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Monitoring and descriptive analysis of radon in relation to seismic activity of Northern Pakistan

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ABSTRACT

Earthquakes are one of the major causes of natural disasters and its forecasting is challenging task. Some precursory phenomenon exists in theory in relation to earthquakes occurrence. The emission of radioactive gas named 'radon' before the earthquakes is a potential earthquake precursory candidate. The study aims to monitor and to analyze the radon in relation to seismic activity in Northern Pakistan. For this purpose RTM-2200 has been used to monitor the changes in radon concentration from August 01, 2014 to January 31, 2015 in Northern Pakistan. Significant temporal variations has been observed in radon concentration. The bivariate analysis of radon with other variables manifests its positive relationship with air pressure and relative humidity and negative relationship with temperature. 2σ upper control limit on monthly basis are computed for detection of anomalous trends in the data. Overall increasing trend is detected in radon concentration. Five earthquakes from August 01, 2014 to January 31, 2015 have been selected from earthquake catalogue, depending upon their magnitude and distance from monitoring station and out of which radon concentration can be associated with only two earthquakes correlated with tectonic effect of radon concentration. Both of events have same magnitude 5.5 and occurred on September 13 and October 14, 2014 respectively. Very large variations have been observed in radon for the last two months of the study period, which may be occurred due to some other geological and environmental changes, but are not related to the earthquake activity.

1. Introduction

An earthquake is a sudden, rapid shaking of the Earth caused by the release of energy stored in the rocks along the tectonic faults. Forecasting earthquakes is challenging task (Asim et al., 2017; Jashank et al., 2014; Oh and Kim, 2015; Martinelli and Dadomo, 2017; Rundle et al., 2000). Prior to the occurrence of earthquakes some precursory phenomenon exists in theory. Initially earthquake forecasting was defined by the seismic-cycle (Lawson and Reid, 1908; Turcotte and Spence, 1974; Bak et al., 1988). Later the degassing of earth has diverted the researchers' attention to correlate the earthquake activity with the emission of geo-chemical process. There are many physical and geo-chemical processes continuously occurring in the crust of the earth. The geo-chemical processes involve the emission of different quantities that naturally occurred for instance, the Helium gas emanation from the earth's crust (Toutain and Baubron, 1999), the impulsive metals e.g: *Hg*, *As* and *Sb* emissions (Sugisaki et al., 1980; Alekseev et al., 1995), the electromagnetic emissions in different frequency bands (Brûlé et al., 2014; Pulinets, 2014; Chimonas and Hines, 1970; Hao, 1988; Nikiforova and Michnowski, 1995; Vershinin et al.,), the gravity wave that coupling with ionosphere (Pulinets and Boyarchuk, 2004), the densely measured grid of ionospheric mapping (Pulinets and Boyarchuk, 2004), the thermal infrared (Ouzounov et al., 2006; Saraf et al., 2012), the outgoing long wave radiations (Ouzounov et al., 2006), the ultra low frequency (Bleier et al., 2009), the planetary alignment (Tanaka et al., 2004), the total electron content (Liu et al., 1996; Pulinets and Boyarchuk, 2004)and the radiations emissions (Hopke, 1987; Nazaroff and Nero, 1988).

Radon is radioactive colorless and odourless gas having three isotopes: ^{219}Rn, ^{220}Rn and ^{222}Rn. The Actinon (^{219}Rn), Thoron (^{220}Rn) and radon (^{222}Rn) (Cothern and Smith, 1987; Wilkening,

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1990). Radon (^{222s}Rn) isotope is the bi-product of uranium and has the longer life when compared with other two isotopes. In atmosphere, the radon gas is present at everywhere with different concentration levels. Although the ultimate cause of Radon is the presence of uranium in soil or in upper part of the Earths crust. Its concentration is sourced from soil, water and air (Cothern and Smith, 1987; Wilkening, 1990). The compression decompression in the upper part of earth crust produced by seismic activities can move the radon upward. Hence its concentration can be used as precursory factor for earthquake forecasting.

In relation to the seismic activities, radon concentration has been monitored and analyzed in several studies. For instance, it has been monitored at remote station in thermal springs at Bakreswar, West Bengal India, where its concentration from 2σ was taken as an anomaly. These anomalies correlates with seismic event occurred around Nicobar and Andaman Islands (Das et al., 2006). Similarly its concentration has been linked with seismic activities at Ravne Fault in NW Slovenia (Vaupotič et al., 2010), in Tuzla fault line located in western Turkey (Muslim Murat et al., 2011), in Jooshan SPA, Kerman province of Iran (Namvaran and Negarestani, 2013), in northern areas of Pakistan (Jouanne et al., 2014) and in Balakot Bagh, Paksitan (Jouanne et al., 2011).

Pakistan and adjoining region has history of many large earthquakes. Main source of earthquakes in this region is the convergence between the Eurasian and Indian plate which results in crustal lessening of Indian plate northern margin accommodate south verging thrusts. These thrust faults includes the Main Mantle Thrust (MMT), the Main Karakorum Thrust (MKT) and the Main Boundary Thrust (MBT) (Thakur, 2004). Based on earthquake activity and location of tectonic faults Pakistan may be divided in three regions: Northern Pakistan, Hindu Kush and Southern Pakistan. The current study aims to monitor radon concentration in connection to earthquake activities in a spot in Northern Pakistan, which has faced the earthquake (Magnitude = 7.6) on October 08, 2005. Northern Pakistan comprises northwest Himalayas extending from Hazara Kashmir syntax in the west towards the eastern boundary (Jacob and Quittmeyer, 1979), and its thrust faults includes the MBT, MMT and MKT (Lisa et al., 2004).

2. Material and methods

2.1. Instrument RTM 2200

In current study, radon dataset was taken from network of Centre for Earthquake Studies (CES), National Centre for Physics, Islamabad, Pakistan. The data was monitored through RTM- 2200. It was developed by a German company SARAD and offers a wide range of gas sensors for various applications. Handling the wide range of sensor demands the different measurement principals regarding range, uncertainty, cross sensitivity and ambient conditions. Hence the use of RTM-2200 demands the full knowledge about the cite specific conditions, geological and atmospheric environments. Radon Concentration in Soil gas has been studies in current research. Air accumulated in a PVC pipe of diameter 3 inches and length 3 feet, dumped in a hole inside the soil has been sucked with a pump installed inside RTM 2200. This air then reached the ionization chamber through internal air loop. The Radon concentration in the soil gas measured by the short living daughter products, generated by the Radon decay inside a measurement chamber. Daughter products which are already present in the atmosphere will be kept out by a filter system. Directly after the decay, the remaining Polonium-218-nuclei will be charged positively for a short period, because some shell electrons are scattered away by the emitted alpha particle. Those ions are collected by the electrical field forces on the surface of a

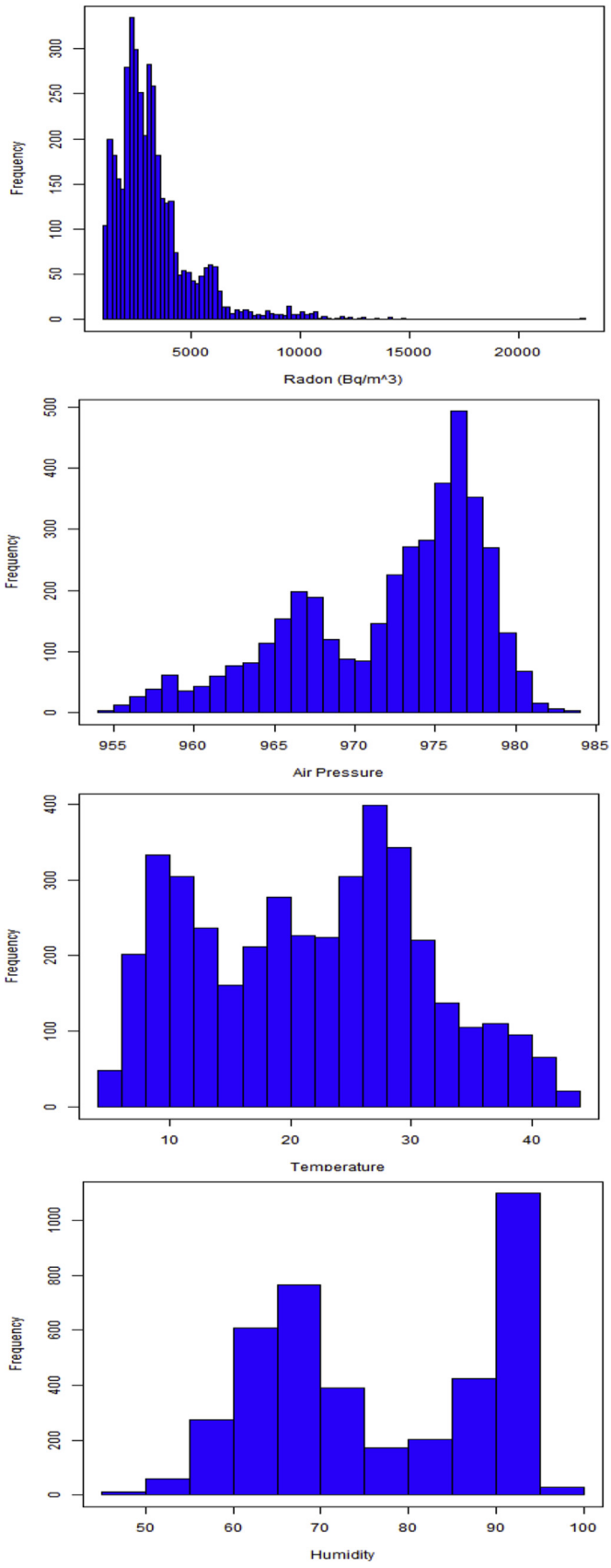

Fig. 1. The distributions of radon, air pressure, temperature and relative humidity are displayed through histograms, and are presented in top, upper middle, lower middle and bottom panel respectively.