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Determining Radon Concentration in Water in Dong Pao Rare Earth Mine Area and Neighboring Residential Areas

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Dong Pao rare earth mine is a rare earth mine being exploited in Lai Chau province, Vietnam. During the mining process, the flow of groundwater is formed and comes into contact with soil and rock containing Uranium, leading to an increase in water concentration in the mining area and surrounding residential areas. In this study, the radon concentration in the Dong Pao rare earth mine area and neighboring residential areas was analyzed by using RAD7 machine. The results showed that calculated parameters were higher than these of the USEPA and WHO recommended limit.

Keywords: RAD7, radon concentration, Radiation safety, Dong Pao rare earth mine, Radon in water.

1. Introduction

Water is an indispensable ingredient for the life of humans and creatures on Earth. At the same time, water is also one of the natural sources containing many radioactive elements such as uranium, thorium, radium and their descendant isotopes. Radon is formed in the decay of radium (226Ra) nuclei in the uranium decay chain; Therefore, wherever there is a lot of uranium, there is a possibility that radon concentrations will be high. When a seismic tectonic event occurs, the structure inside the ground is changed and faults are created. Groundwater flow is often formed at those fault locations. Flowing through fault locations also means that the water will come into contact with rocks containing a lot of uranium, so high radon concentrations at that location are inevitable. In addition, other processes such as diffusion and dispersion occur simultaneously, so radon is transported everywhere. This is an important reason why groundwater contains more radon than other types of common water [1].

When water is drunk directly, the water will first enter the stomach and then reach other parts of the body, so some radon dissolved in water can diffuse up the stomach wall and penetrate the stomach wall. thick [2]. Here, radon decays into alpha particles. These alpha particles will bombard the nuclei of stomach cells, causing chromosomal defects and negatively affecting the cell division mechanism. In addition, a certain amount of radon and decay products passing through the stomach will be absorbed into the blood and transported throughout the body, so the above cell destruction process is similar, and drinking water also happens. will provide a dose to other organs. In short, if we drink water containing high radon concentrations, the number of bombarded cells will be very large, leading to a high probability of causing cancer, especially stomach cancer.

Dong Pao rare earth mine located in Ban Hon village, Ban Giang commune (Tam Duong district, Lai Chau) was granted mining license No. 3220/GP-BTNMT by the Ministry of Natural Resources and Environment on December 30, 2014 allowing Rare Earth Joint Stock Company Lai Chau - Vimico with area: 132.74 hectares, term of 30 years. Accordingly, the investment in rare earth mining and processing at Dong Pao mine includes 3 component projects: Mining and sorting with a capacity of 75,700 tons/year (44.05% rare earth concentrate, barite and fluorite concentrate).; Hydrometallurgy with a capacity of 33,000 tons/year of total rare earth oxide 97%; Extracting with a capacity of 30,000 tons/year individual rare earth oxides with content ≥99%. The project's environmental impact assessment report was approved by the Ministry of Natural Resources and Environment in Decision No. 2096/QD-BTNMT dated December 3, 2012. During project implementation, radiation monitoring and natural environmental impact assessments must be carried out periodically. Monitoring Radon concentration in water is an important indicator in assessing the impact of the project on the environment and population surrounding the project area.

2. Experimental method

2.1 Sampling method.

Water samples were taken from streams and domestic water of people in the survey area as described in the picture. At the sampling location, water is put into 2 litter bottles and the sampling location is clearly recorded. The total number of samples collected in this study is 40 samples (Figure 1).

Figure 1: Sampling location

2.2 Measurement procedure.

The radon concentration measurement experiment was performed with the RAD7 machine and the RAD-H2O kit (manufactured by DURRIDGE Company) with a closed working process. In the picture of 2the RAD7 machine with screen and working keys, the RAD-H2O set includes: desiccant tube standing upright on a specialized iron leg, cups containing water samples [3]. Figure 2 is the aeration process.

The operation of this system is as follows: the water sample is taken into a container (in this study, choose a 250 ml cup) and installed as shown in Figure 2. Then, declare the water sample measurement mode. The air pump (included in RAD7) will aerate air into the measuring cup, push dissolved radioactive gases out nướcand cốccreate a closed circulation flow through the measuring chamber. The pump will stop after pumping for 5 minutes, then RAD7 will determine the concentration of radioactive gas in the measurement chamber.

Figure 2: RAD7 machine and tool set $RAD - H_2O$

RAD7 determines radon concentration based on measuring the alpha ray energy spectrum. The pump sends a stream of gas containing radon (dried by a desiccant tube) into the measuring chamber of the machine. The built-in detector will receive the electrical signal caused by the alpha rays hitting it. The processor determines the energy of each alpha ray, constructs its energy spectrum and automatically calculates the radon concentration. Radon concentrations (including 222Rn and 220Rn) are calculated by recording alpha rays emitted from the descendants of 222Rn. (218Po (6.00 MeV), 214Po (7.69 MeV)) and descendants of 220Rn (216Po (6.78 MeV), 212Po (8.78 MeV)). [4]

Test Start - Starts testing according to the installed protocol. The screen displays: Start counting, now the counting has started. The status screen will appear with the motion time counting down. At this time, the pump will be pumped for five minutes to remove Radon gas from the water cup and put it into the RAD7 machine. When the time counter reaches 0, RAD7 will automatically calculate the Radon concentration, save the results in memory and clear the count on the screen and display the parameters for the next cycle. The new cycle begins immediately after the previous cycle ends. If you need to stop during the measurement process, select Test Stop, the screen displays Stop counting. After each cycle, the machine automatically prints a copy of the results of that cycle, and after one measurement (including four cycles), a summary result is automatically printed.

End of measurement: after the end of the four cycles with the signal that the measurement time is up, we open the lid of the cup, lift the aeration head out of the cup, then pump air to push water out of the aeration head. After finishing the measurement cycle, the machine will print a short report using an infrared printer. This report tells us the results of the radon concentration in the water sample just measured in units of Bq/m3 or pCi/liter (depending on the initial unit setting).

3. Results of analysis of Radon concentration in water samples in the experimental area

Table 1. Statistics of Radon measurement results in 40 water samples taken at Dong Pao mine area and neighboring residential areas

	Greatest value (Bq/L)	Minimum value (Bq/L)	The average value (Bq/L)	Number of samples (Bq/L)
Civil water	20056,7	3802.0	8990.2	6
Stream water across the road	7362.8	1887.0	4623.8	4
Spring water flows through areas F7, F3, factory	3999.5	871.1	2582.7	5
Waste lake	10150.2	462.0	3851.4	3
Stream at the end of TN F3 landfill, past F3	6158.7	5820.4	5989.6	2
The water from the mountains is falling	105017.0	6221.8	33355,4	7
Brook	54263.6	6072.0	30167.8	2
Rain water	4564.7	4564.7	4564.7	first
Stream flows around the village	8780.9	6015.7	10948.0	5
Water from streams and mountains flows down to people	49469.2	1110.8	15465.26	5

According to recommendations of USEPA and WHO, the allowable value of Rad concentration in water is 11 Bq/L [5]; 100Bq/L, respectively. From the results obtained from the study, it can be seen that Radon concentrations in water samples conducted in surveys and experiments are quite high compared to the allowable limit, so appropriate recommendations should be made. Among 40 water samples measured for Radon concentration, the water sample had the highest result of 105017.0 Bq/ L corresponding to the type of water from high mountains; The water sample with the lowest result is 462.0 Bq/L corresponding to water taken from the waste lake.

There are a few locations with unusually high values of Radon gas concentration in water:

- Water sample No. 34 (sample number MNR40) and water sample No. 37 (sample number MNR43) are both mountain water with Radon concentration values of 105017.0 Bq/L and 87061.5 Bq/L respectively. These are the two samples with the highest value among the 40 samples and many times higher than the given standard.

- Water sample No. 35 (sample number MNR41) has a Radon concentration value of 49469.2 Bq/L, which is from mountain water going down to civil water tanks and is many times higher than the prescribed standard.

- Water sample number 29 (sample number MNR35) has a Radon concentration value of 54263.6 Bq/L and is water taken from a small hot spring.

- Water sample number 23 (sample number MNR28) has a Radon concentration value of 20056.7 Bq/L, which is residential water.

4. Request

To prevent and minimize the effects of radiation due to high Radon concentrations in water directly on human health, solutions are needed:

- Assessment of occupational radiation dose requires control of drinking water sources and water supplies from underground water sources. Water samples are taken every 6 months to assess the level of radioactive contamination in drinking water.

- To control the environment, it is necessary to evaluate water samples at all wells as mining well as surface water sources before and during operation. It is possible to consider adding a number of other locations depending on the nature of exploitation, composition and density of radionuclides in rare earths. their solubility in water, and their distance from the hazard group among members of the public.

- Initially, take samples and measurements every 6 months. After 2 years of operation, re-evaluate the frequency of application (usually once a year) depending on the circumstances, for example according to the concentration of radionuclides measured in the water.

- Propose regulations on the management of rare earth minerals, perfecting mineral management in a reasonable manner and in accordance with the law. It is necessary to propagate, urge and educate the community in exploiting mineral resources and protecting the environment. The government and all levels need to conduct health checks for people in the region to determine the level of illness of the people. In the affected area, there are appropriate measures to treat water sources for people before use.

- Applying modern technology in exploration and exploitation of radioactive rare earth mineral resources to limit resource loss and minimize the impact of radiation on the environment.

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