**Eurasian Journal of Physics and Functional Materials**

**2020, 4(4), 336-342**

# Assessment of the dose burden and health status of the uranium processing workers of the Republic of Kazakhstan

M.N. Aumalikova*[,1,2], D.S. Ibrayeva[1,2], K. Ilbekova[2], P.K. Kazymbet[2], M.M. Bakhtin[2], D.D. Janabaev[2], N.Z. Altaeva[3]

[1]L.N. Gumilyov Eurasian National University, Nur-Sultan, Kazakhstan

[2]Institute of Radiobiology and radiation protection, Nur-Sultan, Kazakhstan

[3]Astana Medical University, Nur-Sultan, Kazakhstan

E-mail: abulmalik.md@gmail.com

DOI: **10.29317/ejpfm.2020040407**
Received: 10.11.2020 - after revision

The main objective of current study is to assess the dose burden and health status of workers at the uranium processing hydrometallurgical plant in order to develop measures aimed at reducing their incidence. This article presents the results of radiation monitoring and data on the health status of workers at the hydrometallurgical plant of the Stepnogorsk Mining and Chemical Combine (SMCC). The data of the accumulated effective dose for the entire length of service, as well as data on the incidence rate for the period 2013-2019, obtained from the base of the Industrial Radiation and Epidemiological Register, have been analyzed. Based on the results of measurements of the uranium content in urine, the expected effective dose of internal irradiation of the enterprise personnel was calculated. The assessment of the health status of workers was carried out based on the materials of outpatient and hospital visits, as well as the results of mandatory periodic medical examinations over the past 5 years. Based on the results, an excess of the expected effective dose of internal irradiation was revealed based on the analysis of a urine sample by 3 times. The most typical for the studied contingent of the main group turned out to be diseases of the eye and its adnexa (23%).

**Keywords:** uranium, dose burden, morbidity, uranium workers.

# Introduction

The advances in nuclear technology and the "peaceful" atom and their application have become the engines of society's progress. The uranium mining and uranium processing industries are developing rapidly in many countries, and this trend is likely to continue with increasing demand for nuclear fuel.

The Republic of Kazakhstan occupies a leading place in the world in terms of uranium ore reserves, where about 25% of the world's proven uranium reserves are concentrated. With the intensive development of uranium production in our country, the number of persons in contact with sources of ionizing radiation has also increased [1-3].

In the USSR, in the process of fulfilling the strategic task of providing the necessary raw materials for the creation of the "nuclear shield", the nuclear industry enterprises operated in a "secret" mode, the issues of the possible impact of the radiation factor on the environment and the health of workers of uranium mining and uranium processing enterprises were not discussed in the open press. After the collapse of the Union, a number of enterprises of the uranium industry operated on the territory of Kazakhstan, the largest of which is the hydrometallurgical plant of the Stepnogorsk Mining and Chemical Combine (SMCC), which has been operating since 1956.

Workers of the nuclear industry and the population of the regions living in the immediate vicinity of the places where uranium ore is mined and processed can be exposed to the threat of chronic exposure to low doses of radiation [4]. Population genetic studies of working uranium mines in the USA, Canada and Czechoslovakia, carried out in the postwar years, showed a significant increase in the incidence of cancer in the studied populations. The effect of ionizing radiation on the human body in the so-called "Low doses" has been studied to a much lesser extent compared to the effect of high doses [5-8]. In Kazakhstan, studies about the impact of negative factors at the enterprises of the uranium industry not so many [9, 10].

Long-lived isotopes of uranium can enter the body through the food chain or by inhalation, accumulating in various tissues, disrupting metabolism, provoking somatic mutations at the next stages of differentiation [11-13]. The effect of chronic low-level irradiation can be enhanced under conditions of the combined impact of other technogenic factors [14-16]. It is known that the defeat of hereditary human structures by ionizing radiation underlies the appearance and realization of a number of pathological conditions - both stochastic (hereditary and oncological diseases) and deterministic effects [17-19].

The main objective of current study was to assess the dose burden and health status of the SMCC workers for the development of measures aimed at reducing their morbidity.

# Materials and methods

The study of the content of uranium in the urine of workers in the uranium industry is a mandatory method of research during the annual medical examination of workers, according to the Order of the Acting Minister of Health of the Republic of Kazakhstan dated October 15, 2020. No.QR DSM-131/2020 [20]. Based on earlier work on the determination and analysis of the mass content of uranium in urine using an ICP MS 7800 inductive plasma mass spectrometer [21]. The expected effective dose of internal radiation was calculated based on the analysis in accordance with the formula given in the ICRP document [22]. When calculating the expected effective dose of internal radiation, taking into account the intake of uranium by inhalation, taking into account the size of the AMAD particles (average aerodynamic diameter of activity) equal to 5 microns. The calculation was made for the chemical form for the medium-soluble uranium type M.

Data of the accumulated effective dose for the entire length of service, as well as data on morbidity for the period 2013-2019, obtained from the base of the Industrial Radiation and Epidemiological Register (IRER), carried out on the basis of the Institute of Radiobiology and Radiation Protection, were analyzed for 54 workers.

The assessment of the health status of workers was carried out based on the materials of outpatient and outpatient and hospital visits, as well as on the basis of the results of mandatory periodic medical examinations over 5 years in dynamics.

The statistical analysis of the research results was carried out using the software IBM SPSS Statistics 20 and the program. For the analysis of the research data, the Pearson correlation coefficient was used [23]

# Results

Laboratory mass spectrometric studies of urine samples [21] from workers of the SMCC showed that in 34 workers the uranium content in urine is <1 μg/L, in 13 workers - from 1 to 5 μg/L, in 3 workers - from 5 to 15 μg/L and over 15 μg/L for 4 workers (Figure 1).

Based on the results of the determination of uranium in urine [21], the expected effective dose of internal irradiation due to uranium was calculated [22]. The calculation results show that the expected effective dose of personnel, depending on the chemical forms and the average content of uranium in urine, can vary with a minimum value of 0.036 μg/L $\approx$0.08 mSv/year, with a maximum value of 26.7 μg/L $\approx$59.3 mSv/year. According to the normative hygienic documents of the Republic of Kazakhstan, the effective dose from occupational exposure is 20 mSv per year [24].

For SMCC workers with more than 20 years of experience, the maximum cumulative dose is 452 mSv, the minimum is 187 mSv, with 16-20 years of experience, the maximum dose is 231 mSv, the minimum is 84 mSv, from 11-15

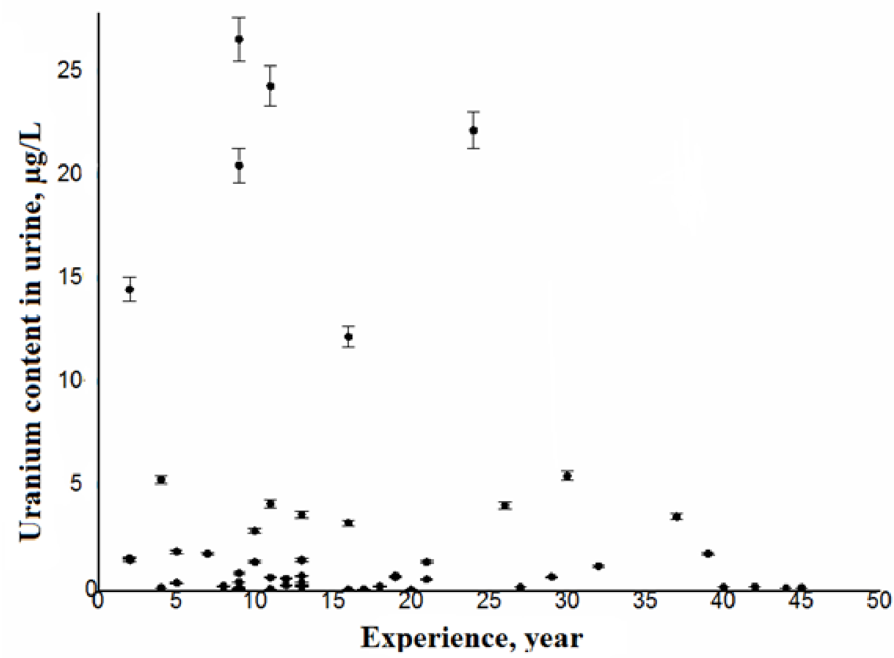


Figure 1. Distribution of uranium content in urine by length of service among workers of SMCC.

years the maximum dose is 213 mSv, the minimum dose is 43 mSv, with 6-10 years of experience, the maximum dose is 130 mSv, the minimum dose is - 48 mSv, with 1-5 years of experience, the maximum dose is 74 mSv, the minimum dose is 21 mSv.

When analyzing the data of somatic pathology of employees of the State Medical Institute, it was revealed that the level of their overall morbidity in almost all classes of diseases according to ICD-10 exceeds. In general, the prevalence of diseases was 510.7 per 100 workers (Table 1).

The calculation of extensive indicators in the study groups was carried out only for those groups of somatic diseases, the high probability of the occurrence of which could be directly or indirectly related to the radiation factor. Blood diseases, congenital anomalies, and symptoms, signs, and abnormalities identified in clinical and laboratory studies were excluded from the study. Diseases of the eye and its adnexa (23%) were the most typical for the studied contingent, the second place was taken by diseases of the digestive system (16.5%), the third position in the study group was the pathology of the cardiovascular system (13.7%), (Figure 2).

Among specialists in human radiation protection, it is customary to use the sign - "dose dependence" - as a criterion allowing to classify or not classify certain changes as radiogenic [25]. To calculate the radiation risk, the initial data were the individual total accumulated radiation doses by the workers of the uranium production based on the results of individual dosimetric control. The documented dose load of workers ranged from 10.37 to 451.54 mSv. Depending on the accumulated radiation dose, the study was divided into 2 subgroups: 1) 0-100 mSv (20 people, 37%); 2) 100 or more mSv (34 people, 63%). With an increase in the radiation dose, the incidence of eye disease in workers significantly increases.

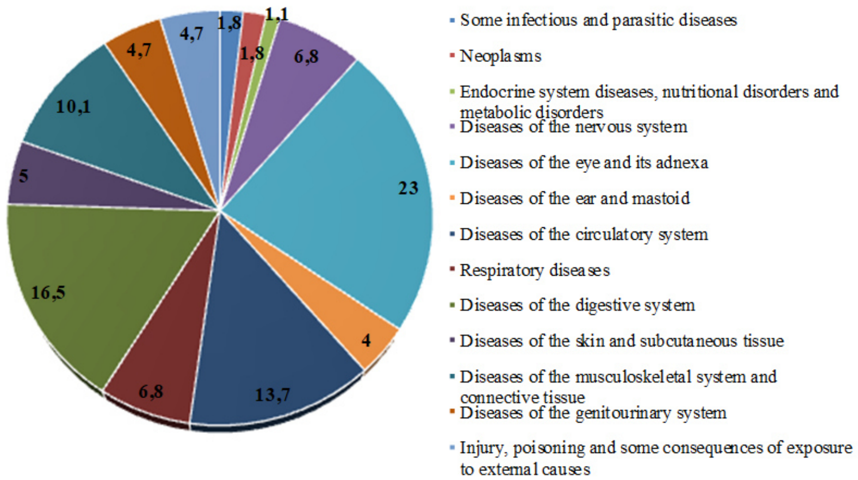


Figure 2. The structure of the prevalence of diseases among workers by classes of diseases (in % of the total).

Table 1.
Structure of the prevalence of diseases of the studied groups of workers (per 100 workers).

| Disease class according to ICD 10 | Morbidity per 100 employees |
|---|---|
| | Study contingent (n = 54) |
| Some infectious and parasitic diseases | 9.2 |
| Neoplasms | 9.2 |
| Endocrine system diseases, nutritional disorders and metabolic disorders | 5.5 |
| Diseases of the nervous system | 35.2 |
| Diseases of the eye and its adnexa | 118.5 |
| Diseases of the ear and mastoid | 20.4 |
| Diseases of the circulatory system | 70.4 |
| Respiratory diseases | 35.2 |
| Diseases of the digestive system | 81.2 |
| Diseases of the skin and subcutaneous tissue | 25.9 |
| Diseases of the musculoskeletal system and connective tissue | 51.8 |
| Diseases of the genitourinary system | 24.1 |
| Injury, poisoning and some consequences of exposure to external causes | 24.1 |
| Total: | 510.7 |

The results of the correlation analysis showed a weak direct reliable relationship between diseases of the eye and the accessory apparatus and the total accumulated dose ($R = 0.5$, $p = 0.01$), (Figure 3).

Taken together, the results of the study testified to the negative impact of working conditions on the overall prevalence of diseases in workers in the uranium industry who were chronically exposed to low doses of radiation. The working conditions prevailing at the enterprise of the uranium industry have

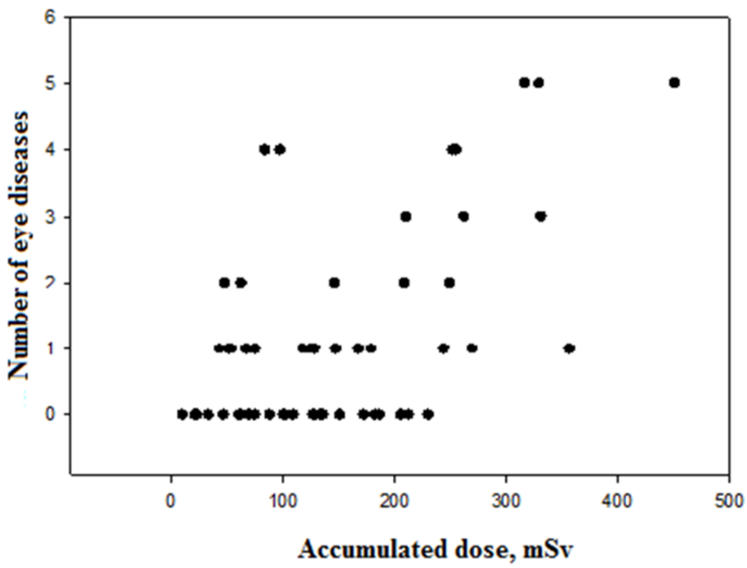


Figure 3. The correlation between accumulated dose and eye and adnexa appear diseases of workers.

an impact on the formation, level and nature of general somatic morbidity. Our research data illustrated improving the health of workers is achieved through measures for primary and secondary prevention, including measures to improve working conditions, promote a healthy lifestyle, and prevent the development of occupational, production-related and major non-communicable diseases. These measures together help to preserve the health of employees and prevent the growth of major non-communicable diseases, reduce occupational and industrial morbidity, and thereby reduce economic damage in one of the leading sectors of the country's economy.

# Conclusion

1. Values of expected annual dose of internal exposure and concentration uranium in urine due to the content of uranium in the urine of workers at SMCC, which exceeds up to requires value need organizational action on the part of the authorized and local bodies of health, Ministry of health, as well as the leadership of the SMCC.

2. Diseases of the eye and its adnexa (23%) were the most typical for the studied contingent of the main group, the second place was taken by diseases of the digestive system (16.5%), the third position in the study group was diseases of the cardiovascular system (13.7%).

# References

[1] The concept of disposal of radioactive waste in the Republic of Kazakhstan (Text-book, Almaty, 1993). (in Russian)

[2] Educational-methodical guidance on radioecology and radioactive waste management for the conditions of Kazakhstan (Text-book, Almaty, 2002) 304 p.

(in Russian)
[3] P.K. Kazymbet et al., Astana medical journal **3** (2005) 61-65. (in Russian)
[4] D. Ibrayeva et al., Radiation Protection Dosimetry **189**(4) (2020) 517-526.
[5] S.A. Nazarenko et al., Nuclear therochemical production and genetic health (Pechatnaya manufaktura, Tomsk, 2004) p.207. (in Russian)
[6] L.A. Ilyin, Radiation medicine // Moscow (2001) 432. (in Russian)
[7] National Academy of Sciences Committee on the Biological Effects ionizing Radiation (BEIR). Report VII. Health effects of exposure to low levels of ionizing radiations: time for reassessment (National Academy of Sciences, Washington DC, 2005) 141 p.
[8] F.K. Bekenova, Risks of chronic diseases of internal organs in workers of uranium processing industry of Kazakhstan (Dissertation, Astana medical university, 2001). (in Russian)
[9] P.K. Kazymbet et al., Astana medicine journals **4** (2006) 12-19. (in Russian)
[10] P.K. Kazymbet et al., Bulletin of KazNU. Ecological series **1**(18) (2006) 30-36. (in Russian)
[11] W.B. Oatway, S.F. Mobbs, Methodology for estimating the doses to members of the public from the future use of land previously contaminated with radioactivity (NRPB, Chilton, 2003) 145 p.
[12] A graded approach for evaluating radiation doses to aquatic and terrestrial biota (Standard USA Department of Energy, Washington, 2001) 347 p.
[13] S. Bouet et al., International Archives of Occupational and Environmental Health **92**(2) (2018) 249-262.
[14] Materials of the report of the Director General of the MLP at the International Labor Conference (National review, 2006) 126 p. (in Russian)
[15] A.A. Ismailova, Hygiene of labor and medical ecology **4** (2012) 178-182. (in Russian)
[16] N.F. Izmerov, V.V. Tkachev, Hygiene of labor and medical ecology **5** (1995) 1-4. (in Russian)
[17] J.E. Dodge et al., J. Biol. Chem. **280** (2005) 17986-17991.
[18] S.T. Borno et al., Cancer Discov. **2** (2012) 41.
[19] P.K. Kazymbet et al., Materials of 17th Hiroshima International Symposium (2012) 25.
[20] Order of the acting Of the Minister of Health of the Republic of Kazakhstan dated October 15, 2020 No. QR DSM-131/2020. (in Russian)
[21] M. Aumalikova et al., Radiat Environ Biophys **59** (2020) 703-710.
[22] ICRP, 1997. Individual Monitoring for Internal Exposure of Workers (preface and glossary missing). ICRP Publication 78. Ann. ICRP 27 (3-4).
[23] A.M. Merkov, L.E. Polyakov, Sanitary statistics (M: Moscow, 1974) 384 p.
[24] Hygienic Regulations "Sanitary and epidemiological requirements for radiation safety" Order of the Minister of National Economy of the Republic of Kazakhstan **155** Information and legal system of regulatory legal acts of the Republic of Kazakhstan (2015).
[25] M.B. Moiseeva, Medical Radiology and Radiation Safety **3** (2018) 5-11. (in Russian)