Radio-Ecological Situation in the Area of the Priargun Production Mining and Chemical Association – 13522

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ABSTRACT

"The Priargun Production Mining and Chemical Association" (hereinafter referred to as PPMCA) is a diversified mining company which, in addition to underground mining of uranium ore, carries out refining of such ores in hydrometallurgical process to produce natural uranium oxide. The PPMCA facilities are sources of radiation and chemical contamination of the environment in the areas of their location.

In order to establish the strategy and develop criteria for the site remediation, independent radiation hygienic monitoring is being carried out over some years. In particular, this monitoring includes determination of concentration of the main dose-forming nuclides in the environmental media. The subjects of research include: soil, grass and local foodstuff (milk and potato), as well as media of open ponds (water, bottom sediments, water vegetation). We also measured the radon activity concentration inside surface workshops and axillaries. We determined the specific activity of the following natural radionuclides: U-238, Th-232, K-40, Ra-226.

The researches performed showed that in soil, vegetation, groundwater and local foods sampled in the vicinity of the uranium mines, there is a significant excess of ^{226}Ra and ^{232}Th content compared to areas outside the zone of influence of uranium mining.

The ecological and hygienic situation is as follows:

- at health protection zone (HPZ) gamma dose rate outdoors varies within 0.11 to 5.4 μSv/h (The mean value in the reference (background) settlement (Soktui-Molozan village) is 0.14 μSv/h);
- gamma dose rate in workshops within HPZ varies over the range 0.14 - 4.3 μSv/h.
- the specific activity of natural radionuclides in soil at HPZ reaches 12800 Bq/kg and 510 Bq/kg for Ra-226 and Th-232, respectively.
- beyond HPZ the elevated values for ^{226}Ra have been registered near Lantsovo Lake – 430 Bq/kg;
- the radon activity concentration in workshops within HPZ varies over the range 22 - 10800 Bq/m^3. The seasonal dependence of radon activity concentration is observed in the air of workshops (radon levels are lower in winter in comparison with spring-summer period).

- in drinking water, intervention levels by gross alpha activity and by some radionuclides, in particular by Rn-222, are in excess. Annual effective dose of internal exposure due to ingestion of such water will be 0.14-0.28 mSv.

INTRODUCTION

JSC The Priargun Production Mining and Chemical Association" (hereinafter referred to as PPMCA) is a diversified mining company involved in the following operations:
– underground mining of uranium ores;
– processing of these ores in hydrometallurgical process to produce natural uranium oxide;
– brown coal mining;
– production of sulfuric acid for the processing industry;
– extraction well water for drinking and industrial sites throughout the city of Krasnokamensk;
– repair and mechanical maintenance of the main production;
– electric power generation and domestic provision of industry and urban consumers with electricity, water and heat.
The main facilities of PPMCA affecting the environment are central heat and power generation plant, hydrometallurgical plant (HMP) with sulfuric acid workshop (SCW) and Uranium mining Administration (UMA).

Figures 1 and 2 show dynamics of discharges and effluents from PPMCA [1-5].

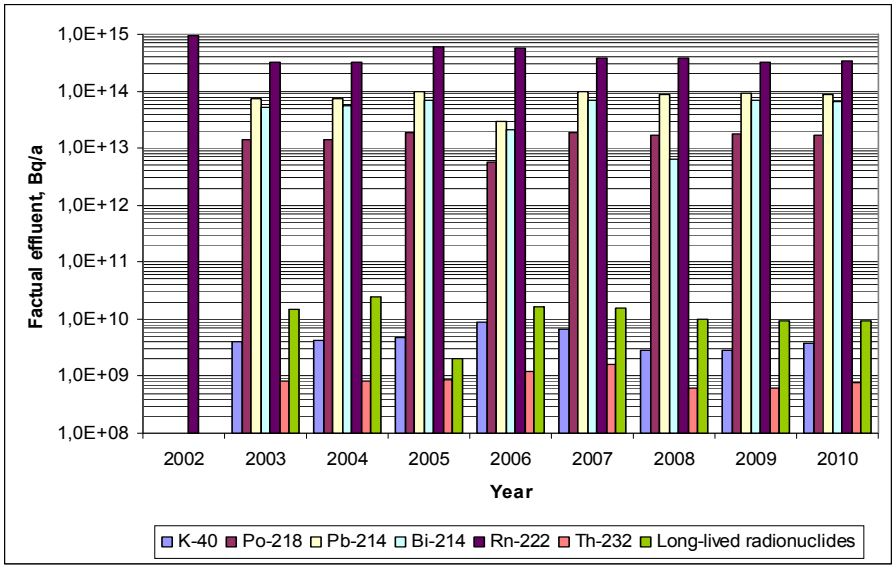

Figure 1. Dynamics of radionuclide effluents.

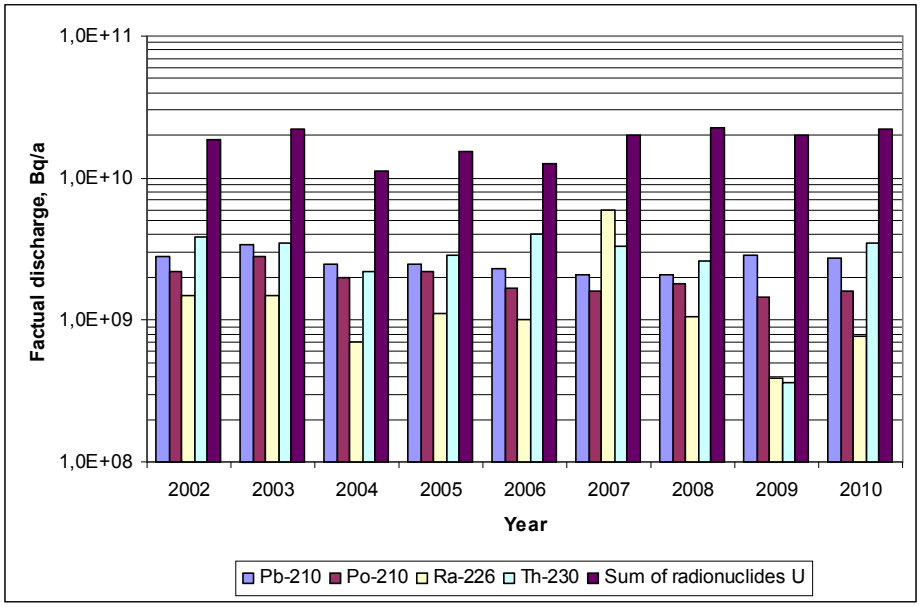

Figure 2. Dynamics of factual discharges of uranium isotopes via waste waters.

MATERIALS AND METHODS

The subjects of research include: soil, grass and local foodstuff, as well as media of open ponds (water, bottom sediments, water vegetation). We also measured the radon activity concentration inside surface workshops and axillaries.

We determined the specific activity of natural radionuclides in the environmental terrestrial and water media samples using gamma spectrometers with semiconductor and scintillation detectors. We used “CANBERRA” spectrometers with the broad-band germanium detector BEGe.
The activity of natural radionuclides was determined for:
- U-238 by gamma rays of the daughter nuclide Pa-234m with energies 1001.03 keV;
- Ra-226 by radiation of progenies Bi-214 (609.31, 1120.3 and 1764.49 keV) and ^{214}Pb (295.22 and 351.93 keV);
- Th-232 by radiation of progenies Tl-208 (583.19 and 2614.53 keV), Pb-212 (238.63 and 300.09 keV) and Bi-212 (727.3 keV);
- K-40 by 1460.83 keV gamma line;
- U-235 by 185.7 keV gamma line minus contribution of Ra-226 186.2 keV gamma rays.

Before the measurements samples were kept in the sealed containers for 30-40 days to establish equilibrium between the child and the parent radionuclide.
The radon activity concentration in air was being measured by integral track method with passive air sampling for the duration of exposure to the sample chamber with dielectric track detector

inside. The sample chamber has been designed so that thoron and radon progenies do not penetrate to the capacity inside.
To measure gamma dose rate and concentration of natural radionuclides in soil we used portable spectrometry complex MCS-01A "Multirad-M". It supports spectrometric measurement of the radionuclide activity, gamma scanning of workshops and outdoor areas with geo-reference using the global GPS navigation systems.

RESULTS

Figures 3 and 4 show the measured dose rates outdoors and in above-ground structures within the health protection zone (HPZ). For comparison, Table I includes the dose rates on-site and beyond HPZ.

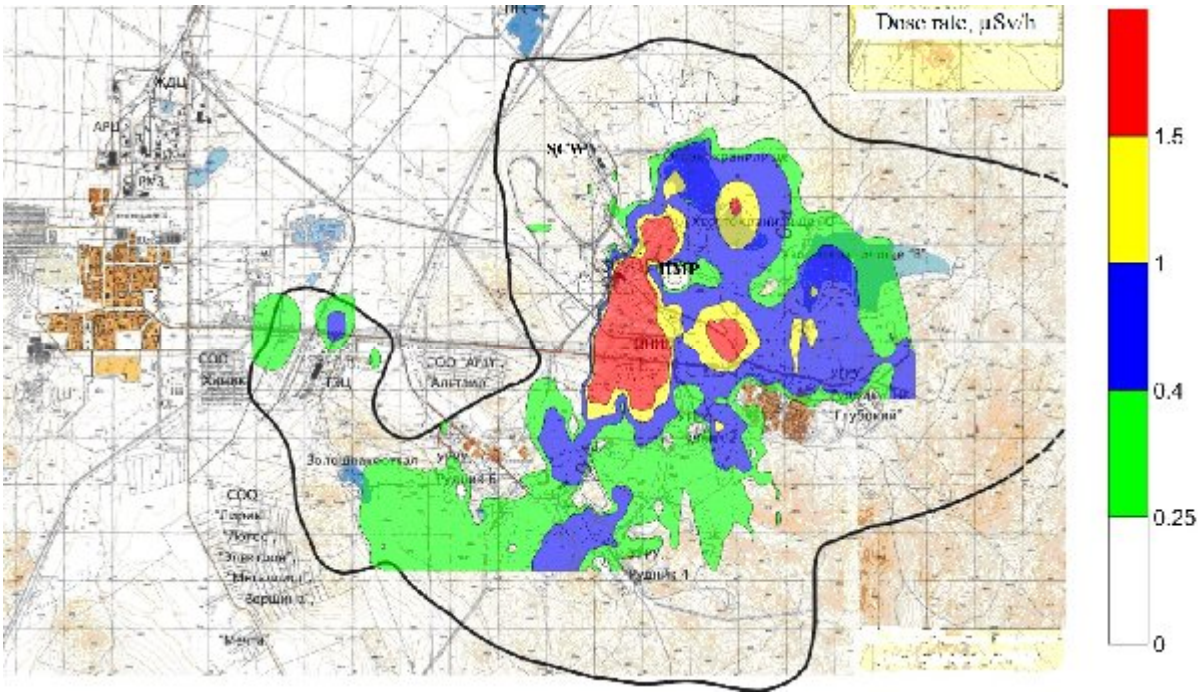

Figure 3. The dose rate within the health protection zone.

Table I. Gamma dose rate in the vicinity of PPMCA beyond HPZ

Place of sampling	Specific activity Bq/kg		
	Ra-226	Th-232	K-40
Lantsovo Lake	42±14	66±14	211±42
Umykey Lakes	50±5	51±10	290±20
Backing reservoir	36±6	70±8	280±24

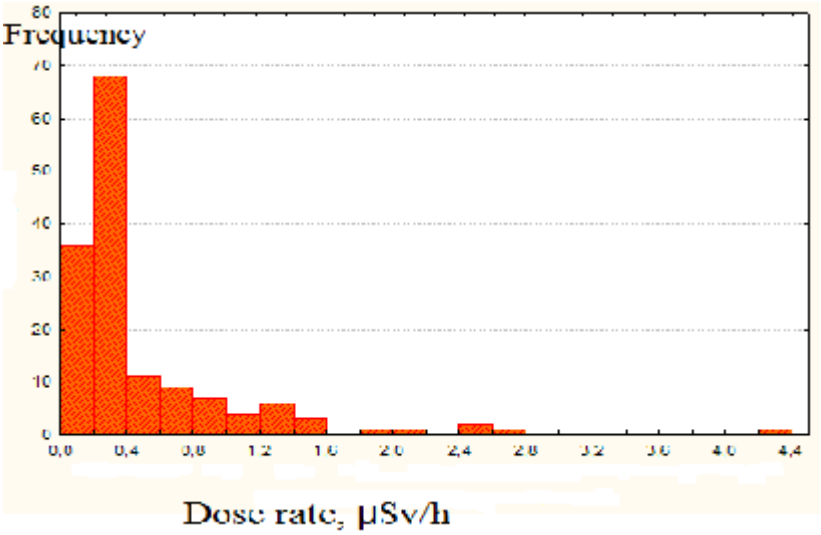

Figure 4. Gamma dose rate distribution by above-ground structures on-site HPZ of PPMCA

The PPMCA location is considered as radon hazardous area. Figure 5 shows the activity concentrations of radon in above-ground structures, measured in different seasons.

Table II illustrate characteristics of the radon activity concentration distribution by all premises where we made our measurements.

Table II. Distribution characteristics of radon activity concentration by the above-ground constructions within HPZ

Distribution characteristics	Activity concentration, Bq/m^3		
	Winter 18.10.10 - 04.03.11	Spring 11.03.11- 20.07.11	Summer 20.07.11- 19.09.11
Mean	720	1430	1110
Minimum	105	22	106
Maximum	5020	10830	8450

The figure 6 shows the specific activities of Ra-226 and Pb-210 in local foodstuffs from Octyabrsky village, which was located on-site HPZ, and Soktui-Milozan village located in 30 km from PPMCA.

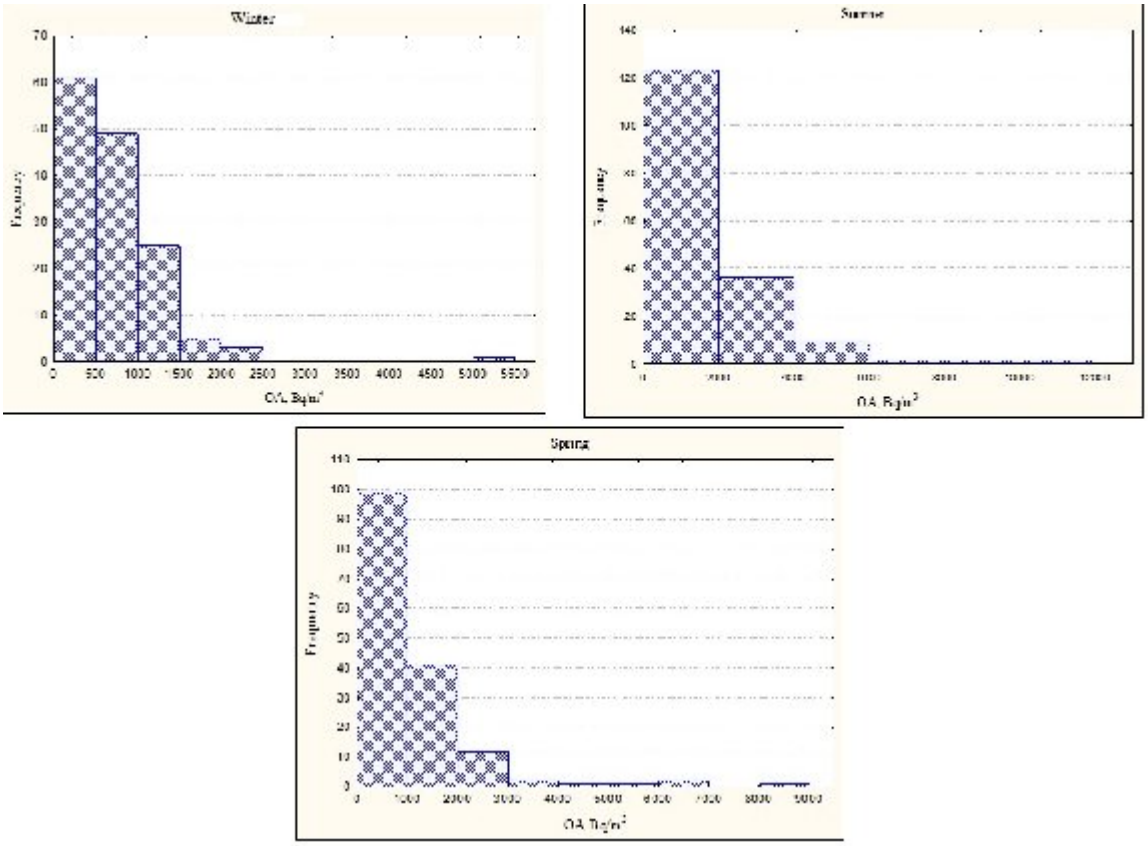

Figure 5. Distribution of radon activity concentration by the premises of above-ground buildings.

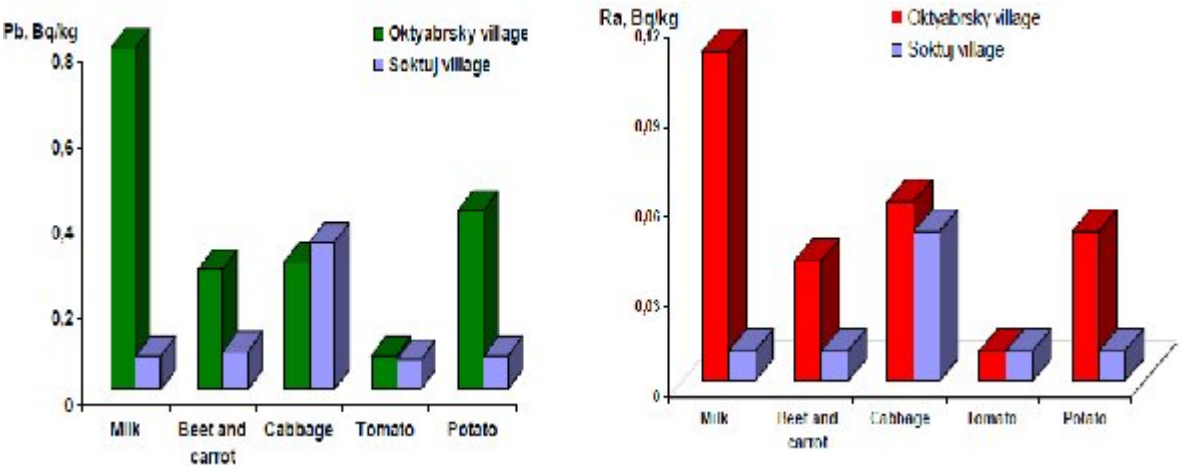

Figure 6. The specific activities of Ra and Pb in local foodstuffs.

Tables III and IV includes the measured data of the water environmental media.

Table III. Activity concentration of natural radionuclides in water.

Place of sampling	The activity concentration, Bq/l					
	U-238	Ra-226	Th-232	U-235	K-40	Pb-210
Lantsovo Lake		0.21	0.015	0.028	0.11	
Umykey Lakes, 2620 m from the discharge point	2.31	0.12	0.0082	0.091		
Umykey Lakes, in the discharge point	4.80	2	0.46	0.14	3	12.5
Backing reservoir	1.6	0.35	0.020	0.067	0.053	0.61
Flooded carrier 2	4.4	0.054	0.025	0.28	0.77	0.77

Table IV. Specific activity of natural radionuclides in bottom sediments of the surface water reservoirs.

Place of sampling	The specific activity, Bq/kg		
	Ra-226	Th-232	K-40
Lantsovo Lake	42±14	66±14	210±40
Umykey Lakes	50±5	51±10	290±20
Backing reservoir	36±6	70±10	280±25

DISCUSSION OF THE RESULTS

Long-term studies do not show significant change in gamma dose rate on-site PPMCA. The increased levels have been registered near dumps of discarded ore, tailings and the central lodge, where the mined ore is stored. When transporting ore, local contamination can arise along the roads, but such areas are quickly identified and eliminated.

Gamma dose rate outdoors varies within HPZ beyond the industrial sites from 0.11 to 5.4 μSv/h. The highest levels have been registered nearby the lodge, where uranium ore is stored.
Beyond HPZ, the increased dose rate, 0.32 μSv/h, has been registered near Lantsovo Lake, due to excessive concentrations of K-40 and Ra-226 in soil. In the reference settlement (Soktui-Milozan village) located beyond the area of PPMCA impact, the mean value is 0.14 μSv/h.
In above-ground structures within HPZ gamma dose rate varies over the range from 0.14 to 4.3 μSv/h (the dose rate is not higher 0.4 μSv/h for 70 % of premises inspected). High gamma dose

rates have been registered in premises for the uranium ore management (bunker mines, hydro-cyclone service site).

The specific activity of natural radionuclides in soil within HPZ reaches 12800 Bq/kg and 510 Bq/kg for Ra-226 and Th-232, respectively. There are some local areas with excessive concentration of natural radionuclides near the cinder storage facility (emergency contamination resulted from leakages via the tailing dam) and close to above-mine buildings.

The NORM concentrations in the grass covering are also high there (up to 63, 37 and 11 Bq/kg for Ra-226, Pb-210 and Po-210, respectively).

Beyond HPZ, excessive ^{226}Ra values has been registered near Lantsovo Lake – 430 Bq/kg; This lake is replenished by rainwater and melt water from areas of the city, mechanical repair factory and building products, and drainage water from garden plots. In the reference settlement Soktui-Milozan village the mean specific activity values for K-40, Ra-226 and Th-232 in soil are 760±30, 88±7 and 109±5 Bq/kg, respectively.

The radon activity concentration in above-ground workshops within HPZ varies over the range from 22 to 10830 Bq/m^3. Radon activity concentration in air of premises depends on the season (radon levels in winter are lower than those in spring-summers).There are different types of ventilation in the workshops inspected (mechanical plenum ventilation, mechanical exhaust, forced-air mechanical and natural) and modes of the ventilation system operation are also different (round-the-clock or daily from 8:00 till 16:00). The highest radon activity concentrations have been registered in workshops of chafts under round-the-clock mechanical plenum ventilation.

Reservoirs beyond HPZ have different functions. The backing reservoir is used for technical needs of the central heat and power generation plants and for watering of country sites. Domestic waste water and, partially, the city industrial waste from CHP are discharged to Umykey Lakes. The population uses these reservoirs as recreational area and for fishing. Lantsovo Lake and Flooded carrier 2 are not used. These lakes are replenished by rainwater and melt water from areas of the city, mechanical repair factory and building products. The drainage water enters to this water reservoir from garden plots, located west of the city of Krasnokamensk, through drainage ditches.

Activity concentration of natural radionuclides in water of all reservoirs exceeds the intervention levels established for drinking water but is lower than levels established for the service water ponds. Concentrations of natural radionuclides in bottom sediments are relatively uniform excepting for Umykey Lakes. There is some part of this lake, located 80 meters from the discharge of domestic wastewater, where concentrations of natural radionuclides in the sediments are several times higher than in the rest of the lake.

SUMMARY

The activities of PPMCA resulted in manmade contamination of HPZ. The HPZ area is 137 km^2, while that of its contaminated parts is 0.755 km^2 [5]. Radon makes the most contribution in exposure to workers.

The contamination of Umykey Lakes is of the greatest concern, because of their use for discharge of domestic sewage and industrial effluents of CHP. Today the re-equipment of the treatment system is scheduled, and the commissioning of this system will improve the radio-ecological conditions of the Lakes.

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