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Measurements of uranium in urine samples of uranium workers and inhabitants of nearby settlements in Akmola Region, Kazakhstan

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The main purpose is determine and evaluate uranium concentration in urine of the inhabitants of nearby settlement of uranium mining sites and workers of uranium processing sites. As uranium enterprises working in Stepnogorsk of Akmola Region and its exploitation could be a risk of radiation exposure for the workers as well as for the local population, monitoring of biosamples could allow information about the exposure to uranium for the workers and inhabitants. Workers and inhabitants of male genders were asked to collect 24 h-urine samples. The concentration of uranium in urine was measured in mass spectrometry (ICP-MS). Uranium concentration in urine samples from workers values ranged from 0.05 to 12.5 μgL^{-1} , for Akmola region inhabitants values ranged from 0.10 to 0.60 μgL^{-1} . The results of concentrations of uranium in the urine of inhabitants living near SMCC were comparable to values reported in other studies. The concentration of uranium in the urine of the workers had slightly elevated values, comparable to the conditional norm of 0.9 µg/L.

Keywords: uranium mining; uranium in urine; concentration; mass-spectrometry; radiation monitoring

Introduction

Kazakhstan has one-third of the uranium world resources, which are located in 12 uranium provinces. One of the largest percentages of the deposits are

located in Northern Kazakhstan, where include processing enterprises of the Hydrometallurgical plant of Stepnogorsk mining and chemical combine (further – SMCC). The main products of SMCC are uranium ores with receiving protoxide-oxide of uranium. SMCC wastes are tailings of uranium ore processing, which, according to the content of radionuclides, belong to wastes of a very low or low level of activity.

The villages of Zavodskoy, Aqsu and Kvartsitka are located behind the sanitary buffer of the tailings. The distance to the south from the tailing dump less than 5 km [1].

The aim of this study is to provide a descrption the concentration of uranium in the urine of residents of nearby settlements of uranium mining sites and workers of the SMCC for a comparative analysis.

At present, this study can help determine the proportion of uraniumconcentration in the urine of SMCC uranium miners in comparison with the analysis of uranium content in the population living near this enterprise. The urinary uranium level provides the best information on the amount of uranium in the body resulting from ingestion and inhalation [2, 3]. Urinary excretion is directly related to the intake of uranium and, therefore, to its content in the body. Due to the absence of a norm for the content of uranium in urine in the Republic of Kazakhstan, the permissible concentration of uranium in urine was taken as 0.9 μgL^{-1}. This value is based on previous studies [4] and is accepted as a convention by the U.S. Nuclear Regulatory Commission [5].

Materials and Methods

Sample Collection of Urine

For the study of uranium concentration in urine 130 samples were collected. They include 104 samples of SMCC workers and 26 samples of local people as control from Akmola region settlements. Workers of SMCC from main technology workshops, were exposed to long lived radionuclides. Local people from Aksu, Zavodskoy, Kvartsitka settlements of Akmola region. Radiation situation of Aksu, Zavodskoy, Kvartsitka settlements were early studied [4] and had increased of background values.

Local residents were given precise instructions on how to collect 24-hour urine. Urine was collected into polyethylene bottles, washed by pure nitric acid and rinsed by ultra-pure water. Aliquot volumes of urine were transferred into 20 ml polyethylene vials washed with nitric acid, refrigerated and shipped to a testing laboratory. Direct injection of diluted samples into inductively coupled plasma quickly clogs the capillary of the atomizer, so the bioassays underwent acid decomposition in the Multiwave PRO microwave system (Anton Paar, Austria).

Uranium in urine measurements

The uranium concentration in the urine samples was introduced at the test laboratory of radiochemistry and radio-spectrometry using mass spectrometry (ICP-MS)

model 7800 (Agilent Technology, USA). The mass spectrometry parameters and the method have been explained by early studies [4]. Three aliquots were taken from each urine sample and analyzed. Fifteen urine samples (each 3 aliquots) were randomly selected and channeled again into measurement sequence for analyst-blind repetition. The urine samples were diluted 1:10 in 5% HNO_3. The instrument was calibrated using tuning solution for ICP-MS (Agilent Technology, USA). After ten measurements regularly, three blank determinations and a control determination of a standard (500, 5000 ngL^{-1}) were executed. Results were calculated in a computerized laboratory data management system, correlating sample measurements with calibration curves, blank determinations, and control standards.

Results and discussion

A total of 130 biosamples of uranium mining workers and residents of Akmola region were studied. According to the results of measuring bioassays of residents, the maximum value was 0.60 μgL^{-1}, the minimum value was 0.10 μgL^{-1}, and the median value was 0.24 μgL^{-1}. Based on literation data [7], permissible concentration of urinary uranium for residents can be considered as 0.4 μgL^{-1}. As it can be seen in Figure 1, most of the results of uranium concentration in the urine of are at the lower limit of this value.

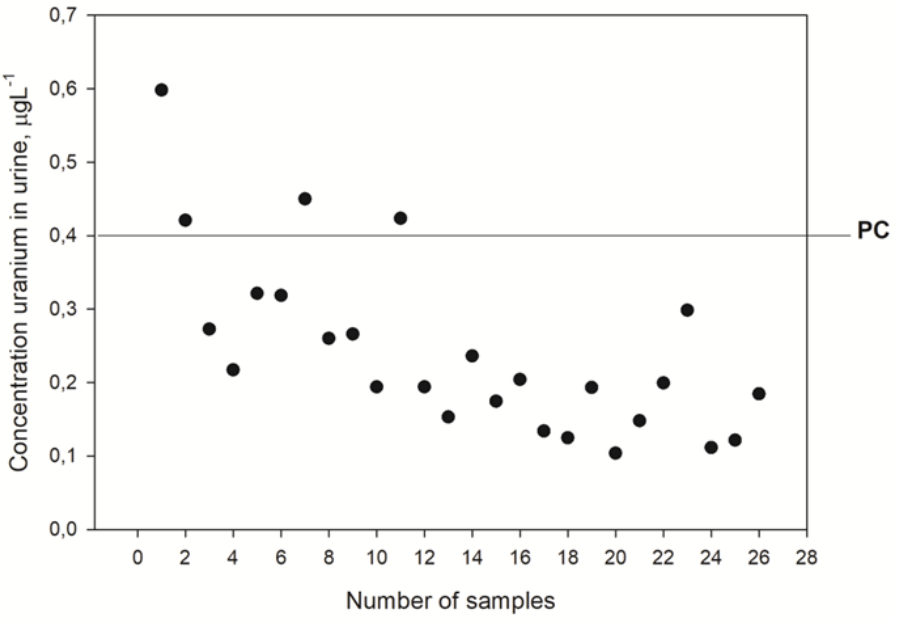

Figure 1. Concentration of uranium in urine for residents, here PC – permissible concentration (0.4 μgL^{-1}).

The results of uranium concentration in the urine of SMCC workers in the range from 0.05 to 12.5 μgL^{-1}. As a conditional norm for the value used, the US Nuclear Regulatory Commission (hereinafter NRC) [5] established the maximum permissible concentration of 0.90 μgL^{-1} for uranium workers, then the limit value for workers 12.5 μgL^{-1} exceeds the conditional limit by 14 times (Figure 2).

Based on the measurement of 104 bioassays results 22 bioassays exceed the conditional norm, the rest are below the maximum permissible concentration value.

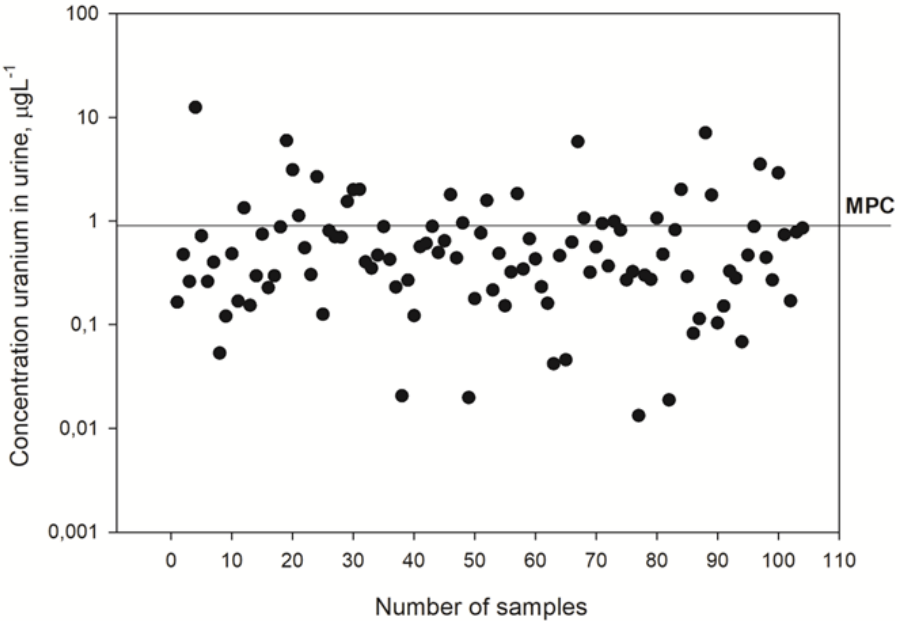

Figure 2. Concentration of uranium in urine of SMCC workers, here MPC is maximum permissible concentration (0.90 μgL^{-1}).

Bioassays with high value concentration urinary uranium concentrations were considered separately (Figure 3). Eleven samples (from 0.98 to 1.84 1.84 μgL^{-1}) have a value increased up to 2 times, seven samples (from 2.00 to 3.53 1.84 μgL^{-1}) up to 4 times, and the rest (from 5.84 to 7.09 1.84 μgL^{-1}) to 7 times.

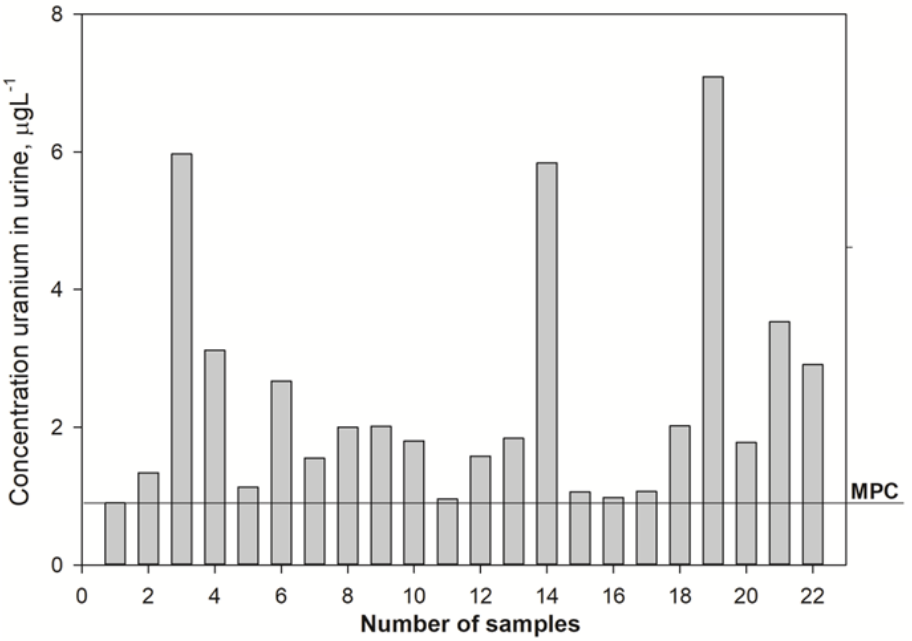

Figure 3. Results of high concentration of uranium in urine of SMCC workers, here MPC is maximum permissible concentration (0.90 μgL^{-1}).

In early studies, the concentration of uranium in urine of the SMCC workers was found to exceed the conventional norm by more than 30 times, the reason for

this was worn-out equipment that led to the excess of the permissible volumetric activity of radionuclides (1.5 times) from the permissible norm [4]. As part of this study, workplace radiation monitoring reports for 2020 were analyzed (indicators such as dose rates, long-lived alpha-particle activity concentrations and equivalent equilibrium volume activity of radon (EEVA) are within acceptable levels. A possible cause of excessive uranium content in the urine of workers is continued work on worn-out equipment. In addition, the pathway of aerosol exposure is crucial for hazard assessment when inhaled exposure to relatively insoluble uranium oxide particles (repeated extraction of U_3O_8 involves the main technological processes at the plant) is a potentially long-term reservoir of internal alpha decay activity that can lead to cell damage [8, 9]. Also, uranium is nephrotoxic and necessary to consider creatinine-correction before analyzing the determination of the concentration of uranium in urine. Creatinine in nephrotoxic research had an effect on the association between uranium and kidney outcomes [10–12].

Conclusions

According to the results of the measurement of uranium in urine of the residents of the Akmola region who live near the uranium mining enterprise uranium concentrations are within the normal range of 0.4 μgL^{-1}, with the exception of one sample with a result of 0.6 μgL^{-1}. Therefore, according to early studies [6], environmental samples (soil, water, food samples) of the settlements of Aksu, Kvartsitka and Zavodskoy (Akmola region) did not exceed the content of natural radionuclides. The results of the concentration of uranium in urine of the SMCC workers have exceeded the conditional maximum permissible concentration (0.9 μgL^{-1}) from 2 to 14 times. A possible reason for such an excess may be in the deterioration of equipment and intake with poorly soluble uranium compounds during the working process. Adjusting for variable urine dilution, "creatinine correction" should be used and further investigation considered.

References

[1] D. Ibrayeva et al., Radiat Prot Dosim **189**(4) (2020) 517-526. [*CrossRef*]
[2] P. Roth et al., A study of uranium excreted in urine. GSF-Report (2001) 36 p. (Accessed 3 Jan 2001) [*Weblink*]
[3] V. Hollriegl et al., Proceedings of the European IRPA Congress, Florence **8** (2002). [*CrossRef*]
[4] M. Aumalikova et al., Radiation and Environmental Biophysics **59** (2020) 703-710. [*CrossRef*]
[5] D.S. Ibrayeva et al., Eurasian Journal of Physics and Functional Materials **5**(1) (2021) 52-63. [*CrossRef*]
[6] M. Aumalikova et al., Radiation and Environmental Biophysics **59** (2020) 703-710. [*CrossRef*]

[7] ICRP, 1975. Report of the Task Group on Reference Man. ICRP Publication 23. Pergamon Press, Oxford. [*Weblink*]
[8] H. Hernandez-Mendoza et al., Quim. Nova **36**(6) (2013) 865-869. [*CrossRef*]
[9] ICRP, 1994. Human Respiratory Tract Model for Radiological Protection. ICRP Publication 66. Ann. ICRP 24 (1-3). [*Weblink*]
[10] R. Shelley et al., Journal of Exposure Science & Environmental Epidemiology **24** (2014) 58-64. [*CrossRef*]
[11] X. Arzuaga et al., J Toxicol Environ Health B Crit Rev. **13**(7-8) (2010) 527-45. [*CrossRef*]
[12] E. Starosciak, L. Rosiak, J Radioanal Nucl Chem. **304**(1) (2015) 75-79. [*CrossRef*]