Measurements of Uranium in Urine Samples and Assessment of Internal Doses in Uranium-Mining Industry in Ukraine

I. Bonchuk[1]; I. Likhtarov[1]; M. Tsygankov[2]

[1]*Ukrainian Radiation Protection Institute*

[2]*State Institution "National Research Center for Radiation Medicine of the National Academy of Medical Sciences of Ukraine"*

53, Melnikova str., 04050, Kyiv, Ukraine

Iurii Bonchuk

bonchuk@rpi.kiev.ua

Introduction

The State Owned "Eastern Mining and Processing Complex" (SkhidGZK) was established in 1951. Now it is the largest uranium mining enterprise in Europe. The SkhidGZK is the only enterprise in Ukraine engaged in the mining of uranium ore and in the production of a uranium oxide concentrate. Several thousand workers of the SkhidGZK have a risk of incorporation of uranium radionuclides.

Pilot project for measurements of uranium radionuclides in urine samples of the SkhidGZK personnel was started in 2009. It was a first attempt at the SkhidGZK to determine content of uranium radionuclides in urine of personnel and to perform internal dose assessments on the base of bioassay samples.

A pilot measurement of uranium radionuclides in urine samples is the first step for the organization of individual monitoring of internal exposure at the SkhidGZK.

Measurements of uranium radionuclides in urine samples

108 daily urine samples from 7 workers from the calcination shop were collected during 11 months. Measurements of ^{234}U and ^{238}U contents in samples were performed:

- results are in range from 3.6 to 766 mBq per sample;
- geometric means are 50.5 mBq of ^{234}U and 50.3 mBq of ^{238}U per daily sample;
- average uncertainty of measurement is 18%;
- average ratio ^{234}U:^{238}U is 1.004.

Initial data for estimation of internal doses

- composition of natural uranium;
- equilibriums in radioactive decay chains (^{238}U, ^{235}U, ^{232}Th) are reached;
- radon radionuclides and their progenies were excluded from the consideration;
- assumed ratios of radionuclide activities to activity of ^{238}U:

Radionuclide	Ratio to ^{238}U
^{234}U, ^{234m}Pa, ^{234}Th, ^{230}Th, ^{226}Ra	1.0
^{232}Th, ^{228}Th, ^{228}Ac, ^{228}Ra, ^{224}Ra	0.22
^{235}U, ^{231}Pa, ^{231}Th, ^{227}Ac, ^{223}Ra	0.046
^{227}Th	0.045

Models and approaches for dose estimation

- ICRP 66 Publication;
- ICRP 68 Publication;
- 'dose per unit measurement' (DPUM) approach.

Contribution of radionuclides to the total internal dose, %

Radionuclide	Type F materials	Type M materials	Type S materials
^{230}Th	43 [a)]	48	25
^{227}Ac	27	12	5.8
^{232}Th	10 [a)]	11	9.9
^{228}Th	7.2 [a)]	8.1	16
^{231}Pa	6.4 [a)]	7.2	2.8
^{226}Ra	3.4 [a)]	3.8	6.1 [a)]
^{234}U	< 1	3.8	16
^{238}U	< 1	3.1	14

[a)] Type M materials were used for dose estimation

Assessment of internal doses

It seems unlikely that measured contents of ^{234}U and ^{238}U are the results of intake of only slow soluble uranium compounds (type S). Assumption about intakes of Type S materials leads to internal doses of several tens of mSv.

The assumption about inhalation intakes of Type M materials is more likely for examined workers. Most internal doses are in the range from 10 mSv to 20 mSv (maximal dose is about 50 mSv).

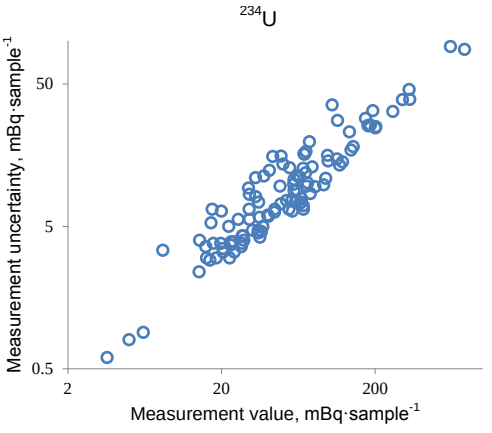
The most likely assumption for measured results is inhalation intakes of fast 'soluble' compounds (Type F). The internal doses of 7 examined workers are in range from 8.3 mSv to 40 mSv.

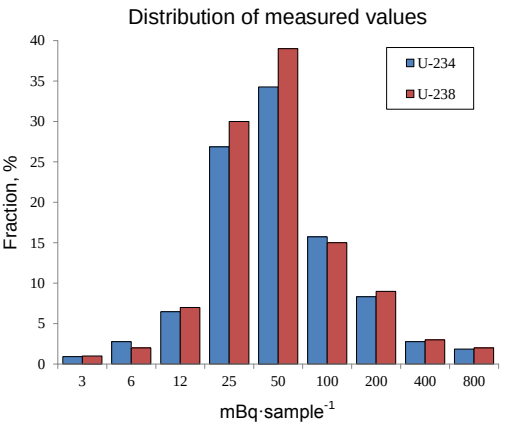
Conclusion

1. Inhalation of Type F materials (fast 'soluble' compounds) is the most likely assumption about intake on the basis of 108 examined urine samples. With this assumption the internal doses of 7 workers from the SkhidGZK are in range from 8.3 mSv to 40 mSv. The average internal dose is 20 mSv.
2. Information about Type of inhaled material is the most important initial data that can significantly reduce the uncertainty of internal dose assessment for workers in the uranium mining and milling industry. Information about AMAD at the workplaces has less significance.
3. The use of the 'effective dose per unit measurement' (DPUM) functions in a retrospective analysis helps to reduce uncertainty of internal dose assessments. The uncertainty associated with lack of knowledge about AMAD almost completely eliminated by the use of the DPUM functions.

Measurements of uranium radionuclides in urine samples

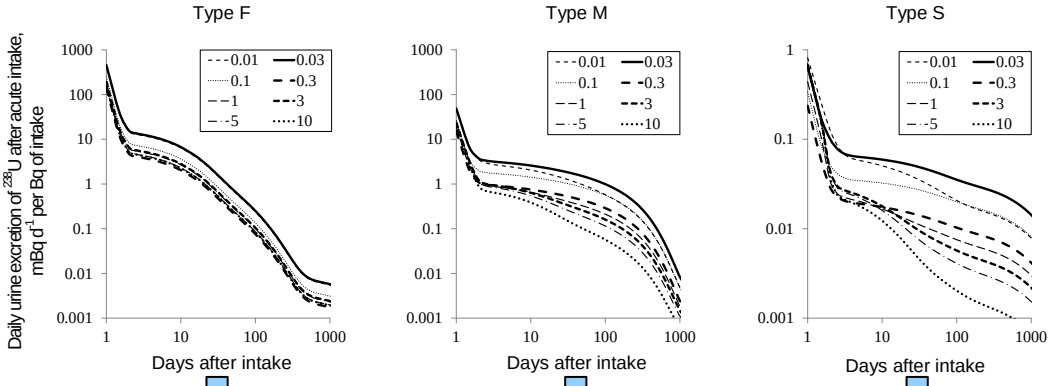
7 workers, 108 daily urine samples





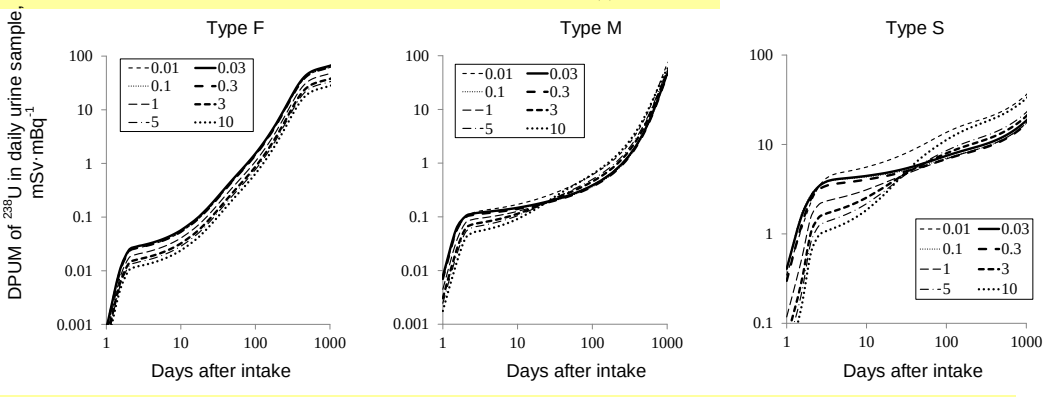
Excretion and DPUM functions

Urine excretion functions $u^{AMAD,TM}(t)$



$z^{AMAD,TM}(t) = e^{AMAD,TM} / u^{AMAD,TM}(t)$

DPUM ('dose per unit measurement') functions $z^{AMAD,TM}(t)$



The DPUM functions have significantly less variability than excretion functions

Interpretation procedures – assessment of internal doses

Measurements

Measurements and approximation (example for Type F)