Ecological Impacts of Radon Gas Concentration in the Irankooh Ore Deposit

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***Abstract*---**Radon gas decay from radioactive element of radium and radium produced from decay of uranium. The amount of air radioactivity in the result of radon gas is measured by unit (Bq/m^3) of air. The study mine is located 20 kilometers southwest of Isfahan and in the Irankuh mountain.

Radon measurements with RAD 7 DURRIDGE machine, model 711, serial number 01872 made of US and manufactured in two modes, radon meter and Torun meter. This research showed that radon concentration is in the permissible limit. In some levels for example 1480 and 1490 levels radon concentration is below the limit, but because the amount of radon concentration can be changed in different seasons and during the day, and also workers pick up stones in these horizons, radon concentration needed to be monitored constantly . In the 1500 m level average radon concentration during a day was determined 3/28 Bq/m^3. But at the end of the horizon Radon concentration was determined 146 Bq/m^3 that looks impressive.

***Keywords*----**Ecological Impact, Gushfil mine, Permissible limit, Radon, Torun**.**

I. Introduction

RADON is a colorless, odorless, tasteless and radioactive noble gas element that achieved naturally from the decay of uranium and thorium. 39 isotopes of radon known (^{193}Rn and ^{231}Rn); But radon is seen as three natural isotopes, which are derived from various decay chains (Finn, 1992).

Between different isotopes of radon, ^{222}Rn is important over two other isotopes in the environmental issues. In the most resources when it comes to talking about radon, ^{222}Rn is of the same order and two other isotopes are known with the name of Torun and Aktynon. Half-life of isotope ^{222}Rn is 3.8 days, and it has enough opportunities to remain weather of human environment and cause threats to human health such as lung cancer (Frengstad et al., 2001).

Radon breathing in indoor air is leading to 20,000 deaths from lung cancer annually in the U.S. and 2000-3000 in Canada. After smoking, radon has second degree in mortality from lung cancer.

Radon from two possible source entered in groundwater (Frengstad et al., 2001).

- Dissolved radium decay and radon from uranium and thorium minerals were directly released into the reservoir rock of underground aquifers. Generally, radon concentrations in the groundwater is mainly dependent on a set of factors such as hydrodynamic parameters, geometric parameters, reservoir rock containing uranium, the type of minerals containing uranium and thorium. (Nelson et al. 1983, Michel 1990, Ball et al. 1991, Albu et al, 1997).

Radon remains solution in the water until appear by disturbance or by reducing the pressure. If radon directly radiated to gas phases, gases such as carbon dioxide lead radon will change to gas phases. This appears in some limestone formationd.

In underground, caves and fissures are capable to rapid transfer of gas phase. Radon in water could be exposed public in two ways.

1) By drinking water,

2) The release of radon in water when bathing or loss

In this mode Radon and its decay products can be inhaled and enter the lungs (Darby, et al. 2005).

Breathing air and dust particles join and remain suspended in the air or on surfaces sit and possible increased risk of lung cancer (Darby, et al. 2005).

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II. Geological Setting

Isfahan and Irankuh Mountain range can be part of West central Iran tectonic zone has been called Esfandaghe – Marivan .Irankuh mining area is in the 20 kilometers southwest of isfahan and between longitudes 51 , 31 degree to 51 , 45 degree and is located at latitude 32 , 28 degree to 32 , 37 degree. Trend of this mountain is West and North-West to the East and South East and average length of 25 km and a width of 3 km. Minimum Elevation of area from sea level is 1670 meters and maximum 2750 meters.

The oldest rocks in the area belong to the Lower Jurassic that consist of black shale with siltstone and sandstone rocks and just observed in the north of the mountain ridge. This shale match with shemshak shale. In this range Middle and Upper Jurassic formations haven't been found. The mountain original rocks, including Cretaceous carbonate rocks that located by Unconformity on Lower Jurassic rocks. This sediments age are Barremian to lower Albian and their thickness are generally about 800 meters that formed from limestone and dolomite with small amounts of shale and marl.

III. Gushfil Mine

Gushfil mine is located in the northern of Irankuh Mountains and is near to the Sepahanshahr city. This mine has 67 km distance from south-east of Abnyl . The start of exploration in this area discovered several deposits, that generally there are three forms below.

A: The masses that roughly follow bedding planes.

B: masses those are associated with karst phenomena

C: tectonic breccias

This mine works in two forms: open pit and underground mining and in 1978, its mining activity began. South side of mine consist of Cretaceous dolomites and north side from Jurassic shale. Ore is in the contact of two zone into gushfil fault, and shale is the hanging wall of ore. Gushfil fault has general direction of the North West - South East and dip of 55 to 80 degrees.

Gushfil underground mine began in 2006. Tunnel length is 2500 m and cross-sectional area is 20 m^2. Slope was 12.5% and difference of elevation between beginning and end of mine is 300 m. Fixed reserves for underground mining are 2500000 tons.

Second tunnel entrance has been excavated in the 1590 m horizon. But after the collapse of the shale part, this entrance was blocked and now used it only for the air Conditioning, Waste and mineral Depot.

Uranium radioactive element is expected in different layers of the earth, particularly in the lead mine, because ^{206}Pb is the last element of ^{238}U, concentration of these elements are very high. ^{222}Rn is one of radioactive elements in this series, so evaluation of ^{222}Rn concentration in lead mining is necessary. In this study radon concentration in underground lead and zinc mine of Irankuh that located in the Isfahan province of (Gushfil) was chosen .

IV. Radiation And Radon Gas Effects On Health

Rays can react with electron of molecules in cells and make changes such as ionization of atoms and molecules. Ionization of water molecules can be changed in the tissue. Beams Caused ionizing and can cause chemical changes in DNA molecules. DNA variations can lead Biological effects and developed abnormal cells that some of these effects can be seen long after radiation.

It is interesting to note that radon gas as a chemical Product remained for decades and even is significant in mineral water as a therapeutic agent. The first Radon was considered relatively safe gas or as combinations of geological gas, but recently, its importance is known as a dose radioactive supplier to the public.

Radiation with High dose effects on humans, which can cause premature death within a few days or a few weeks, but radiation with low dose causes visible skin damage (Zdrojewicz, et al. 2006). Radon in the environment have a late effect and settle in the second group.

V. Methods For Measuring Radon Gas

The are too weak and its energy is 51/0 MeV. Some detectors, experimental measurement and detection methods based on counting the alpha particles emitted from radon gas. The main particle radiated from radon gas is alpha particle with 486 / 5 MeV energy. Different detectors are used for radon gas measurement. However, radon gas emitted gamma particles too, that measurement radon concentration by gamma radiation.

Radon measurements occur in two-way passive and active. In the active method Rad7 is devices which can measure. These devices produced and marketed in various models to determine the radon and Torun concentration in the air and soil water. This devices includes a pump sucking air, intake air passes from a chamber such as dehumidifiers material (for example coal). Air to arrive into the counting chamber, it consists of a detector and the detector can be an ion cell or needles. Alpha particles hit to the detector, signals to establish and be ready for processing by an electronic devices system. The information stored in memory. The device is equipped with printers and screen is able to show in two ways.

In Active method Rad7 is fastest device with respect to accountability and decrease the time and is able to measure radon concentration until 200 Bq/m^3 in less than an hour with the 10% standard error. measurment can be expression in units of Bq/m^3, Ci / Lit. In most countries are used the SI unit Becquerel (Bq). Every Becquerel refers to the amount of radioactivity will decay in one second. In this paper was used to RAD7 Durridge machine model 711 serial number 01872 build America. Measure does in two ways, the radon meter and Torun meter. Figure 1 shows a plot of the RAD7 device.

In this study use Geiger Muller detector to measure the amount of radiation from gamma rays in place. Units Show according to Gray (Gy) and rad.

Fig. 1 Illustration of radon meter device

VI. Discussion

In Several horizons with different height above sea level measurements of radon and Torun were carried (Figure 2). The relationship between the concentration of radon and altitude horizon above the sea level shows with increasing height horizon above sea level radon concentration is decreases. Also Torun changes according to height is shown and can be seen that with increasing altitude, concentration of Torun decrease.

Fig. 2 Location of the device installation at the end of the ore Rocks tunnel

Torun $^{220}_{83}Rn$ is one of the radioisotopes of radon$^{222}_{83}Rn$, which is a natural radioactive gas as a member of other elongated chain from natural radioactive isotopes, thorium$^{232}_{90}Th$. Studies show anywhere near radon gas is present Torun gas; Torun concentrations is equal to or even greater than radon gas. Torun concentration in place makes sure presence for radon concentration. If Torun concentration is high in place to make sure the radon concentration in the area should be studied.

In another measure to a certain height, (1500 m height above the sea level), Radon is measured over 24 hours period and to be reviewed changes along a day (24 hours)(Figure 3). The measurements from 12:15 pm on Saturday, 15 January, 2011 starting and at 12: 15 on Sunday, 16 January, 2011 was finished. Device is automatically set up for each one and half hour of reading to do, and 16 times readings were performed within 24 hours. After 24 hours the device was turned off automatically.

The radon concentration began to rise in the early morning hours and the highest concentration is at 7 to 9 oclocks in the morning and again in the afternoon concentration decreases. Lowest concentrations of radon is 16 Bq/m^3 in the evening (16-18 pm) and in the morning (7 am) highest concentrations of radon is about 43.3 Bq/m^3. Deviation within 24 hours is 27 Bq/m3 in the 1500 horizon of the mine.

Fig. 3 Horizon of 1500 meters in the mine where the devices is placed for 24 hours

TABLE I
CHANGES IN RADON CONCENTRATION DURING A DAY

Measuring times	Time of measurement	Radon concentration in terms of Bq/m^3
1	15::00-16:30 P.M	18 ± 17
2	16:30-18:00 P.M	16 ± 16
3	18:00-19:30 P.M	26 ± 12
4	19:30-21:00 P.M	24 ± 11.9
5	21:00-22:30 P.M	26.9 ± 12.6
6	22:30-24:00 P.M	32.7 ± 13.3
7	24:00-01:30 P.M	25 ± 11.9
8	01:30-03:00A.M	35.6 ± 13.8
9	03:00-4:30 A.M	29.8 ± 12.8
10	04:30-06:00 A.M	33.6 ± 13.6
11	-07:30 A.M06:00	9.5± 13.6
12	07:30-09:00 A.M	43.3 ± 15.1
13	09:00-10:30 A.M	32.7 ± 13.5
14	10:30-12:00 A.M	30.8 ± 13
15	12:00-13:30 A.M	21.1 ± 11.1
16	13:30-15:00 A.M	21.1 ± 11.3

In Canada, for jobs that are radon concentration and its decay products within 24 hours highest than 400 Bqm-3, provided legal regulations. With the exception of the short-lived radon daughter's in the places where the air in the environment is less than Jm^{-3} 6/24×10^{-7}. The estimated annual dose equivalent for workers aged 18 years and above is 20 mSv. This average dose to be compared with the maximum dose per person in Canada (2.5 mSv), mean dose Cornwall residents of Canada (an area with high levels of radon, 7.5 mSv) and dose of nuclear employees (4.5 mSv). In America, radiation limits to be change with work type and legislation agency. Agency for Health Security of miners (MSHA), covers underground miners. While occupational security and health agency (OSHA) regulates the amount of radon gas and its decay products for other mining activity.

By MSHA law, no more than (100 pCiL^{-1}) radiation of radon and its products received in active regions. MSHA proposed the annual radiation radon products to any person less than 4 WLM. OSHA to be limited the annual radon or radiation until 30 pCiL^{-1} or 0.33 WL. Annual radiation consists of 40 hours of continuous exposure over a week and 52 weeks a year.

Finally, the American Environmental Protection Agency (EPA) fixed radon limit to (4 Pcil^{-1}) 148Bqm^{-3}, because: In longer periods of radiation, the risk of lung cancer is more, that this disease is common among the miners. So in this research basis of permissible concentration of radon is the American Environmental Protection Agency (EPA).

According to the numbers of the tables, the measurements at two days in different parts of the mine, is not exceeded from permissible limit. In some horizons, including elevations 1480 and 1490 m above sea level, although the radon concentration is below the limit, however, the radon concentration can be changed in different seasons and even during a day, and in these areas where miners working and removing ore minerals too, so radon concentration must be monitored.

Radon concentration increases with decreasing height. Due to the increase air pressure and decrease the move air and air

conditioning. Thus radon in the air moving slowly to other locations. Increasing the radon concentration in the environment depends on the air unsuitable ventilation. Even at higher horizons in the lateral branches with decreases of ventilation, increase radon concentration . For example, in the horizon of 1500 meters, although the average radon concentration in a given day is 28.3 Bq/m^3, at the end of the sub-channels at this horizon where the ore is collected, Radon concentration were measured 146 Bq/m^3 that is significant , because at the end of the channel the air ventilation is very low.

Radon concentration is measured and has changes in many areas over a day. As shown in this study, the radon concentration can be varied over a day. The highest is in the morning could be related to climatic conditions. Of course, the outside air is more sensible. For example, radon concentration at the bottom of the valley is 100 Bq/m^3 in the morning.

VII. Conclusion And Recommendations

Mines can be reduced dose of radon radiation.

- First, created suitable ventilation in mine spaces, particularly in deeper areas. Engineers must be create air Ventilation and moving the air by suitable pump in the lower horizons and create ventilation in different layers.

- The next step is the protection of workers. Because radiation of alpha particles from radon can be damaging, short-range particles are absorbed by a thin protective layer. To prevent the entry of particles inhaled into the lungs of workers, they required to use the appropriate filter masks. Because alpha particles can be absorbed by the surface layer of skin, so it can not be a serious threat to the body's internal organs. But it is possible these radiation to damage skin tissue; it is better that workers to use hand covers. Also damage the eyes, when dust sink into the eye, by radon particles cling to dust particles is possible. So the eye guards are also recommended.

- Last factor as an important factor that we mentioned here are the working hours of workers in mines, must comply with standards set by the relevant international organizations. Observe your mind can greatly contribute to the reduction of incoming light in their lives; and mines personnel health will increase.

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