Radioactivity levels and health risks associated with Himalayan salt consumption

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Abstract: Table salt commonly refers to a refined salt containing primarily sodium chloride. During the refining process, salt is often treated with chemicals to remove all impurities and also to achieve the desired color and structure of the final product. Himalayan salt is usually less processed than regular refined table salt and may contain trace nutrients and minerals which are assumed to provide various health benefits. However, some of these impurities (such as radionuclides and heavy metals) may also lead to potentially harmful effects. This study was conducted to investigate specific activities of natural radionuclides in five different samples of Himalayan salt available in Serbian markets. Average specific activities ± standard deviations of ^{226}Ra, ^{232}Th, and ^{40}K were 1.4 ± 0.2, 0.5 ± 0.3, and 113 ± 48 Bq kg^{-1}, respectively. The annual effective doses from radionuclides and radiological risks were estimated. The results indicate that Himalayan salt consumption is radiologically safe in all age groups.

Keywords: Himalayan salt, natural radionuclides, annual effective doses, lifetime cancer risk

1. Introduction

Himalayan salt extracted from mines in the Himalayas is often promoted as being healthier than conventional refined table salt due to the higher content of trace nutrients and minerals which are beneficial for the human body. However, health benefits of Himalayan salt have been brought to question due to the potential presence of certain impurities such as radioactive elements. This study aims to estimate radiological health risks associated with Himalayan salt consumed in Serbia.

2. Materials and methods

Samples of the five most frequently consumed types of Himalayan salt (provided by different suppliers) were purchased from well-known markets in Kragujevac City. Samples were sealed in 450 mL Marinelli beakers for a month to achieve radioactive equilibrium between ^{226}Ra and its progeny. Specific activities were measured using coaxial HPGe detector (GEM30-70 ORTEC with 30% relative efficiency and 1.65 keV FWHM for ^{60}Co at 1.33 MeV) enclosed in a 10 cm lead shield to reduce the background. Measurement of each salt sample lasted for 48 h. The energies of photopeaks used for the estimation of specific activities of radionuclides are listed in Table 1.

Table 1. Gamma lines commonly used for measurement of specific activities of radionuclides.

Radionuclide	Progeny	Gamma energy [keV]	Intensity [%]
^{226}Ra	^{214}Pb	351.9	37.1
	^{214}Bi	609.3	46.1
	^{214}Bi	1764.5	15.9
^{232}Th	^{228}Ac	338.3	12
	^{228}Ac	911.1	29
	^{228}Ac	968.9	17.5
	^{208}Tl	338.3	86
	^{208}Tl	860.6	12
^{40}K		1460.7	10.7

3. Results and discussion

Specific activities of natural radionuclides measured in salt are presented in Fig. 1. The average values obtained for ^{226}Ra, ^{232}Th, and ^{40}K were 1.4, 0.5, and 113 Bq kg^{-1}, respectively. Specific activities of ^{226}Ra were slightly higher than those of ^{232}Th in all samples, but both these radionuclides were detected in rather low concentrations. On the contrary, specific activity of ^{40}K ranged between 78 and 195 Bq kg^{-1}.

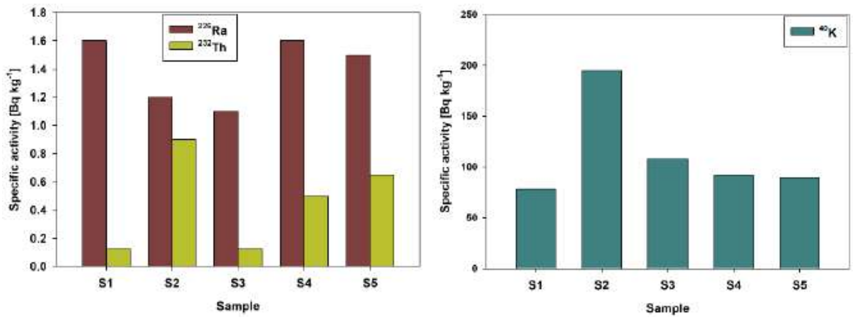

Figure 1. Specific activities of natural radionuclides in Himalayan salts.

Annual effective dose (AED) due to ingestion of natural radionuclide R in salt was calculated using the following equation [1-3]:

$$AED_R = A_R \times I \times F_R \quad (1)$$

where A_R is the specific activity of radionuclide R (in Bq kg^{-1}), I is the annual intake of salt, and F_R is the dose conversion factor (Sv Bq^{-1}) for ^{226}Ra, ^{232}Th, and ^{40}K given in [2, 4] for four age groups (children: 2–7y, 7–12y, 12–17y; adults: >17y). The results of calculating AED are presented in Table 2 for ^{226}Ra, ^{232}Th, and ^{40}K as well as total AED obtained by summing individual contributions of all three radionuclides. Although specific activities of ^{40}K are rather high compared to ^{226}Ra, the annual effective doses from ^{226}Ra are higher than those from ^{40}K in certain age groups. The lowest values of total AED were estimated for adults (>17y).

The radiological risk associated with consumption of radionuclide R in salt was calculated using the following equation [1-3]:

$$Risk_R = D_{intR} \times SF_R \times t \tag{2}$$

where D_{intR} is the average daily intake of radionuclide R (in pCi day^{-1}), *SF* is the slope risk factor of each radionuclide (in pCi^{-1}), and t is exposure duration (in days). The slope risk factors used for ^{226}Ra, ^{232}Th and ^{40}K were 5.14×10^{-10}, 1.33×10^{-10} and 3.43×10^{-11} pCi^{-1}, respectively [2, 5]. The exposure duration was taken as 5 y (= 1825 days) for 2-7 years group, 10 years (= 3650 days) for 7-12 y group, 15 years (= 5475 days) for 12-17 y group, and 70 years (= 25550 days) for adults (>17y) [2, 4]. The average daily intake of radionuclide R can be obtained by the following equation [2]:

$$D_{intR}\left(\frac{pCi}{day}\right) = \frac{A_R \times I}{365} \times 27.027 \tag{3}$$

where factor 27.027 appears due to the conversion from Bq to pCi; A_R and I have already been defined above.

Table 2. Annual effective doses, total annual effective doses, and total radiological health risk.

			S1	S2	S3	S4	S5
AED [µSv y^{-1}]	**2 – 7 y**	^{226}Ra	1.81	1.36	1.24	1.81	1.70
		^{232}Th	0.08	0.57	0.08	0.32	0.42
		^{40}K	2.99	7.47	4.14	3.53	3.45
	7 – 12 y	^{226}Ra	2.34	1.75	1.61	2.34	2.19
		^{232}Th	0.07	0.48	0.07	0.26	0.34
		^{40}K	1.85	4.63	2.56	2.18	2.14
	12 – 17 y	^{226}Ra	4.38	3.29	3.01	4.38	4.11
		^{232}Th	0.06	0.41	0.06	0.23	0.30
		^{40}K	1.08	2.70	1.50	1.28	1.25
	>17 y	^{226}Ra	0.82	0.61	0.56	0.82	0.77
		^{232}Th	0.05	0.38	0.05	0.21	0.27
		^{40}K	0.88	2.21	1.22	1.04	1.02
Total AED [µSv y^{-1}]	**2 – 7 y**		4.88	9.41	5.46	5.66	5.56
	7 – 12 y		4.25	6.85	4.23	4.78	4.67
	12 – 17 y		5.52	6.40	4.57	5.88	5.65
	>17 y		1.75	3.20	1.84	2.07	2.06
Total Risk [×10^{-6}]	**2 – 7 y**		0.87	1.83	1.06	1.00	0.97
	7 – 12 y		1.73	3.66	2.11	1.99	1.95
	12 – 17 y		2.60	5.49	3.17	2.99	2.92
	>17 y		12.13	25.64	14.80	13.96	13.62

Table 2 presents the values of total risk from radionuclides in salt. Average total risk is 1.15×10^{-6} (for 2-7y age group), 2.29×10^{-6} (for 7-12y age group), 3.44×10^{-6} (for 12-17y age group), and 16.03×10^{-6} (for adults). All these values are lower than the recommended limit of 1x10^{-4} – 1x10^{-6} reported by USEPA [6]. It is important to indicate that all doses and risks presented here were calculated assuming salt intake of 5 g per day (i.e., 1.825 kg y^{-1}) which is recommended by The World Health Organization [7]. However, the studies conducted by Jovičić-Bata in Novi Sad [8] indicate that the real intake of salt in the Serbian population exceeds the WHO recommendation by double (or even more). Therefore, the real radiological risk from

Himalayan salt consumption can be higher than the estimated values, but probably still within the acceptable limits.

3. Conclusions

The Himalayan salts investigated in the study contain low levels of natural radionuclides and their consumption can be considered radiologically safe in all age groups.

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