

Determination of $^{240}\text{Pu}/^{239}\text{Pu}$ Isotopic Ratios in Human Tissues Collected From Areas Around The Semiparatinsk Nuclear Test Site By Sector-Field High Resolution ICP-MS

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DETERMINATION OF $^{240}\text{Pu}/^{239}\text{Pu}$ ISOTOPIC RATIOS IN HUMAN TISSUES COLLECTED FROM AREAS AROUND THE SEMIPALATINSK NUCLEAR TEST SITE BY SECTOR-FIELD HIGH RESOLUTION ICP-MS

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Information on the $^{240}\text{Pu}/^{239}\text{Pu}$ isotope ratios in human tissues for people living around the Semipalatinsk Nuclear Test Site (SNTS) was deduced from nine sets of soft tissues and bones, and 23 other bone samples obtained by autopsy. Plutonium was radiochemically separated and purified, and Pu isotopes (^{239}Pu and ^{240}Pu) were determined by sector-field high resolution ICP-MS. For most of the tissue samples from the former nine subjects, low $^{240}\text{Pu}/^{239}\text{Pu}$ isotope ratios were determined: bone, 0.125 ± 0.018 (0.113-0.145, n=4); lungs, 0.063 ± 0.010 (0.051-0.078, n=5) and liver, 0.148 ± 0.026 (0.104-0.189, n=9). Only ^{239}Pu was detected in the kidney samples; the amount of ^{240}Pu was too small to be measured, probably due to the small size of samples analyzed. The mean $^{240}\text{Pu}/^{239}\text{Pu}$ isotope ratio for bone samples from the latter 23 subjects was 0.152 ± 0.034 ,



ranging from 0.088 to 0.207. A significant difference (a two tailed Student's t-test; 95% significant level, $\alpha=0.05$) between mean $^{240}\text{Pu}/^{239}\text{Pu}$ isotope ratios for the tissue samples and for global fallout value (0.178 ± 0.014) indicated that weapons-grade Pu from the atomic bombs has been incorporated into the human tissues, especially lungs, in the residents living around the SNTS. The present $^{239,240}\text{Pu}$ concentrations in bone, lung and liver samples were, however, not much different from ranges found for human tissues from other countries that were due solely to global fallout during the 1970s-1980s.

Table 1. Results of $^{239,240}\text{Pu}$ concentrations and their $^{240}\text{Pu}/^{239}\text{Pu}$ isotope ratios in human tissues from nine subjects

Sample No. (Lab. ID)	Tissue	Concentration				Isotope ratio $^{240}\text{Pu}/^{239}\text{Pu}$
		^{239}Pu (mBq g ⁻¹ -ash)	^{240}Pu (mBq g ⁻¹ -ash)	$^{239,240}\text{Pu}$ (mBq g ⁻¹ -ash)	$^{239,240}\text{Pu}$ (mBq kg ⁻¹ -wet)*	
1(#20)	Bone(vertebra)			0.080 ± 0.003	8.2 ± 0.3	0.113 ± 0.012
	Lungs	1.56 ± 0.04	0.27 ± 0.03	1.83 ± 0.19	10.9 ± 1.2	0.051 ± 0.004
	Liver	2.44 ± 0.05	1.06 ± 0.05	3.50 ± 0.17	17.5 ± 0.9	0.123 ± 0.002
	Kidneys	0.25 ± 0.01	n.d.			
2(#70)	Bone(vertebra)			0.129 ± 0.017	13.1 ± 1.7	0.107 ± 0.039
	Lungs	0.37 ± 0.01	n.d.			
	Liver	2.10 ± 0.03	0.98 ± 0.05	3.08 ± 0.17	20.2 ± 1.1	0.133 ± 0.002
3(#71)	Lungs	0.044 ± 0.003	n.d.			
	Liver	1.80 ± 0.04	1.24 ± 0.04	3.05 ± 0.12	25.8 ± 1.0	0.189 ± 0.002
	Kidneys	0.047 ± 0.006	n.d.			
4(#139)	Lungs	0.62 ± 0.02	0.13 ± 0.03	0.75 ± 0.15	7.8 ± 1.5	0.067 ± 0.005
	Liver	2.41 ± 0.07	1.42 ± 0.04	3.83 ± 0.16	36.2 ± 1.5	0.161 ± 0.002
	Kidneys	0.069 ± 0.004	n.d.			
5(#155)	Lungs	0.91 ± 0.02	0.17 ± 0.03	1.08 ± 0.22	11.5 ± 2.3	0.061 ± 0.002
	Liver	1.08 ± 0.02	0.37 ± 0.04	1.45 ± 0.16	13.9 ± 1.6	0.104 ± 0.005
6(#158)	Lungs	0.66 ± 0.01	0.12 ± 0.02	0.78 ± 0.15	8.6 ± 1.7	0.059 ± 0.003
	Liver	4.83 ± 0.06	2.74 ± 0.02	7.57 ± 0.12	46.8 ± 0.7	0.155 ± 0.003
	Kidneys	0.050 ± 0.007	n.d.			
7(#337)	Bone(vertebra)			0.049 ± 0.007	5.1 ± 0.7	0.145 ± 0.008
	Lungs	0.21 ± 0.005	n.d.			
	Liver	0.39 ± 0.01	0.20 ± 0.03	0.60 ± 0.09	2.6 ± 0.4	0.156 ± 0.014
8(#348)	Lungs	0.12 ± 0.01	n.d.			
	Liver	0.46 ± 0.01	0.25 ± 0.04	0.71 ± 0.11	7.3 ± 1.1	0.170 ± 0.010
9(#379)	Bone(vertebra)			0.051 ± 0.005	5.3 ± 0.5	0.135 ± 0.008
	Lungs	0.22 ± 0.01	0.043 ± 0.020	0.26 ± 0.12	1.2 ± 0.6	0.078 ± 0.005
	Liver	0.49 ± 0.01	0.25 ± 0.02	0.75 ± 0.06	5.0 ± 0.4	0.144 ± 0.010
	Kidneys	0.084 ± 0.010	n.d.			

*The values in terms of mBq kg⁻¹-wet were tentatively estimated by using ash-wet weight ratios listed in Table 1. The levels of $^{239,240}\text{Pu}$ in bone samples were measured by alpha-ray spectrometry and error shows one sigma of counting statistics. Tissue samples other than bone samples were measured by ICP-MS and error shows one standard deviations from three replicate. n.d.: not detected.