

## Determination of Radioactivity in Chinese Phosphate Rock and Fertilizer

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**Abstract** The presented paper reported the radioactivity of U-238, Ra-226, Th-232 and K-40 in Chinese phosphate rocks by gamma spectrographic analysis during 1985-1990. The results showed that the decay chain of U-238-Ra-226 was the main source of radionuclides in phosphate rocks. The radionuclides in phosphate fertilizer differed from the forms of phosphate fertilizer. U-238 was the most important radionuclide in phosphoric compound fertilizer. The transfer rate of radionuclides was also estimated in this paper.

### Introduction

The phosphate rock is the raw material of phosphate fertilizer, which contains natural radionuclides such as U-238, Th-232, Ra-226 and K-40. These radionuclides are distributed in fertilizer following production and put into farmland with fertilizer. The radioactivity of Chinese phosphate rock and fertilizer are determined by  $\gamma$ -spectrographic analysis to estimate the migration rate of radionuclides from phosphate fertilizer to farmland.

### Material and methods

The 77 samples of phosphate rock are mainly taken from the 33 areas which are Yunnan, Guizhou, Hunan, Hubei, Jiangsu, Sichuan, Shanxi, Jiangxi and Anhui Provinces. Among the six kinds of phosphate fertilizer such as calcium super phosphate and calcium magnesium phosphate; 63 samples are taken correspondingly during 1985 to 1990.

All the samples are air-dried, broken into pieces and passed through a screen with a size of 0.25 mm. The determining cups are filled with sample powder up to 1 liter. Then they are weighed and kept sealed up for more than 15 days. The samples are determined with  $\gamma$ -spectrographic analysis, under characteristic energy of 92.6 keV, 352 keV, 911 and 1460 keV, for, U-238, Ra-226, Th-232 and K-40, respectively. The standard substance is made of the standard rock powder with equilibrium of U-238 and Ra-226, the standard rock powder of thorium and KCl chemical agent, the unit weight of which is proofread by which the instrument of  $\gamma$ -spectrograph is graduated. One-fifth of the samples are determined comparatively by Chinese Institute of Atomic Energy to get the highest of accuracy below the permissible error.

### Results and discussion

The phosphate rock contains natural radionuclides such as U-238, Th-232 and K-40 among which the radioactivity of U-238 is higher than that of Th-232 and K-40. It is in

balance state of U-238 and Ra-226. The decay chain of U-238 and Ra-226 is the main source of radionuclides in phosphate rock. The radioactivity of phosphate rock is given in Table 1, and the distribution of radioactivity for U-238 is shown in Figs. 1 and 2 as a normal distribution.

The radioactivities in phosphate fertilizers differ from the forms of phosphate fertilizer. The radioactivity in calcium superphosphate and calcium magnesium has the same level as that in phosphate rock which is used as their raw material, but the radioactivity of U-238 and Ra-226 is reduced to 0.6-0.5 times of that in phosphate rock. The phosphoric compound fertilizer produced with phosphoric acid contains radionuclide of U-238 because U-238 is concentrated and transferred to the product in the production process, the other radionuclides are separated from the product. The radioactivity of U-238 in  $(\text{NH}_4)_2 \text{HPO}_4$  is 5 times higher than that in the phosphate rock.

According to the quantity of phosphate fertilizer used every year and per unit area, and the radioactivity in which the transfer rate of radionuclides from phosphate fertilizer to farmland is estimated.  $6.33 \times 10^8$  kg ( $\text{P}_2\text{O}_5$ ) was used in 1990, which can be converted as  $1.86 \times 10^{10}$  kg phosphate rock from Guizhou that contains 34.02% of  $\text{P}_2\text{O}_5$ . The transfer rate of U-238, Ra-226 and Th-232 is  $8.0 \times 10^{12}$ ,  $7.0 \times 10^{12}$ ,  $2.0 \times 10^{11}$  Bq  $\text{y}^{-1}$ , respectively (Table 1), and it is 32, 28, 0.7, Bq  $\text{y}^{-1} \text{m}^{-2}$ , if 15 kg of  $\text{P}_2\text{O}_5$  was used per unit area. U-238 is the most important radionuclide in phosphoric compound fertilizer.

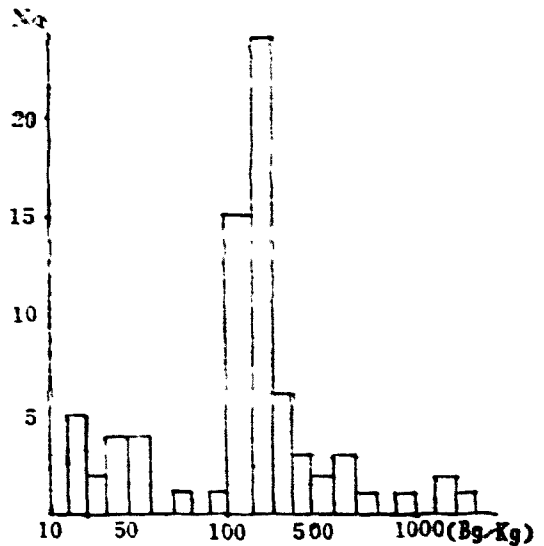


Fig 1. The distribution of  $^{238}\text{U}$  as phosphate rock samples.

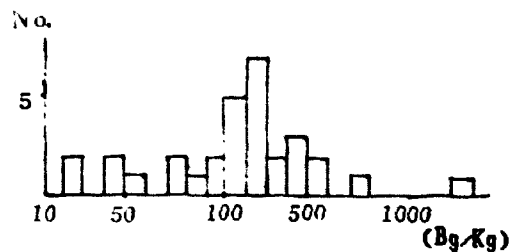


Fig 2. The distribution of  $^{238}\text{U}$  as phosphate rock areas.

Table 1 Radioactivity of phosphate rock in China. (Bq/kg)

Provinces	Site	Number	U-238	Ra-226	Tb-232	K-40
Yunnan	Kunyang	9	255	197	17	118
	Jianning	2	271	201	13	241
	Haikou	2	415	268	12	0
	Anning	1	163	169	2	47
	Laogaoshan	1	319	416	8	0
Guizhou	Shangsuanshan	1	272	279	49	44
	Kaiyang	14	432	375	9	87
	Zhijin	2	532	493	14	98
	Pingba	1	154	153	10	121
	Guiding	1	264	278	36	286
Hunan	tongren	1	3032	3120	43	57
	Liyang	4	181	178	16	243
	Mation	7	716	729	34	121
	Shimen	3	50	48	1	84
	Xixi	1	92	89	14	288
	Louxi	1	184	231	10	215
	Dayong	1	415	449	1	0
	Huanjingping	1	513	403	27	0
	Huailua	1	231	219	0	443
	Hubei	Jingxiang	3	47	23	5
Jingzhou		1	25	24	3	197
Jingzhong		1	24	31	1	253
Yichang		5	71	72	9	265
Huangmailing		1	135	118	54	558
Jiangsu	Baokang	1	55	42	0	95
	Jinping	4	281	264	32	109
Sichuan	Xinpu	1	150	146	1	0
	Jinhe	1	338	326	29	56
Shanxi	Jinjiahe	1	100	98	6	155
	Hejiayan	1	75	73	1	27
Jiangxi	Guangfeng	1	277	283	29	147
	Shangrao	1	90	86	9	123
Anhui	Susong	1	15	13	17	464