Correlation Between Ground Level Gamma Radiation and Radon Gas Concentration in Soil At Different Baptism Depth of Oil Exploration Areas within Aizawl District of Mizoram, India

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***Abstract* - The health hazards of radon gas on the general public is well known. To understand the exact level of radon gas concentration in soil gas of oil exploration areas in Aizawl district of Mizoram, India, survey is carried out with portable Smart RnDuo, an electronic devices that detect radon gas. At the same time, ground level background gamma radiation survey is also conducted with Russian base Gamma Survey Meter (PM 1405). The Radon gas concentration at different baptism depth beneath the ground surface is studied and a correlation graph is drawn with the background gamma radiation. The oil exploration areas including Maubuang(MB), Keifang(KF) and Phulmawi(PL) in Aizawl district, are studied. The RnDuo machine devised to survey Radon 222 (^{222}Rn) is connected to a soil probe of 1mtr long to be baptized at different depth. The background gamma radiation at ground level varies from 162 nSv/hr at PL-3 to 190 nSv/h at MB-3 location with an average of 176 nSv/h. An in-situ measurement of soil gas was carried out at three different spots at four different depths namely, 10cm, 30cm, 50cm and 70cm. The radon gas concentration beneath the soil, within the study area ranges from 0.10 kBq/m^3 at KF-2 to 1.60 kBq/m^3 at MB-2 location. The Radon gas concentration obtained in these areas are below the worldwide average of 35-40 kBq/m^3 (UNSCEAR 2000).**

Key words: Soil Probe, in-situ measurement, Gamma survey meter PM-1405.

I. INTRODUCTION

The presence of radionuclides inside the earth cannot be denied. At the same time, in oil exploration areas where crude oils and necessary petroleum gas are being drawn, the content of the soil and materials are definitely different than any other non-oil exploration areas. It is necessary to learn and compare whether the presence of oil and natural gas under the earth causes an increase or decrease in the radon gas concentration, and also it is important to study if the radon gas concentration in those areas were below or above the worldwide average . This can be easily studied and surveyed and compared with the concentration obtained at some non-oil exploration areas and also with the worldwide average radon concentration. The radionuclides present in an underground soil consists mainly of Uranium, thorium, radium, potassium etc, which are a source of natural radioactivity and contribute to background radiation. Apart from these, the earth contains plenty of organic as well as inorganic materials. The background radiation contribute a considerable percentage of the total radiation exposure to individuals (*Porstendorfer et al., 1994).* Natural radionuclides are broadly classified into two types as – Cosmogenic (which comes from cosmic ray particles undergoing nuclear reactions) and Primordial (which are in existence since the origin of Earth) *(Radenkovic et al., 2009; Tzortzis et al., 2003)*. The present study includes the study of radon gas concentration from Primordial source as well as from Cosmogenic and to draw the correlation graph. This is meant to find out whether the background radiation coming from Uranium and its decay products are in good correlations with the background radiation obtained at ground surface. Since the study is conducted at oil exploration areas, it is highly expected that a different result may be obtained. The levels of natural background radiation dose rates vary from 1.4 to 2.4 mSv y^{-1} depending on the abundance of primordial radionuclides in the soil and the latitude and longitude of that place (*UNSCEAR 1993*).

Radon gas comes from the naturally occurring radionuclide. The isotope ^{222}Rn is mostly the decay product of uranium ^{238}U. Approximately 55% of the internal radiations are exposed to human beings (ICPR 1993) and it is found in almost all types of earth and soil. Despite porosity, the radon movement in rock and dense soil depends upon various factors including compaction, fractural, tectonic features like earths thrust, earths faults and earths joints (Choubey *et al.* 1997). Method of surveying the radon content at different depth beneath the earth is introduced.

From a collection of various studies, it is found that the radon concentration at different baptism depth is different (Bourai *et al.*2013). The concentration is proportional to the depth of the earth. It increases with depth. The deeper the baptism depth the higher the radon concentration (Duggal *et al.* 2013). Radon concentration at different baptism depth of oil exploration areas in Aizawl district of Mizoram are studied. In India and Pakistan, radon survey in soil gas was carried out at different parts and locations (Mujahid *et al.* 2008; Ali *et al.* 2010; Prasad *et al.* 2005, 2008; Bajwa *et al.* 2010; Singh *et al.* 2010; Mehra and Bala 2013). The aim of the present study is to find the radon concentration at different baptism dept and to draw the correlation graph with the background gamma radiation at ground level.

II. STUDY AREA

Mizoram is located in the North Eastern part of India neighbouring the state of Assam in the north. The search for oil and natural gas in the state of Mizoram is mainly carried out in six locations. The oil fields chosen are situated at Maubuang, Keifang and Phulmawi villages respectively. The present study location stretches from $23^0$29’42.7” to $23^0$39’14.2” longitude and between 92’42’3.6” to $92^0$57’1.7” latitude. The elevation range from 2870 ft and 2956 ft from sea level. The Fig.1. shows the location maps of oil exploration areas at different districts of Mizoram, India.

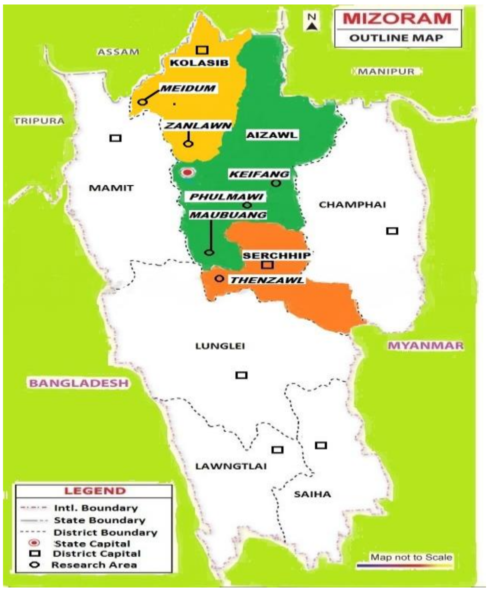


Fig.1, Map of Mizoram, India, showing Oil exploration areas

III. MATERIALS AND METHOD

A. *Measurement of Background Gamma radiation using Gamma survey meter PM-1405* **:** In order to correlate the radiation coming out from the earth and that coming from the cosmos it is necessary to survey the gamma radiation with a suitable survey instrument. At each location of soil sample collection, a gamma radiation survey is conducted with the help of Gamma Survey Meter (PM 1405) as shown in Figure.2. The measurement range for γ radiations is between 0.1µSv/h – 100 mSv/h. The Gamma survey is conducted at the surface of the earth/ground.

Fig.2. Gamma survey meter PM-1405

B. In-situ measurement of Radon concentration at different baptism depth : At each area, three different spots were chosen to cover the entire areas. The radon concentration was determined at four different depths namely 10cm, 30cm, 50cm and 70cm. An *in-situ* measurement was done with Smart RnDuo, an instrument specially designed for the purpose. Fig.3. shows the Smart RnDuo for measuring radon concentration in soil gas. Four reading at 15mins cycle was taken. The mean of the three readings gives the final reading for that depth. Fig.4 shows the block diagram of the mentioned smart RnDuo.

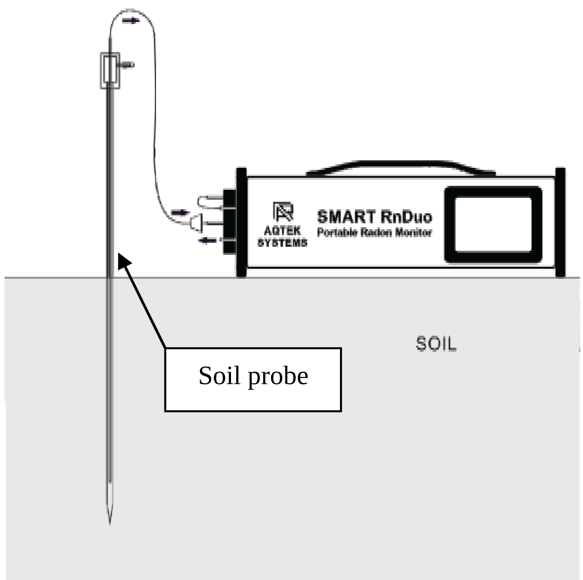


Fig.3. Set up for measurement of radon in soil

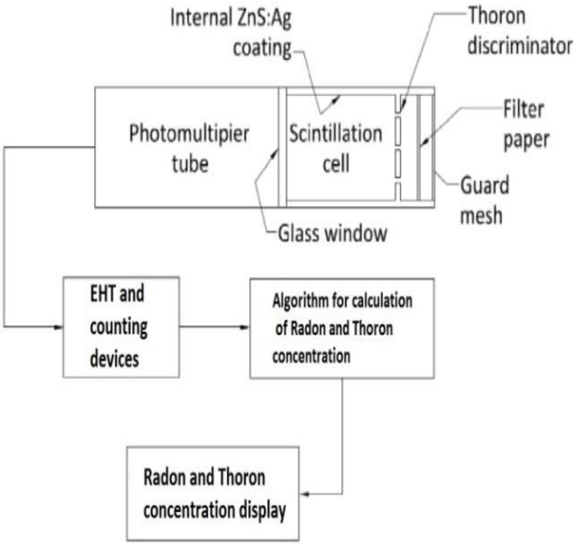


Fig.4. Block diagram of Smart RnDuo

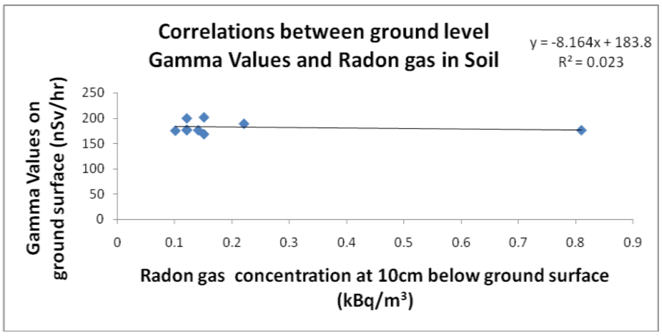
IV. RESULTS

The background gamma radiation at each study location is given in Table-1. The same table shows radon concentration at 10cm, 30cm, 50cm and 70cm deep. The radon concentration varies from 0.10 kBq/m^3 at KF-2 at 10cm depth to 1.60 kBq/m^3 at MB-2 at 70cm depth. The readings are taken during winter season. During this month the weather is dry and there are no rainfall for the last 30 days.

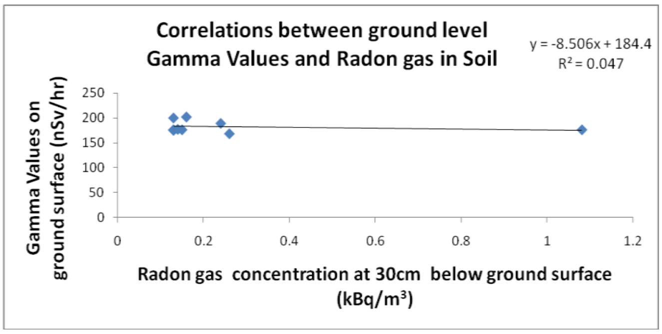
Table-1. *Gamma Radiation at ground level and Radon Concentration in soil gas at various baptism depth of oil exploration areas in Aizawl district of Mizoram, India*

Sl. No	*Sampling ID*	*Ground Level Gamma Radiation (nSv/hr)*	*Baptism Depth*	*Radon Concen-tration kBq/m^3*
1	MB-1	183	10cm	0.15
			30cm	0.23
			50cm	0.35
			70cm	0.42
2	MB-2	170	10cm	1.23
			30cm	1.25
			50cm	1.55
			70cm	1.60
3	MB-3	190	10cm	0.83
			30cm	0.86
			50cm	1.19
			70cm	1.35
4	KF-1	179	10cm	0.11
			30cm	0.13
			50cm	0.15
			70cm	0.16
5	KF-2	180	10cm	0.10
			30cm	0.13
			50cm	0.15
			70cm	0.19
6	KF-3	173	10cm	0.14
			30cm	0.28
			50cm	0.34
			70cm	0.40
7	PL-1	165	10cm	0.40
			30cm	0.42
			50cm	0.47
			70cm	0.52
8	PL-2	180	10cm	0.11
			30cm	0.17
			50cm	0.18
			70cm	0.24
9	PL-3	162	10cm	0.13
			30cm	0.14
			50cm	0.15
			70cm	0.18

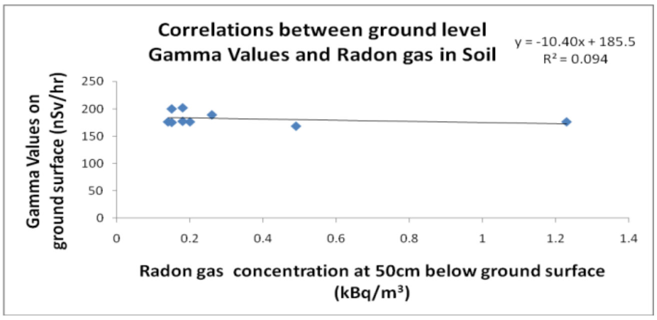
The graph-1, graph-2, graph-3 and graph-4 shows the correlation between Ground level gamma radiation and average radon concentration at different baptism depth such as 10cm, 30cm, 50cm and 70cm respectively.



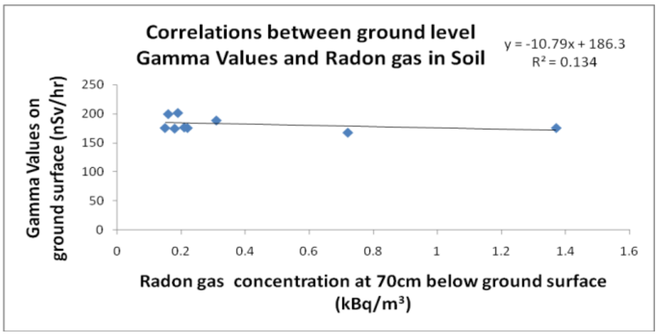
Graph-1. *Correlation between Ground level gamma radiation and Radon concentration at 10cm deep.*



Graph-2. *Correlation between Ground level gamma radiation and Radon concentration at 30cm deep.*



Graph-3. *Correlation between Ground level gamma radiation and Radon concentration at 50cm deep.*



Graph-4. *Correlation between Ground level gamma radiation and Radon concentration at 70cm deep.*

V. DISCUSSION

The concentration of radon gas increases as we baptize the soil probe deeper and deeper. This means that for every spot chosen, the value of radon gas concentration at 10cm deep is lowest and the radon gas concentration at 70cm is highest and the concentration at 30cm and 50cm lie in between. The correlation coefficient (R^2) obtained from the graph was least at 10cm with $R^2 = 0.023$ while it is maximum at 70cm deep with $R^2 = 0.134$. This indicates that the gamma radiation had a better correlation with higher radon concentration. The correlations observed are not that good. The possible reason for this poor correlation may be due to the contributing factor. Whereas the radon concentration at different baptism depth is contributed by Uranium 238, on the other hand, the background gamma radiation at ground level is contributed by many cosmic and terrestrial sources like Uranium, potassium, thorium etc. The radon gas concentration obtained in these locations are far below the world average of 35-40 kBq/m^3 (UNSCEAR 2000).

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