 10 $^{-5}$
^{103}Ru	7.7 ×10 $^{-6}$	8.1 × 10 $^{-7}$
^{106}Ru	8.9 ×10 $^{-5}$	7.5 × 10 $^{-6}$
^{238}Pu bone surface	1.6 ×10 $^{-1}$	1.7 × 10 $^{-2}$
^{238}Pu	1.3 ×10 $^{-2}$	8.8 × 10 $^{-4}$
^{239}Pu bone surface	1.8 ×10 $^{-1}$	1.8 × 10 $^{-2}$
^{239}Pu	1.4 ×10 $^{-2}$	9.8 × 10 $^{-4}$
^{241}Am bone surface	2.0 ×10 $^{-1}$	2.0 × 10 $^{-2}$
^{241}Am	1.2 ×10 $^{-2}$	8.9 × 10 $^{-4}$

* ICRP Publication 56 (ICRP 1989).

Table 2. Annual food intake (kg).

Foodstuff	Edible part (%)	Age groups	
		<1 year	>17 year
Milk powder	100	32.4	
Flour	100		128.1
Meat	79		15.0
Chicken	68		27.0
Salami	100		8.4
Sausage	100		9.1
Oil	100		6.2
Rice	100		42.3
Cheese	100		6.9
Yoghurt	100		35.0
Lentil	100		6.6
Bean	100		5.8
Peas	100		4.0
Sugar	100		8.8
Cubic sugar	100		14.6
Soya	100		1.8
Potato	86		28.8
Egg	89		10.6
Lettuce	68		19.7
Spinach	76		19.3
White cabbage	89		12.0
Parsley	45		3.3
Tea	100		1.5
Radish	49		6.9
Orange	75		43.8
Carrot	87		9.1
Apple	85		100.7
Onion	90		8.4
Cucumber	72		24.5
Beet root	84		13.5
Banana	65		18.9
Tomato paste	100		4.0
Turnip	80		18.6
Water &other drinks	100	249.0	475.0
Supplement food		50.0	
Sum		331	1138
Sum of edible part		331	1056

Table 3. Total food intake (kg).

Age Group	Annual Intake	Food Intake in 280 day ^{103}Ru	Food Intake in 60 day ^{131}I
<1 year	331	254	54
>17 year	1056	810	174

Table 4. PAGs and calculated DILs (Bq. kg^{-1}) for infants and adults.

Radionuclide	PAG (mSv)	DILs	
		<1 year	>17 year
^{90}Sr bone surface	50	503	415
^{90}Sr	5	387	451
^{131}I thyroid	50	250	2177
^{131}I	5	841	7368
^{134}Cs	5	2014	831
^{137}Cs	5	2517	1214
^{103}Ru	5	8521	25403
^{106}Ru	5	566	2104
^{238}Pu bone surface	50	3.1	9
^{238}Pu	5	3.9	18
^{239}Pu bone surface	50	2.8	9
^{239}Pu	5	3.6	16
^{241}Am bone surface	50	2.5	8
^{241}Am	5	4.2	18

^{131}I, $^{134/137}$Cs, $^{103/106}$Ru, $^{238/239}$Pu and ^{241}Am. These radionuclides are expected to deliver the major portion of the radiation dose during the first year following an accidental episode of radiological food contaminations [9]. A single DIL for each radionuclide group was chosen based on the most limiting PAG and age group for the radionuclide group using the following criteria.

At first single DIL for each of the nine radionuclide shown in table 5 was selected using the most limiting DIL for either of the applicable PAGs, and the average DIL was chosen for the radionuclide group Pu+Am, composed of $^{238/239}$Pu and ^{241}Am, and the radionuclide group cesium composed of $^{134/137}$Cs. Due to large differences in DILs for $^{103/106}$Ru, the individual concentrations of ^{103}Ru and ^{106}Ru were divided by their respective DILs and summed. The DIL for the

Table 5. The most limiting DILs (Bq. kg^{-1}) for each radionuclide by age group.

Radionuclide	DILs	
	<1 year	>17 year
^{90}Sr	387	415
^{131}I	250	2177
^{134}Cs	2014	831
^{137}Cs	2517	1214
Cs-group	2266	1023
^{103}Ru	8521	25403
^{106}Ru	566	2104
^{238}Pu	3.1	9
^{239}Pu	2.8	9
^{241}Am	2.5	8
Pu +Am group	2.8	9

ruthenium group composed of $^{103/106}Ru$ is set at less than one i,e:

$$C_3/DIL_3 + C_6/DIL_6 < 1.0$$

Where:

C_3 is the concentration of ^{103}Ru in foodstuff
C_6 is the concentration of ^{106}Ru in foodstuff
DIL_3 is DIL for ^{103}Ru
DIL_6 is DIL for ^{106}Ru

Then using table 5, a single DIL for each radionuclide group was chosen based on the most limiting PAG and age group for the radionuclide group listed in table 6, and compared with FDA values.

As perceived from table 6, except for Ruthenium group, DILs for foodstuffs consumed in Iran for the mentioned radionuclide groups were equal to 387, 250, 1023 and 2.8 Bq kg^{-1}, respectively. These DILs were independently applied to each radionuclide or radionuclide group due to different types of incidents, or in case of nuclear reactor incident to different limiting age groups.

Table 6. A single DIL for each radionuclide group (Bq. kg^{-1}) and FDA values.

Radionuclide group	DILs	FDA
^{90}Sr	387	160
^{131}I	250	170
Cs-group	1023	1200
^{103}Ru	8521	6800
^{106}Ru	566	450
Pu +Am group	2.8	2

The comparison of the above mentioned DILs for foodstuffs consumed in Iran and DILs adopted in the new FDA Compliance Policy Guide which are 160, 170, 1200, 2 Bq.kg^{-1} for ^{90}Sr, ^{131}I, $^{134/137}Cs$, $^{238/239}Pu$ plus ^{241}Am radionuclide groups were in, consistence with cesium and plutonium group and higher values for Strontium and Iodine group [5]. Since our results of DILs for strontium and iodine groups were higher than those noted in FDA studies, the need for national standards in various countries/cultures is implied.

In the case of nuclear accident or radiological events that might affect our country, the calculated DILs can be used to prevent or reduce the exposure due to consumption of foodstuffs.

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