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Urinary excretion of uranium in adult inhabitants of the Czech Republic

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ABSTRACT

The main aim of this study was to determine and evaluate urinary excretion of uranium in the general public of the Czech Republic. This value should serve as a baseline for distinguishing possible increase in uranium content in population living near legacy sites of mining and processing uranium ores and also to help to distinguish the proportion of the uranium content in urine among uranium miners resulting from inhaled dust. The geometric mean of the uranium concentration in urine of 74 inhabitants of the Czech Republic was 0.091 mBq/L (7.4 ng/L) with the 95% confidence interval 0.071–0.12 mBq/L (5.7–9.6 ng/L) respectively. The geometric mean of the daily excretion was 0.15 mBq/d (12.4 ng/d) with the 95% confidence interval 0.12–0.20 mBq/d (9.5–16.1 ng/d) respectively. Despite the legacy of uranium mines and plants processing uranium ore in the Czech Republic, the levels of uranium in urine and therefore, also human body content of uranium, is similar to other countries, esp. Germany, Slovenia and USA. Significant difference in the daily urinary excretion of uranium was found between individuals using public supply and private water wells as a source of drinking water. Age dependence of daily urinary excretion of uranium was not found. Mean values and their range are comparable to other countries, esp. Germany, Slovenia and USA.

1. Introduction

It is well known that the natural content of uranium in the population of different countries varies significantly (UNSCEAR 2000; Al-Jundi et al., 2004). The ingestion intake, a dominant source of uranium content in the body, varies with the uranium content in foodstuffs and water, which depends on the level of uranium in soil and bedrock. The Czech Republic belongs to uranium rich territories; uranium has been mined on a large scale since 1945 in many places both in underground mines and by in-situ chemical leaching. A few uranium ore processing plants were operated on the territory. At most mines mining were terminated years ago. At present, only one mine is in operation. Uranium mine waste is present in many places and its impact on the environment is a subject of public interest. A large governmental remediation program has been carried out for many years.

The aim of this work is to determine urinary excretion of uranium among members of the public in the Czech Republic. It will enable us to distinguish the possible increase of uranium content in the population caused by the presence of waste rock piles, tailings and other anthropogenic activities. At present, the study can help to distinguish the proportion of the uranium content in the urine of uranium miners resulting from inhaled dust. The uranium level in urine gives the best information about the body content of uranium resulting from ingestion and inhalation (Roth et al., 2001; Höllriegl et al., 2011; Malátová et al., 2013; Limson Zamora et al., 2002). When ingestion is the prevailing source of intake of uranium, the substantial part is excreted through faeces within a few days. Only about 2% is actually transferred from the gastrointestinal tract into the systemic circulation. When inhalation is the dominant intake path, only a very small part of it is excreted through faeces. This part depends on the solubility of the uranium inhaled. In biokinetic models it is expressed by the coefficient f_1 of the transfer from upper intestine to blood (ICRP 1979). In ICRP 2006 (Human Alimentary Tract Model for Radiological Protection) coefficient f_1 is replaced by coefficient f_A that is a fraction of the activity which is absorbed from the alimentary tract to blood. The difference between f_1 and f_A is such that in the case of f_1, absorption to blood is assumed in the upper intestine only. According to (ICRP 1997, Limson Zamora et al., 2002), coefficient f_1 for different

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Table 1
Concentration of uranium in urine of 74 inhabitants of the Czech Republic (ng/L).

	n	AM	GM	95% CI	GSD	2.5% quant.	97.5% quant.	Min	Max
Whole group	74	14.1	7.4	5.7–9.6	3.1	0.60	67.6	0.6	84.9
Public supply	44[a]	11.4	6.3	4.5–8.7	2.9	0.68	56.1	0.6	84.9
Private well	19[a]	19.5	11.0	6.4–18.8	3.0	2.46	61.4	2.1	65.5
Females	38[b]	12.2	6.6	4.6–9.7	3.1	0.60	56.4	0.6	57.0
Males	35[b]	16.4	8.3	5.5–12.5	3.2	1.11	78.6	0.6	84.9

n – number of samples.
AM – arithmetic mean.
GM – geometric mean.
95%CI–95% confidence interval for GM.
GSD – geometric standard deviation.
2.5% and 97.5% population quantiles (95% prediction interval).
Minimum and maximum of experimentally found values.
[a] The source of drinking water of 11 individuals is not known.
[b] – sex of 1 individual is not specified.

compounds of uranium is given in the range from 0.002 to 0.02. Generally, the level of uranium is much higher in faeces than in urine, but it gives information about recent ingestion and it could be quite variable. Urinary excretion directly correlates with the content of uranium in the transfer compartment and, therefore, also with a body content.

No data on content of uranium in food in the Czech Republic are available, however, the content of uranium content in drinking water from public supplies is under strict control. According to regulations (Decree 307/2002) each water supplier is obliged to check gross alpha activity annually and when it exceeds 0.2 $Bq.L^{-1}$ uranium content is determined. This level is exceeded in 5% of supply systems of drinking water in the country. Obligatory minimal detected activity for gross alpha is 0.05 $Bq.L^{-1}$ corresponding to 2 $\mu g.L^{-1}$ of uranium under the assumption that the activity ratio of $^{234}U/^{238}U$ is 1. On the other hand the content of uranium in private wells is not regulated by law. It can be assumed that it is higher than in public water supply systems, where surface water makes nearly 50% of used raw water.

2. Material and methods

Altogether 74 samples of 24 h urine were collected from inhabitants of different regions of the Czech Republic.

The individuals were not specially selected. People who collected urine for monitoring of the level of ^{137}Cs in the Czech inhabitants volunteered for this task. Prague and Central Bohemia region were represented mainly by the employees of the NRPI and their family members. Employees of Regional Offices of the State Office for Nuclear Safety and of Public Health Institutes and their acquaintances supplied samples from other regions.

All volunteers were asked about their dietary habits, especially about the source of their drinking water. Volunteers were given exact instructions on how to collect 24 h urine. Urine was collected into polyethylene bottles, washed by pure nitric acid and rinsed by demineralised water. Aliquot volumes of urine were transferred into 20 ml polyethylene vials washed with nitric acid, refrigerated and shipped to a testing laboratory.

Analyses of aliquot volumes of urine for uranium were performed on a commercial basis. First 27 samples were analysed by HR-ICP-MS in Luleå (Sweden) laboratory of ALS Laboratory Group accredited by Swedish Board for Accreditation and Conformity Assessment. Later on, the National Institute of Public Health in Prague accredited by the Czech Accreditation Institute performed the analyses by Q-ICP-MS with the limit of detection of 1.2 ng/L; expressed in activity of ^{238}U, it is 0.015 mBq/L.

3. Results

Concentrations of uranium in urine (ng/L) of 74 inhabitants of the Czech Republic are summarized in Table 1, Figs. 1 and 2. In

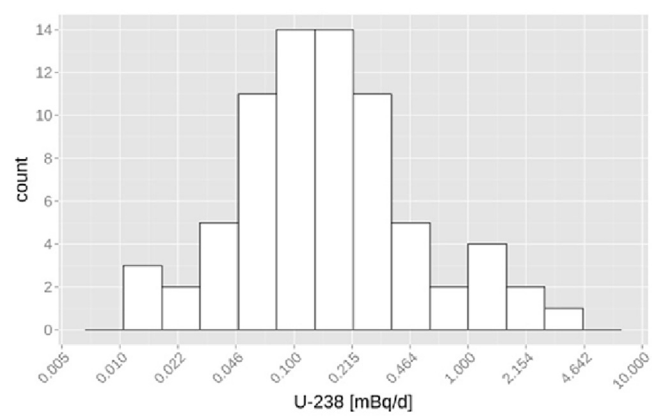

Fig. 1. Daily excreted uranium in urine of 74 individuals from general public of the Czech Republic in the form of histogram with x-axis in logarithmic scale.

Table 2 the uranium concentrations are converted into activity of ^{238}U in 24 h urine in mBq/d according to equation.

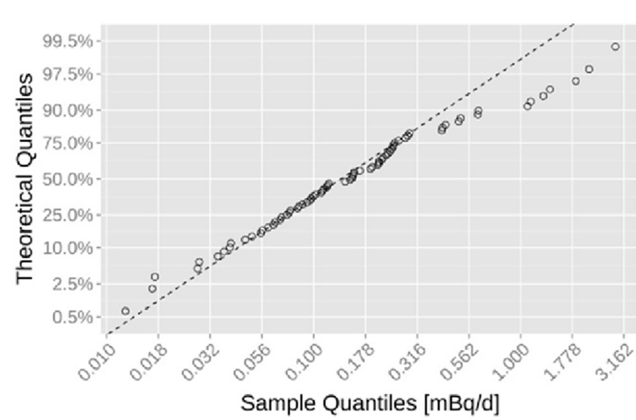

Fig. 2. Q–Q plot of daily excreted uranium in urine of 74 individuals versus lognormal distribution.