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Investigation of Radon Concentrations in Pamukkale-Turkey

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Radon is an inert gas produced by the radioactive decay of radium with a half-life of 3.81 days. Radon is the largest source of natural ionizing radiation and every 2.6 km^2 of surface soil, to a depth of 15 cm, contains approximately 1 gram of radium, which releases radon in small amounts to the atmosphere. On a global scale, it is estimated that 91 TBq of radon are released from soil annually. In this work, the radon concentration in soil gas, which is transported from soil (1 m depth), is measured at five points in Pamukkale and its neighbourhood.

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1. Introduction

Radon is the only gas among the elements of the radioactive chain of Uranium, produced by alpha decay of the Radium (^{226}Ra). Its most stable isotope, ^{222}Rn, has a half-life of 3.8 days. As radium decays, radon is formed and is released into small air or water-containing pores between soil and rock particles. It usually migrates freely through faults and fragmented soils, and may accumulate in caves or water. Migration or transport of radon depends on many factors: the medium porosity, the moisture content of the soil (materials), the pressure differences of the soil and atmospheric air and temperature.

Radon is an odourless, colourless gas, which cannot be perceived by human senses. Presence of radon can be detected only by radioactivity detectors. Its concentration in soil gas varies between 0 and 100 kBq/m^3, depending on the type of rocks and the depth at which it is measured, being variable in the first 25 cm of the soil due to erratic soil moisture content. At greater depth 0.8–1 m, concentration of radon is relatively stable and is considered as the reference value. At greater depth of 1–2 m concentration can reach 100 kBq/m^3.

2. Methods

The Denizli basin, which is an important member of the Western Anatolian extensional province, is a east-west oriented graben, 50 km long and 20 km wide (Fig. 1). The basin fill consists of fluvial, lacustrine and alluvial deposits and travertines, ranging from early Middle Miocene to the present. The Denizli basin includes a lot of geological heritage items of different type. These are hydrogeological, sedimentological, tectonic and paleontological in origin. Most of the geological heritage items are related to travertine localities.

At Pamukkale, it is possible to see hydrothermal and depositional processes and dip slip faults, extensional fissures, travertine fissure ridges and traces of seismicity. Apart from the travertine localities, the geological heritages with tectonic origin are fault planes observed along the basin boundary fault zones. The most prominent representatives of the fault planes are followed at Pamukkale-Karahayıt in the north and near the village of Menteşe in the south.

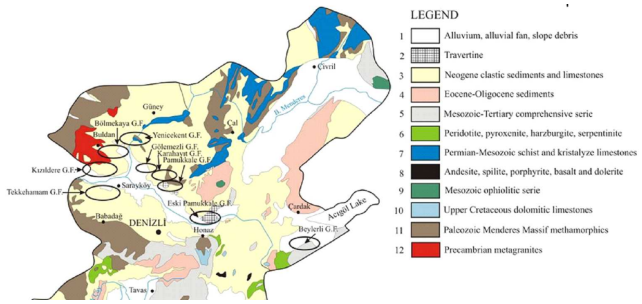

Fig. 1. The geothermal field in the Denizli Province (modified from MTA, 1964).

The measurements have been performed by a portable device, AlphaGuard PQ 2000PRO, designed for long-term monitoring of radon gas concentration. AlphaGuard is an ionizing chamber which measures radon via alpha spectrometric techniques.

The AlphaGuard has several probes for different application. The soil gas probe consists of a drilling rod with an exchangeable drilling tip with air-lock, which is closed by a rivet and capillary probe for transmitting of soil gas. By means of a hammer the drilling rod can be driven into the ground to a desired depth.

3. Results

The radon concentration of the soil gas has been measured at five points in Pamukkale region (see Table), for an hour in 10 minutes intervals, together with the temperature and the humidity and the pressure (Fig. 2). The obtained values of radon varied between 3×10^3–75×10^3 Bq/m^3.

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TABLE

Location of measurement points and measured values.

Measurement Point	latitude	longitude	Radon [kBq]
Jandarma pool	37°55.657’	29°7.467’	8.1
Travertine Slope	37°55.874’	29°7.467’	8.3
Develi Village	37°55.871’	29°5.467’	3
Akköy	37°56.961’	29°4.798’	14.6
Karahayıt Village	37°57.821’	29°6.265’	75

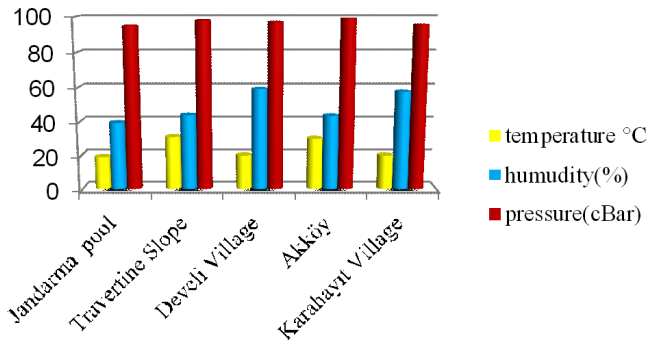

Fig. 2. Temperature, humidity and pressure graph.

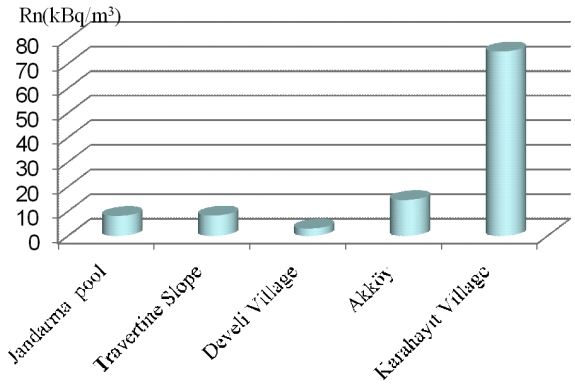

Fig. 3. Rn concentrations.

4. Conclusions

The nearest measurement point to active fault zone is located in Karayıt. There are hot geothermal water sources at 42–52 °C and the soil is of alluvial type at this area. Considerably high levels of Rn concentration are observed in soil gas at that point (Fig. 3). “Travertine Slope” and “Jandarma Pool” measurement points are located near warm (30–34 °C) geothermal sources. The soil is mostly rich in calcium carbonate and is not very permeable at the area. As a result of that, Rn concentrations are relatively low. “Akköy” measurement point is located in agricultural area and there is highly permeable alluvial soil here. Soil gas of this area has significant Rn concentrations. The last measurement point “Develiköy” is located inside the village and the lowest values are measured here. The soil probably contains some building materials and the porosity could be affected by them.

According to measurement data, Rn concentration in soil gas is affected by both porosity and fractured nature of the rocks, especially near the active fault zones. Beside that we didn’t observe any correlation between Rn concentrations in soil gas and the instant temperature, humidity and pressure.

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