Experimental Implementation for the Monitoring of Environmental Radiation by Radon in the Northern Macro-region of Perú.

Félix Díaz[1], Jhonny Rojas[2], and Segundo Rojas[3]
[1]Vicerrectorado de Investigación, Universidad Autónoma del Perú, Lima 15842, Perú, felix.diaz@autonoma.pe
[2]Pontificia Universidad Católica del Perú, Apartado 1761, Lima, Perú, jrojash@pucp.edu.com
[3]Universidad Señor de Sipán, Chiclayo 14000, Perú, segundo.rojas.89@gmail.com

***Abstract*– In the present work, we carry out the preparation and experimental implementation for the measurement and monitoring of environmental radon in the northern region of Peru, which according to geological studies, it is a region with uranium-rich soil. To carry out the monitoring, we use active detectors such as AlphaGUARD and Recon while using the CR-39 as a passive detector. Likewise, using a uranium ore (autunite) as a radon source in a controlled environment, we test diffusion chambers and analyze the correlation between the measurements of the active sensors.**
***Keywords*-- Environmental Radon, AlphaGUARD, Recon, active detectors.**

I. Introduction

Radon is a radioactive gas that is naturally occurring and is present in the environment. It is produced by the decay of uranium and radium in soil, rock, and water. Radon can enter buildings through cracks in the foundation, floors, or walls, and can accumulate to levels that are hazardous to human health [1][2][3].

The International Agency for Research on Cancer (IARC) classifies radon as a Group 1 carcinogen, meaning it is a substance that is known to cause cancer in humans. Long-term exposure to high levels of radon can increase the risk of lung cancer, especially in people who smoke. That is why it is important to measure radon levels in homes and buildings and take steps to reduce exposure if levels are found to be high. By measuring radon levels, individuals and communities can take steps to reduce exposure and lower the risk of related health problems [3][4][5].

To monitor the radon levels, a geographical representation of the radon levels in a particular area is essential, also known as a radon map. It displays the average radon levels in various regions and provides information about the risk of radon exposure in different locations. Radon maps are usually based on data from radon testing in homes and buildings. They also take into account geological, geophysical, and other environmental factors that can influence radon levels. This information can be used to take steps to reduce radon exposure and protect public health. Some countries have national radon maps, while others have maps at the state or local level [3][4].

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Radon measurement in Latin America varies by country and region, but it is generally not as widespread as in other regions such as Europe or North America. There are limited studies and data available on radon levels in homes and buildings in many Latin American countries [3] [4] [6]. However, as awareness of the health risks associated with radon exposure grows, there has been an increase in the number of radon measurement and mitigation efforts in the region. In Perú, some radon-level monitoring activities have been carried out; however, the areas studied are very few compared to the total area of the country [4] [6]. That is why it is essential to monitor environmental radiation, for radon is vital, especially in soils with a significant concentration of uranium.

The present work focuses on the preparation and experimental implementation for monitoring environmental radiation by radon in a Peruvian region with a significant amount of uranium in the soil.

II. METHODOLOGY AND EXPERIMENTAL PROCEDURE:

Uranium is a naturally radioactive element commonly found in soil in many parts of the world, including Perú. The concentration of uranium in the soil varies depending on factors such as the geology of the area and the presence of uranium deposits, as seen in Figure 1. In some cases, elevated levels of uranium in the soil can pose a health risk to humans and the environment. For example, uranium can contaminate water supplies and crops, leading to potential exposure to radiation and health risks. In addition, uranium is the parent element of radon, meaning that radon is produced as a decay product of uranium. It decays through a series of alpha and beta decay processes, eventually producing radon-222, which is a radioactive gas. Radon is highly radioactive and can pose a health risk if it accumulates in enclosed spaces. This radioactive gas can enter indoor spaces from the soil or rock beneath a building, and long-term exposure to elevated levels of radon gas can pose a health risk to inhabitants. The level of radon in outdoor air is generally low and poses a minimal health risk, but the concentration can be higher in certain areas that have high levels of naturally occurring uranium in the soil.

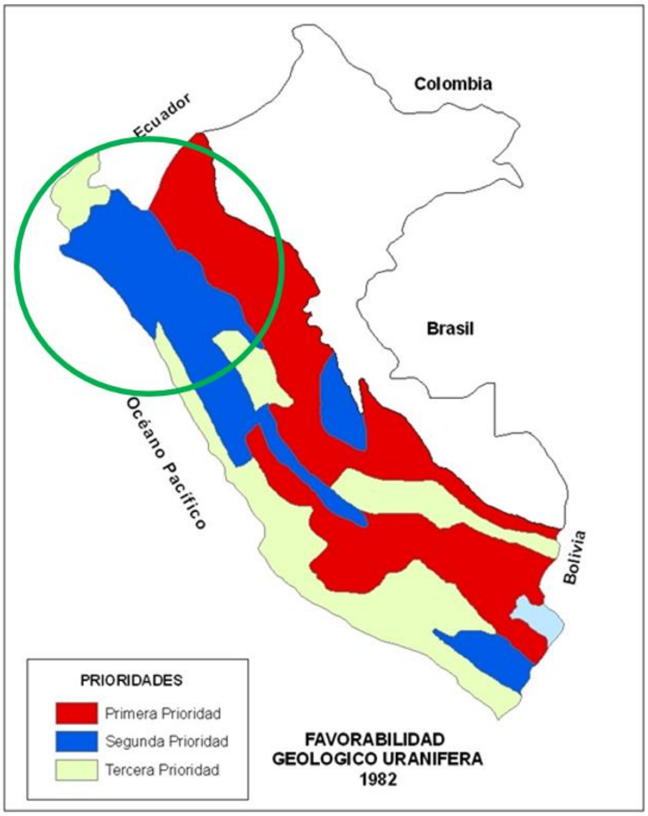

Fig. 1 Map of the uranium geological favorability of Peru. The green circle represents the northern macro-region, where the monitoring of environmental radon levels will begin. The figure was taken from IPEN.

Environmental radon is measured in units of Becquerels per cubic meter (Bq/m^3). The amount of radon in the air is measured in units of Becquerels per cubic meter because radon is a gas and its concentration in the air can be expressed in terms of volume. It is recommended by various health organizations, such as the World Health Organization (WHO) and the US Environmental Protection Agency (EPA), to keep indoor radon levels below $200\ Bq/m^3$. However, some studies suggest that no level of radon is safe, and it is best to keep levels as low as possible.

To measure and monitor environmental radon levels, active detectors, AlphaGUARD and Rad Elec Recon, will be used, see Figure 2. The accuracy of the Rad Elec Recon detector is, on average, $\pm 10\ Bq/m^3$, while AlphaGUARD is $\pm\ 0.01\ Bq/m^3$. However, the advantage of the Rad Elec Recon detector is its easy transport and maneuverability, especially in rough terrain. In order to compare the measurements between both active detectors, they were placed in a chamber with controlled temperature, humidity, pressure, and radon levels, as shown in Figure 3.

Three types of measurement were established for the active detectors (AlphaGUARD and Rad Elec Recon), increasing, decreasing, and constant concentration of radon levels. Figure 3 shows the measurement of the Rad Elec Recon detector with decreasing concentration. This sensor consists of two Electret Ion Chambers (EIC) that detect radon levels independently; additionally, it consists of a temperature, humidity, and pressure sensor, see Figure 3.

As a result of the comparison between the measurements of the active environmental radon sensors, an average error of 10% was obtained for concentrations above $50.0\ Bq/m^3$. In comparison, the error is 15% for concentrations between $20.0\ Bq/m^3$ and $50.0\ Bq/m^3$.

Fig. 2 Active radon detectors to be used in monitoring. The left figure is an AlphaGUARD while the right figure is the Rad Elec Recon detector.

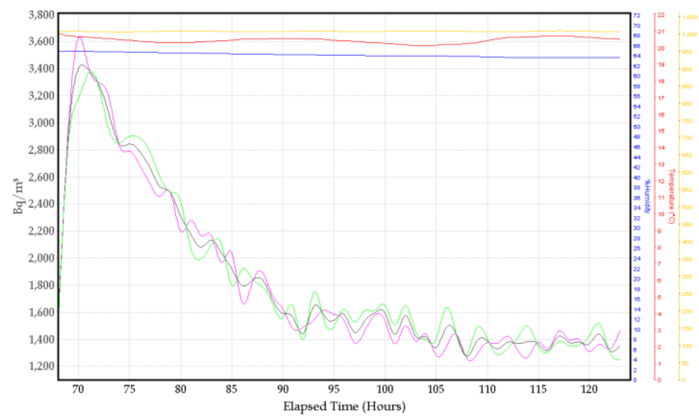

Fig. 3 Measurement results with Recon detector for a decreasing concentration in a controlled environment. The green and magenta lines represent the measurements by cameras 1 and 2, respectively. The black line represents the average concentration between chambers 1 and 2. The yellow, red, and blue lines represent pressure, temperature, and humidity, respectively.

III. CONCLUSIONS AND PERPECTIVES:

We identify a region in Peru with a high probability of contamination by environmental radiation.

The reliability of the Rad Elec Recon detector for environmental radon monitoring was verified with errors of 10% and 15% for concentrations greater than $50\ Bq/m^3$ and between $20\ Bq/m^3$ - $50\ Bq/m^3$, respectively.

The accuracy of radon detectors can vary, and it is recommended to have multiple detectors in a building to get a more accurate reading. Additionally, regular testing is recommended, as radon levels can fluctuate over time.

In order to complete the investigation, it is planned to use CR-39 detectors because they are cheap, easy to use, and have good sensitivity at low radon levels. CR-39 detectors work by exposing the plastic to radon gas, and then analyzing the plastic for the tracks left by the alpha particles. The number of tracks is proportional to the amount of radon exposure, and can be used to estimate the radon concentration in the air.

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