The measurement of the Radon concentration in the environment and the methods of reducing its density in the indoors

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ABSTRACT
In this paper, after a brief review on the properties of the radioactive gas, radon, the method of producing this radionuclide is presented. Radon is an alpha emitter that the alpha emitter enters the respiratory tract via breathing and it will decay rapidly due to their short half-life. In addition of radon alphas, the daughter of next nuclei of decay chain remains in the interiors of respiratory tract as deposition and it will increase the body absorbed dose. About 55% of natural exposure of humans is resulted from radon that it kills many people by respiratory cancers. Finally, the method of reducing this gas in the homes and indoors and the way of measuring radon concentration in soil, water and air will be mentioned.

INTRODUCTION

Radon is considered as one of the main radioactive materials in nature and as most important factor of human exposure. In general, radon exists in air, water and soil as gas. The amount of this gas in the nature depends on geographical position and underground resources of those regions. In the regions that natural deposits of uranium and radium exist or in any way their water and soil of those regions have these materials, this gas will be found in that region more abundant. 55% of exposure per person per year is due to this radioactive gas. 11% exposure resulted from internal exposure because of consuming foods and beverages (foods and beverages also naturally contain some radioactive materials), 8% due to cosmic exposure, 6% due to exposure from earth and 18% due to artificial exposure (including imaging with X-ray by using radiopharmaceuticals in the nuclear medicine and …). That total annual exposure per person from these resources is about 3.6 msv. Radon is the only production of radium cleave that regarding to the presence of radium in the uranium cleave chain, this gas is present in the decay chain of uranium. Radon is a radioactive material with half-life 8.3 days, which itself emits an alpha particle and converts to PO-218, a radioactive material with 3-minute half-life. This material will convert to Pb-214 which is a radioactive material with 26.8-minute half-life, by irradiating alpha particle.

U-238 → ...Ra-226a → Rn-222a → Po-218a → Pb-214γ →
Bi-214γ → Po-214a→Pb-210γ → Bi-210γ → Po-210

As it can be seen in the radon decay chain, number of alpha particles emitted in this chain is high and given that alpha particle considered as one of the most dangerous particles resulted from decays so this gas can be considered as one of the dangerous radioactive gases. Three elements polonium, lead and bismuth which are resulted from consecutive decomposition of radon and have radiation properties, are called radon daughter. These elements are as solid in macroscopic quantities and when they are formed in air they will attach to the dust particles quickly and when we breathe they enter our longs along with air and stick to its surface. These elements emit high-energy alpha particles that their radiation will damage the trachea cells, which can eventually cause lung cancer.

Methodology:
Radon emission in a volume of air is determined easily and quickly with a radon monitor and a steam cap. Radon emission quantities is defined based on the observing increase in quantity of related radon with gas

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volume that is obtained in a specified time. Radon is as gas and it escapes from sands and sediments overlying bedrock and some tools have been made to facilitate the digging for the detection of radon present in soil and after digging trenches in the soil by alpha spectrometry (monitor). Research package and syringe are used, if necessary. If radon is soluble in water, for measuring the radon in the water, nothing doesn't require except a radon monitor and a degassing vessel. The radon soluble in the water sample will degassed by air bubble blowing dish. The degassing Vessel should be connected to radon monitor to create a closed air loop.

![Fig. 1: A radon/thoron monitor set in the filed for radon and thoron environmental measurements in gas/water (SARAD model RTM 2100 Tn, radon/thoron monitor system)](image)

All available detectors measure directly the concentration of radon and its daughters. The basis of all these devices is to suction the air by pump and to trap the radon on the special filters which are located in the air path. Radon accumulated on these filters are counted by special detectors for counting alpha (ionization chambers) and will measure radon.

If radon is as dissolved in water, for measuring its value, radon monitor and a degassing vessel is need, the radon dissolved in water sample degassed by degassing vessel. The degassing vessel should be connected to radon monitor to create a closed air loop. Radon is a gas and will escape from sands and sediments covering bedrock that some tools were made which facilitate the digging for detecting radon in soil.

First by a special syringe, 100cc water samples will be injected into the degassing vessel which is a glass cylindrical and then the completely isolated system will be startup by turning on the pump.

![Fig. 2: diagram of the experimental arrangement utilized for radon passive and integrated monitoring of water samples collected in the sao Vicente mountain range.](image)

The second vessel which is called security vessel is located in the circuit for this reason (Because of avoiding) to avoid penetration of any water and moisture into the pump, the pump will suction for 10 minutes with flow 3.0lit/min that during this process, due to air circulation in a closed circuit and its passing through a glass filter, by micro suction total radon will removed from sample. radon rotating in the air trap in the
ionization chamber during passing through the machine. This is done by special filters for absorbing radon inside the counter machine and the alpha particles emitted from it are counted by ionization chamber in counter machine. The pump will be turn off after 10 minutes and the system will leave to itself for 20 minutes in order to radon reaching to its minimum equilibrium with its daughters. After this period, radon concentration in the water will be measured by software of analyzer and its quantity will be calculated based on error. Temperature and humidity of environment are effective in calculating the radon concentration which these parameters are considered in computing. After any measurement, the system should be empty from radon to be prepared for next samples measurements. Sampling period should not be longer than two hours, otherwise radon diffuses through the walls of the tube. Thus the radon trapped in ionization chamber and the whole system must be empty which is done by using active charcoal. Active charcoal can absorb the radon because of its chemical structure and make the system free from it. There are different devices for measuring radon in environment, that the most common are Ramon2.2, Rad7, RTM1688, Alphaguard that are detectors RAD 7 made by Durrige Company, USA and Alphaguard by Genitron Instruments, Germany.

The measurement by radon digital monitor is among other methods for determining radon quantity that is done during a short time. The measurement process of RTM1688 is such that at first, radon monitor is switched with an external pump connected with an internal pump to measure the radon activated concentration in the closed air. Then steam cap with height h on the surface is examined. Its position should be fixed suitable to enter pressure on the cover of surface and to enter a weight on the cap horizontal. In addition, an additional seal (like silicon paste, sticky tape or solid materials in case of field measurements) is recommended. After that, entrance and exit of monitor are connected with two entries of steam cap via PVC tube. In this method, a closed circuit is obtained through flowing air. Time t from beginning with minimum concentration level (C1 quantum) up to maximum level of radon activated concentration (C2 quantum) is measured and by measuring C_{diff}=C2-C1 and using h, t, the radon emission calculation can be obtained based on E=C_{diff}/h.t. In some cases, stone, brick and cement contain trace amounts of radium that emit radon inside the homes and other buildings, the air pressure inside the house is lower than pressure in soil around the house foundation so the building act like a vacuum and causing penetration of radon through cracks, pores and any penetration ways to the building and therefore the cracks of buildings floor should be watertight, meanwhile by increasing the water temperature, the adsorption will decrease and so the radon level will be decreased. Device Rad7 is a system composed of an alpha detector that is located in a Hemisphere chamber, a nuclear electronic system embedded that allow Rad7 to detect the alpha particle. The air contaminated with radon is pumping into the chamber by internal air pump that embedded in the system. This air can be supplied from water sample that is placed in test glass 40ml and 250ml by filter (NYLON 0.45) and dehumidifiers CaSO4. For measuring well water, Rad7 is mounted on well, the well water enter lateral part of powdering device by piping such that it doesn’t have any contact with air and so the radon soluble in water will release into the chamber. This gas by pump, after dehumidifies enters the device Rad7 and counted. This device is more accurate than others.

The methods of reducing radon in the building:
Before any action, the level of radon in the building, its origin and its penetration way should be determined. The measurement of radon in the building air is an easy task. Most common and simplest way is to place the radon tracking films in at least two rooms for at least 2 months in a cold season. If the resource of radon is construction materials, the solution is to increase the ventilation and covering the radon-producing materials with impenetrable materials. If radon enters from the below of foundation and or around of the ground, as a first action, the air ventilation level should be increased and then its entrance should be blocked. The resistant layers against radon penetration are: sheet (layer), adhesive tape, sealant, adhesive paste, and seamers. In general, whenever the building is in ground level and its floor is in contact with soil, the probability of radon penetration is more. In this regard, floor, foundation, joints, cracks, the radon penetration ways and wells must be degassed very well.

RESULT AND DISCUSSION
To measure the radon emission, device RTM1688-2 is most recommended solution. Its unit presents sensitivity higher than 3 cpm (KBq/m3) that only 130 ml is obtained from a small internal volume. Although sensitivity of RTM2100 is lower 1/5 cpm(KBq/m3) probability it occurs in high humidity and the internal volume is about 3 times more (ml370). RTM1688 is most suitable solution for measuring radon of soil. Today the permissible level of radon in drinking water is determined 100Bq/l, but in the refinery that isn’t prepare for consuming it can be maximum 1000Bq/l. WHO suggested the 100Bq/m3 as permissible level in residential buildings while it is determined as 200 Bq/M3 for in fresh air.
Table I: Specific data of radon measurements devices

<table>
<thead>
<tr>
<th>Method</th>
<th>Type</th>
<th>Field area</th>
<th>Volume</th>
<th>Sensitivity</th>
<th>Time period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha scintillation detectors</td>
<td>Instantaneous</td>
<td>Gas/water</td>
<td>0.11-3.01</td>
<td>0.8-16cpm/Bq m$^3$</td>
<td>1-5min</td>
</tr>
<tr>
<td>Alpha track-etch detectors</td>
<td>Integrated</td>
<td>Gas</td>
<td>456ml</td>
<td>0.03-0.09 tracks cm$^{-1}$/kBq m$^{-3}$</td>
<td>1-2 weeks</td>
</tr>
<tr>
<td>Electret ion chambers</td>
<td>Integrated</td>
<td>Gas</td>
<td>50ml-960ml</td>
<td>3 Bq m$^{-3}$ h$^{-1}$, 1.05 kBq m$^{-3}$ h$^{-1}$</td>
<td>2-40 days</td>
</tr>
<tr>
<td>Barasol detectors</td>
<td>Continuous</td>
<td>Gas</td>
<td>590ml</td>
<td>0.02 pulses h$^{-1}$/Bq m$^{-3}$</td>
<td>15-240 min</td>
</tr>
<tr>
<td>Clipperon detectors</td>
<td>Continuous</td>
<td>Water</td>
<td>590ml</td>
<td>1cpm/362 Bq m$^{-3}$</td>
<td>1 min-48h</td>
</tr>
<tr>
<td>Radon/thoron monitors</td>
<td>Continuous</td>
<td>Gas/water</td>
<td>0.271</td>
<td>0.01cpm/Bq m$^{-3}$</td>
<td>1min-24h (standard 6min)</td>
</tr>
</tbody>
</table>

Conclusion:
It concluded from this paper that the aim of making these devices is first to measure the radon concentration for a long time and at timed intervals in the different regions and second to use these devices in determining the active faults, discovering underground aquifers and uranium deposits regarding radon concentration changes and now one of the aims of scientists is to measure the radon concentration for predicting earthquake.

REFERENCE