ASSESSMENTS OF INTERNAL DOSES BY INGESTION OF RADIOACTIVE FOODSTUFFS IN BANGLADESH

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ABSTRACT

The internal radiation dose to a man from the consumption of foodstuffs was estimated on the basis of the measured radioactivities in the foodstuffs in Bangladesh. The total annual internal effective dose equivalent was found to be 454.56 μSv. The dose from intake of radionuclides by foodstuffs (ingestion dose) in general is so low that no harmful effects will occur directly.

INTRODUCTION

Exposure of man to ionising radiation can cause harmful effects. The extent of these effects is dependent on the dose. The possible exposure pathways to individuals include direct radiation from an airborne radioactive plume, inhalation of radioactive gases and aerosols, external radiation from the contaminated ground, and internal dose from ingestion of contaminated food. Food intakes is one of the important pathways for long term health considerations. There may be a variety of radionuclides of artificial as well as natural origins which normally get entry into human body through foodchain and other pathways and deposited in the critical organ(s) causing internal irradiation (1,2). Artificial radioactivity comes mainly from nuclear weapon testings, major nuclear power accidents and radioactive wastes. Among the naturally occurring radionuclides, ^{40}K and the products of the ^{232}Th and ^{238}U decay series are the most important ones. To assess the radionuclide intake by man thourgh food consumption, it is necessary to measure the radioactivity in different foodstuffs. This study was undertaken to determine the radioactivity levels in foodstuffs in order to estimate the effective dose equivalent from dietary intakes of radionuclide-contaminated foodstuffs in Bangladesh. In this study, ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs radionuclides have been considered.

RADIOACTIVITY IN FOODSTUFFS

Food samples representing the major dietary habits of local people were collected from the local markets. This included cereal, vegetable, milk, fresh fish, fresh meat, fresh fruit, etc. All samples were cleaned, processed and dried at room temperature (3,4). About 1 kg dry sample was used in a Merinelli beaker, which is then sealed for more than 30 days to allow for a radium-radon equilibrium to be reached before further measurements (5). The gamma spectrum of each samples was determined with a HPGe detector connected to a 4096 channel analyzer. The effective volume of the detector was 72.4 cm^3 and its energy resolution was 2.1 keV from 1.33 MeV gamma line of ^{60}Co. Samples and standard were counted in identical containers. Details of the counting and efficiency calibration have been given in earlier reports (3-5). The radioactivity was determined from the counting rate under respective photopeak areas and the efficiency of the detector for respective energies. The photopeaks at 609 keV (^{214}Bi due to ^{238}U), 583 keV (^{208}Tl due to ^{232}Th), 1460 keV (^{40}K), and 662 keV (^{137}Cs) were used for the determination of radioactivity in foodstuffs.

RADIONUCLIDE INTAKE AND DOSE ESTIMATES

The intake of radionuclides with food is dependent on the concentration of radionuclides in the various foodstuffs and on the food consumption. It is obvious that food consumption depends on many factors, some of which concern the individual while others are group related. Information on the range and amounts of foods consumed regularly by individuals is required. Types of food consumed are related, of course, to the specific geographical, as well as the cultural, economic, social and even political, conditions within and amongst countries (6).

The risk associated with an intake of radionuclides in the body is proportional to the total dose delivered by the radionuclides while staying in the various organs. In general it is assumed that stochastic effects occur linearly with dose and usually the effective dose equivalent H_e is used to define this risk. So H_e is a parameter for the biological effect. Intake to effective dose equivalent conversion factors are needed in order to convert the intake into dose on ingestion of radionuclides into the body. The intake to dose conversion factors (50-year period) cited in the ICRP publication no.51 for the members of the public (adults) were used. The factors used for estimation of doses are (1,7,8): 6.2×10^{-9} Sv/Bq for ^{238}U; 7.4×10^{-7} Sv/Bq for ^{232}Th; 5.0×10^{-9} Sv/Bq for ^{40}K; and 1.2×10^{-8} Sv/Bq for ^{137}Cs. Radioactivity levels in foodstuffs were used to estimate internal effective doses. Internal doses were estimated from the foodstuffs by multiplying the average concentrations of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs by the yearly food intake and ingestion dose coefficients.

RESULTS AND DISCUSSIONS

The content of ^{238}U, ^{232}Th, ^{40}K, and ^{137}Cs radioactivity in foodstuffs varies from 0.16 to 1.28 Bq/kg, 0.22 to 1.12 Bq/kg, 95.22 to 220.54 Bq/kg, and 1.19 to 3.89 Bq/kg, respectively. The average concentration of ^{238}U, ^{232}Th, ^{40}K, and ^{137}Cs in foodstuffs, grouped according to their food type, are listed in Table 1.

Table 1. Average radioactivity in foodstuffs in Bangladesh.

Name of foodstuffs	Activity (Bq/kg)			
	^{238}U	^{232}Th	^{40}K	^{137}Cs
Cereal	1.28	1.12	150.27	2.25
Roots & tubers	0.32	0.22	120.51	3.89
Vegetables	0.16	0.36	180.07	3.49
Fish	0.26	0.45	109.11	1.82
Meat	0.37	0.29	95.22	4.65
Fruit	1.11	0.95	188.56	1.57
Milk	1.19	0.88	220.54	1.19
Total	4.69	4.27	1064.28	18.86

Based on the food consumption rates (6) and radionuclide concentration given in Table 1, the annual intakes of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs are estimated. The total annual intakes of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs are estimated to be 337.13 Bq, 295.23 Bq, 45240.45 Bq and 686.87

Bq, respectively. Table 2 gives the daily intake of various food items and the daily intake of various radionuclides through the above foodstuffs.The intake rates for Bangladeshi foodstuffs were taken from the food consumption statistics data given in the report (6). Internal doses were estimated from the foodstuffs by multiplying the average concentrations of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs by the yearly food intake and ingestion dose coefficients. The estimated internal doses are also included in the last column of Table 2. A person receives about 226.24 μSv/y from ^{40}K, 2.09 μSv/y from ^{238}U, 218.01 μSv/y from ^{232}Th and 8.22 μSv/y from ^{137}Cs. The total ingestion dose from the consumption of radioactive foodstuffs due to ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs is estimated to be approximately 454.56 μSv/y.

Table 2. Average annual intakes of radionuclides in the foodstuffs and estimated annual effective dose.

Type of food	Consumption (g/day)	Annual intake of radionuclide (Bq)				Estimated annual effective dose (μSv/y)
		^{238}U	^{232}Th	^{40}K	^{137}Cs	
Cereal	631.7	295.12	258.24	34647.75	518.78	183.20
Roots & tuber	44.8	5.23	3.60	1970.33	63.60	10.67
Vegetables	26.9	1.57	3.54	1768.28	34.27	9.28
Fish	20.3	1.93	3.33	808.51	13.49	4.24
Meat	10.8	1.46	1.14	375.17	18.32	2.11
Fruit	39.6	16.04	13.73	2724.69	22.69	14.09
Milk	36.7	15.94	11.79	2955.23	15.95	15.14
Total	810.8	337.29	295.27	45249.96	687.10	454.56

It should be pointed out that these individual dose estimates are based on measured dietary concentrations of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs radionuclides, taking into account the assumed dietary habits of the general population in Bangladesh. The contributions of other radionuclides to the individual effective dose equivalent can be considered negligible since their concentrations in foodstuffs were found to be less than the lower detectable activities. The dose from intake of radionuclides by foodstuffs (ingestion dose) in general is so low compared to natural external radiation (2000 μSv/y) that no harmful effects will occur directly.

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