



輻射偵測中心 Radiation Monitoring Center



Evaluation for Committed Effective Dose from ingestion of Dietary Foods for Taiwanese Adults

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I INTRODUCTION

- ◆ Ingestion of natural radionuclides depends on the consumption rates of food and on the radionuclide Concentrations. The consumption of foods by individuals varies widely depending on locality, food habits, and cultural dietary preferences.
- ◆ The internal exposure dose due to diet was obtained by body content measurements. However, it will underestimate the uranium and thorium series radionuclides in foods, such as ²¹⁰Po, which are calculated by the ingestion dose coefficients reported by the International Commission on Radiological Protection (ICRP).
- ◆ ²¹⁰Po is present in relatively high concentrations in seafood and offal of animal. Taiwanese have a dietary habit of eating seafood and animal viscera.
- ◆ The committed effective dose of the study was determined to evaluate the radiation exposure to Taiwanese populations with different age. Expect for ⁴⁰K, the committed effective dose for Taiwanese adults was evaluated from radioactivity levels of ⁹⁰Sr, ¹³⁷Cs, ²³²Th, ²³⁸U and ²¹⁰Po in 1,800 dietary foods commonly consumed by Taiwanese people.

II MATERIALS AND METHODS

- ◆ The committed effective dose (D) of ⁹⁰Sr, ¹³⁷Cs, ²³²Th, ²³⁸U and ²¹⁰Po due to dietary intake is provided adapted from an ICRP publication as following :

$$D = \sum \sum C_{fj} M_f h_j$$

D (mSv) : committed effective dose ;
 C_{fj} (Bq/kg) : radioactivity of radionuclide j in food f ;
 M_f (kg/yr) : average annual intake rate of food f ;
 h_j (mSv/Bq) : committed effective dose coefficient

- ◆ There are 1,800 food samples common in the daily diet for Taiwanese were collected by the Taiwan Radiation Monitoring Center (RMC) from public markets in five counties in Taiwan (Taipei, Taichung, Kaohsiung, Yilan and Taitung) between 2017 to 2022.
- ◆ The intake scenario is based on the survey results of the Taiwanese people's eating habits by the "National Food consumption Database" established by the Taiwan's Ministry of Health and Welfare.
- ◆ The dose coefficients (h_j) for adults were as following :

Age	The dose coefficients by intake for Adults (from ICRP 60)				
	Cs-137	Th-232	U-238	Sr-90	Po-210
12-17	1.30E-08	2.50E-06	6.70E-08	8.00E-08	1.60E-06
>17	1.30E-08	2.30E-07	4.50E-08	2.80E-08	1.20E-06

- ◆ As for ⁴⁰K, although it's absorbed from food, it's not affected by the intake habit but the body's muscle mass because of the body's metabolic mechanism. Therefore, this study refers to the NCRP 160 report to evaluate the ⁴⁰K committed effective dose.

III RESULTS AND DISCUSSION

◆ Dose estimation from intake of dietary products

- 1,800 food samples were divided into 22 categories by the local intake scenario based on the "National Food Intake Database". Five nuclides (⁹⁰Sr, ¹³⁷Cs, ²³²Th, ²³⁸U and ²¹⁰Po) were measured in 632 out of all.

Categories	Major Food items	Number of Samples	C _{fj} :Radioactivity of radionuclide j in food f (Bq/kg)					
			²³⁸ U	²³² Th	²¹⁰ Po	¹³⁷ Cs	⁹⁰ Sr	
Rice	Paddy Rice, Brown Rice	108	ND-3	ND	-	ND	ND-0.063	
Flour	Flour	42	ND-0.23	ND	-	ND	ND-0.079	
Grains	Food Corn	4	ND	ND	-	ND	-	
Beans	Soybean, Adzuki Bean, Peanut	48	ND	ND	-	ND-0.71	0.057-0.323	
Livestock	Poultry	56	ND	ND	ND-3.51	ND-0.06	ND-0.087	
	Hogs	Pork and its offal	53	ND-0.3	ND	ND-0.04	ND-0.08	ND-0.033
	Cattle	Beef and its offal	45	ND-0.95	ND-0.23	ND-0.58	ND-0.79	ND-0.049
	Goats	Mutton and its offal	5	-	-	ND-0.04	-	-
	Egg	Egg	46	ND-1.19	ND-0.17	-	ND	ND-0.051
	Milk	Milk	46	ND-0.55	ND	-	ND	ND-0.066
Vegetables	Leaf & Fruit Vegetables	89	ND-0.43	ND	-	ND-0.16	ND-0.086	
	Root & Stem Vegetables	90	ND-3	ND	-	ND-0.27	ND-0.046	
	Mildews	Shiitake, Mushroom	9	ND	ND	-	ND	-
	Sea Weeds	Algae, Sea tangle, Ulva, Gelidium	23	ND-2	ND-2	-	ND-0.07	-
Fruits	Berries	79	ND-0.96	ND	-	ND	ND-0.068	
	Citrus	Banana, Pineapple	40	ND-0.64	ND	-	ND-0.21	ND-0.078
	Other Fruits	Longans, Plum, Sugar Apple...	17	ND	ND	-	ND	ND-0.019
Fisheries	Freshwater Fish	56	ND-0.59	ND-0.07	0.51-242.81	ND-0.2	ND-0.041	
	Marine Fish	493	ND-3	ND-0.18	ND-755.85	ND-0.74	ND	
	Shellfish	49	ND-1	ND-1	18.92-75.95	ND-0.06	-	
	Shrimps and Crabs	56	ND-2	ND-0.2	8.29-184.3	ND-0.09	-	
	Cephalopods	22	ND	ND-0.1	1.26-11.08	ND	-	

- The intake scenario of adults with different age and the average concentration of 22 food types be used to calculated the committed effective dose. Then, the annual effective dose of ⁹⁰Sr, ¹³⁷Cs, ²³²Th, ²³⁸U and ²¹⁰Po for adults in Taiwan is calculated based on the weighted population ratio.

Age	Proportion of all Adults (%)	D:Committed Effective Dose(mSv/y)				
		²¹⁰ Po	²³² Th	²³⁸ U	⁹⁰ Sr	¹³⁷ Cs
16-17	1.08	0.470	1.87E-05	3.96E-04	7.29E-04	4.13E-05
17-18	1.12	0.352	1.26E-05	2.66E-04	2.55E-04	4.13E-05
19-65	78.18	0.395	1.29E-05	2.99E-04	3.25E-04	5.50E-05
> 65	19.62	0.303	7.41E-06	2.88E-04	2.80E-04	5.37E-05

◆ Dose estimation from Natural Potassium-40

- The background radionuclide ⁴⁰K produces radiation doses (D) that have significant trends with gender, age and body mass index (BMI). The annual effect dose for adults as function of age (years) and BMI(kg/m²) from NCRP 160 Report are :

$$\text{Male : } D_{K-40/M} = 0.0885(2.946 - 0.0062 \times \text{Age} - 0.0311 \times \text{BMI})$$

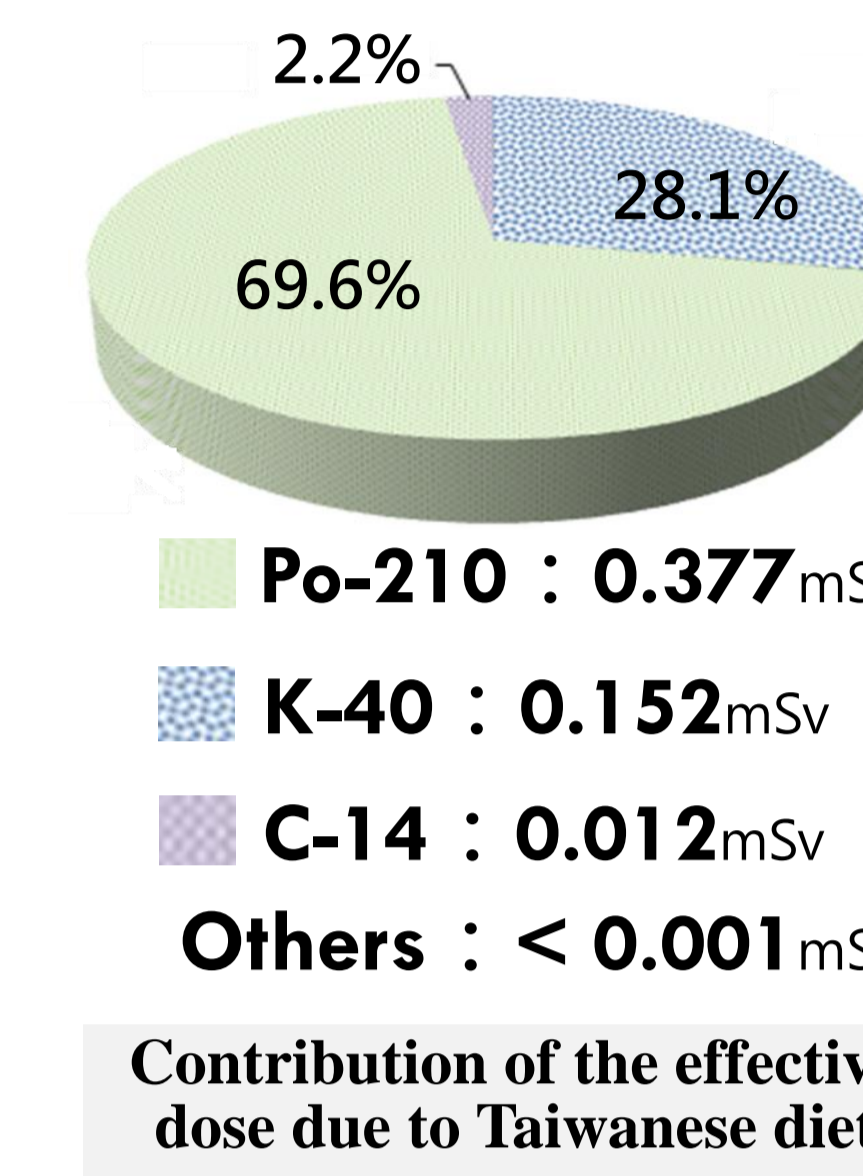
$$\text{Female : } D_{K-40/F} = 0.0876(2.5 - 0.00512 \times \text{Age} - 0.0292 \times \text{BMI})$$

- According to the survey results of Taiwan's Ministry of Health and Welfare, the average BMI values of men and women of all ages in Taiwan are between 24.3 and 25.1, and 23-24.8 respectively.

Age	Average BMI					Proportion of all Adults (%)					Committed Effective Dose (mSv/y)
	16-18	19-44	45-64	64-74	>75	16-18	19-44	45-64	64-74	>75	
Male	21.2	24.6	25	25.1	24.3	1.7	21.6	17.1	5.8	3.0	0.139-0.194
Female	22.1	23	24	24.6	24.8	1.5	20.9	17.9	6.5	4.1	0.111-0.155

- The annual effective dose of ⁴⁰K for adults in Taiwan is calculated based on the weighted population ratio. Average of the annual committed effective dose of ⁴⁰K in the body of men and women is 0.167 mSv and 0.136 mSv, respectively. Average over all adults, the annual committed effective dose of ⁴⁰K is 0.152 mSv.

IV CONCLUSION



Nuclide	Committed Effective Dose (mSv/y)			
	Taiwan	Japan 2022	UNSCEAR 2008	USA (NCRP160)
⁴⁰ K	0.152	0.18	0.17	0.15
²³² Th	1.28E-05	3.90E-04	3.80E-04	-
²³⁸ U	3.07E-04	6.70E-04	2.50E-04	-
²¹⁰ Po	0.377	0.73	0.070	0.13
²¹⁰ Pb	-	0.058	0.021	-
²²⁶ Ra	-	0.012	0.006	-
²²⁸ Ra	-	-	0.011	-
¹⁴ C	0.012	0.014	0.012	0.01
¹³⁷ Cs	5.62E-05	7.80E-04	-	-
⁹⁰ Sr	3.32E-04	1.70E-03	-	-
Total	0.54	0.99	0.29	0.29

- The annual committed effective dose for adult food intake in Taiwan is 0.54 mSv, of which the dose of ¹⁴C (0.012 mSv/y) is based on the 1998 RMC study.
- The average annual effective dose of ²¹⁰Po at 0.377 mSv was the highest, followed by ⁴⁰K at 0.152 mSv, both of which are natural nuclide found in food.
- The artificial nuclide (⁹⁰Sr, ¹³⁷Cs) in food are attributed to the long-term deposition of radioactive contaminated dust caused by foreign nuclear tests or nuclear accidents. The annual effective dose is 0.37 μSv, which is a significant decrease from the past (1.2 μSv/y in 1998 RMC study).
- The annual committed effective dose from food intake in Taiwan is estimated to be 0.54 mSv, as in Japan (0.99 mSv) with similar dietary habits of eating seafood and animal offal, and higher than the global average (0.29 mSv) and the U.S.(0.29 mSv).



Common Taiwanese offal dishes

FURTHER INFORMATION

- Radiation Monitoring Center (RMC) <https://www.nusc.gov.tw/rmc/>
- Nuclear Safety Commission (NSC) <https://www.nusc.gov.tw/>
- Natural Background Radiation Dose Assessment in Taiwan. <https://reurl.cc/NQm3Ox>
- Assessment of internal radiation exposure dose people due to food intake in Taiwan. (Chinese version) <https://reurl.cc/jWjxOy>

