Investigation on Radon Concentration in Groundwater Samples from Regions Belonging to North-Western Part of Punjab, India

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Abstract
The hazards of exposure to radon gas and its daughter products from natural background to human health are well known. In the present research work, radon concentrations were analyzed in 70 groundwater samples collected from 15 villages of Amritsar district of Punjab, by using solid state alpha based detector RAD7-H2O with closed loop aeration scheme. It was found that the range of mean radon concentration from the studied area varying from 1.9 BqL^{-1} to 9.2 BqL^{-1} with an average of 5.43 BqL^{-1}. The results of radon concentrations achieved were compared with safe limit values recommended by US Environmental protection agency, which has proposed that the allowed maximum contamination level (MCL) for radon concentration in water is 11 BqL^{-1} and United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) which has suggested a value of radon concentration in water for human consumption between 4 and 40 BqL^{-1}. The comparison reveals that the values of radon concentration are well within the permissible limit.

Keywords
Exposure, Radon Concentrations, RAD-7 Detector, Closed Loop, Permissible

I. Introduction

Radioactivity present in human environment is the major source of radiation dose being received by population. Radon is a naturally occurring radioactive noble gas that forms in rocks and soils from the decays of 238U via 226Ra.Radon-222 (radon gas), radon-220 (thoron) and radon-219 (actinon) are considered as the most common isotopes of radon [1]. Among the different isotopes of radon, Rn-222 is most stable with the half life of 3.82 days and decays into many short lived daughter progenies. The lifetime of Radon-222 is considered long relative to the other isotopes. This is of significance, since radon is formed in the ground or building materials [2] and has significantly more time to diffuse through the material into the indoor environment as well as the outdoor atmosphere. It is an established fact that the enhanced levels of indoor radon in dwellings can cause health hazards and may cause serious diseases like lung cancer in human beings [3-5]. In addition to the radon present in air, radon dissolved in drinking water can lead to significant health problems for humans [6] because water is a major part of total body weight and most prominent source for life. The major risk of radon dissolved in water comes from ingestion and its contribution to indoor air. The radon content in groundwater sources depends in the radium concentration in the rock of the aquifer [7-8]. Dissolved radon is contained in natural groundwater due to primordial uranium in rocks and soils with which it comes in contact [9]. Human beings are exposed to radon through inhalation and ingestion. Radon monitoring has been increasingly conducted worldwide because of the hazardous effects of radon on the health of human beings. The expanding concern about the radiological health risks posed by waterborne radon progenies attracts many researchers to this field of research. Thus many studies have been conducted worldwide to determine its concentration in different environmental media in order to reduce its adverse effects on the human beings [10-15].

II. Geography of the Study Area

The samples were taken from villages fall under the Amritsar district of Punjab (shown in fig. 1). Amritsar is a city in north-western part of Punjab (India). It is the spiritual centre for the Sikh religion. It is located at 31.63°N 74.87°E [16] with an average elevation of 234 meters (768 ft). Amritsar has a semiarid climate, typical of North-Western India and experiences four seasons primarily: winter season, summer season, monsoon season and post-monsoon season [17]. The villages from where the most of samples were collected in are near to the border with Pakistan.

Fig. 1: Map of the Study Area

III. Experimental Technique

Ground water samples used for drinking purposes were taken from the study area and radon concentrations in these samples were measured with solid state alpha detector based RAD7 (Durridge Co. USA). The RAD7 is a continuous monitor based on the alpha spectrometry technique. It uses a solid state semiconductor detector that directly converts an alpha radiation to an electrical signal. Its accessory [18] RAD H_2O is used to measure the radon in water

over a wide range of concentration. The unit features the fastest response and recovery time of any system on the market, and is able to measure radon concentrations at the 0.2 BqL^{-1} action level in less than one hour with 10% standard deviation. The virtual absence of intrinsic background (0.2 Bq/m^3) gives the RAD7 an extremely low detection threshold, easily measuring below 4 Bq/m^3. Additional accessories allow measurement of radon in soil and water (continuous and sample measurement); the RAD AQUA continuous water measurement accessory allows measurement of water radon to extreme low concentrations, whereby the air volume and water volume are constant and independent of the flow rate.

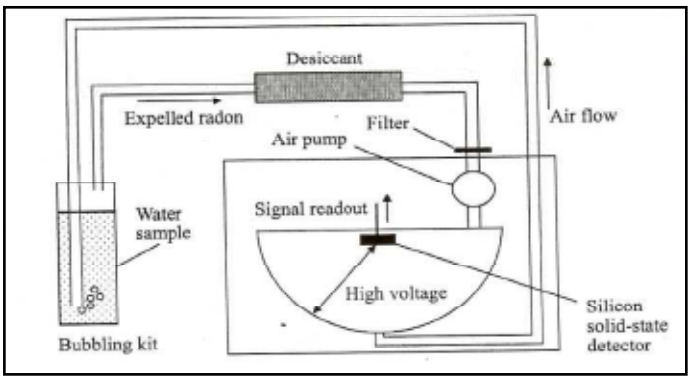

Fig. 2: The RAD7 Connected with RAD7H2O Accessories

The RAD7-H_2O method employs a closed loop aeration scheme in which the air is recirculated through the water sample collected in vial and the radon is continuously extracted until a state of equilibrium develops as shown in fig. 2 [19]. It continually measures radon and thoron concentration, showing both on a spectrum printout, and also functions as a sniffer with audible count signal to locate radon entry points. The RAD-H_2O system reaches this state of equilibrium within about 5 minutes, after which no more radon can be extracted from the water sample. The extracted radon is pumped in the test chamber the detector measures the radon concentration. The extraction efficiency, or percentage of radon removed from the water to the air loop is very high, typically 99% for a 40ml sample and 94% for a 250ml sample. The RAD H_2O gives results after 30 minutes analysis with a sensitivity that matches or exceeds that of liquid scintillation methods. Here, the present work tries to explore the concentration of radon in groundwater samples taken from Amritsar district of Punjab.

IV. Result and Discussions

The results for radon concentration in groundwater samples collected from different villages of north western part of Punjab are summarized in Table 1. The values of radon concentration in samples from different locations lie in the range of 1.9Bq L^{-1} to 9.2 BqL^{-1} with an average value of 5.43 BqL^{-1}. The US Environmental protection agency has proposed that the allowed Maximum Contamination Level (MCL) for radon concentration in water is 11 BqL^{-1} [20]. During the literature survey on radon concentration in water samples in the region of Punjab, we found that Ajay etal. [21] had reported the radon concentration in the range of 0.23 BqL^{-1} to 2.1 BqL^{-1} from the Kapurthala district of Punjab, Duggal etal. [22] had reported the radon concentration in the range of 0.9 BqL^{-1} to 5.1 BqL^{-1} of Bathinda district, Punjab and Rani et al. [23] had reported the radon concentration range 0.5 to 85.7 BqL_{-1} in groundwater samples of near Punjab area, India and Navjeet etal. [24] have reported the radon concentration in the range of 1.23 BqL^{-1} to 7.24 BqL^{-1}, 2.07 BqL^{-1} to 6.34 BqL^{-1}, 1.42 BqL^{-1} to 11.04 BqL^{-1}, 5.19 BqL^{-1} to 8.22 BqL^{-1} from the Jalandhar, Amritsar, Bathinda and Gurdaspur districts of Punjab respectively whereas Sameer et al. had reported the value of radon level in drinking water across Amritsar district of Punjab in range of 6.14 BqL^{-1} to 10.50 BqL^{-1} [25]. The United Nations Scientific Committee on the Effects of Atomic Radiation has suggested a value of radon concentration in water for human consumption between 4 and 40 BqL^{-1} [26]. The recorded values of radon concentration are within the recommended safe limit of 4-40 BqL^{-1}. When the recorded radon concentration values were compared with the European Commission recommendations on the protection of the public against exposure to radon in drinking water supplies, which recommends the action level of 100 BqL^{-1} for public water supplies [27], all the recorded values were found to be well below the action level and hence safe for drinking purposes.

Table 1: Radon Concentration in different samples collected from various Villages.

Sr. No.	Location	No. of Samples	Coordinates	Radon Concentration (in BqL^{-1})			Temp. (in ºC)
				Max.	Min.	Mean	
1	Fathewal	5	31°52’53”N 75°3’13”E	4.9	4.3	4.6	27
2	Lakhuwal	5	31°53’37”N 74°42’0”E	6.1	5.7	5.9	28
3	Granthgarh	4	31°59’47”N 74°52’4”E	5.8	5.4	5.6	27
4	Pakha Pind	3	31°34’28”N 75°38’22”E	4.8	4..6	4.7	28
5	Gurala	3	31°52’54”N 74°45’39”E	3.3	3.1	3.2	28
6	Ajnala	5	31°84’50”N 74°76’52”E	4.7	4.3	4.5	28
7	Srawa	5	31°58’9”N 74°51’52”E	2.0	1.8	**1.9**	27
8	Shekhpatti	5	31°59’17”N 75°66’12”E	7.9	7.3	7.6	28
9	Mihoka	6	31°33′18″N 74°13′35″E	2.2	2.0	2.1	24
10	Kala Jiwan Singh	5	31°43′54″N 74°19′25″E	7.8	7.2	7.5	23
11	Rampura	5	31°30′26″N 74°1′36″E	9.3	9.1	**9.2**	24
12	Jheeta Kalan	5	31°35′38″N 74°51′56″E	7.5	6.9	7.2	24
13	Jandiala	4	31°33′41″N 75°1′36″E	6.2	6.0	6.1	24
14	Bandala	5	31°30′26″N 75°22′33″E	3.7	3.3	3.5	25
15	Bishambarpura	5	31°36′42″N 74°34′35″E	8.0	7.8	7.9	25

V. Conclusion

The values of radon concentration from all samples collected from the various villages under the Amritsar district of North -western Punjab were in the range of 1.9 BqL^{-1} (Srawa) to 9.2 BqL^{-1} (Rampura). The mean of the average radon concentration in water samples for the whole of the studied area is 5.43 BqL^{-1}. The recorded values of radon concentration in groundwater are within the safe limit recommended by the US Environmental Protection Agency [25] and United Nations Scientific Committee on the Effects of Atomic Radiation [26].

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References

[1] Mudd, G.,"Reviews in Environmental Science and Biotechnology, 7 (4): pp. 325-353, 2008.
[2] A.V. Nero, A J Gadgil,W.W Nazaroff , and K L Revzan,An Overview on Indoor Radon and Decay products, 1990, P 1 – 53.
[3] O. Axelson, Envint. Health Perspectives, 1995, 103 (2), 37-43.
[4] F. Bochicchio, F. Forastiere, D. Abeni and E. Rapiti, Radiat. Prot. Dosim. 1998, 78 (1), 33-38.
[5] R.W. Field, D.J. Steck, B.J. Smith, C.P. Brus, J.S. Neuberger, E.F. Fisher, C.E. Platz, R.A. Robinson, R. F., Woolson and C.F. Lynch, Am J. Epidemiol, 2000, 151 (11), 1091-10,
[6] K. N. Yu, Z. J. Guan, M. J. Stokes and ECM Young, Appl. Radiat. Isot.,1994, 45, 809.
[7] Prasad Y, Prasad G, Ramola RC, Radiat. Meas, 2009, 44, 122.
[8] Hamlat MS, Kadi H, Djeffal S, Brahimi H, Applied Radiation Isot, 2003, 58, 125.
[9] Hess CT, Fleischer RL, Turner LG, Tech. Inform. Series Report No. 83 CRD 278, General Electric, New York, USA, 1978.
[10] Sharma N, Sharma R, Virk HS, Advances in Applied Science Res, 2011, 2(3), 186.
[11] Rani A, Mehra R, Duggal V, Radiation Protection Dosim, 2012, 1-6.
[12] Kumar A, Kumar A, Singh S, Advances in Applied Science Res, 2012, 3(5), 2900.
[13] Subber ARH, Ali MA, Al-Asadi TM, Advances in Applied Science Res, 2011, 2(6), 336.
[14] Abdallah SM, Habib RR, Nuwayhid RY, Chatila M, Katul G, Radiation Meas, 2007, 42, 298.
[15] Cosma C, Moldovan M, Dicu T, Kovacs T, Radiation Meas, 2008, 43, 1423.
[16] "Falling Rain Genomics, Inc - Amritsar". Fallingrain.com. Retrieved 2012-07-17.
[17] [Online] Available: http://www.imdpune.gov.in/Temp_ Extremes/histext 2010.
[18] J.Nikolov, N.Todorovic, S.Forkapic, I.Bikit, D.Mrdja world Academy of Science, Engineering & Technology 76 2011.
[19] Durridge Company Inc., Reference Manual version, RAD7 Electronic Radon Detector.
[20] USEPA. United States Environmental Protection Agency. Federal Register 40 Parts 141 and 142 National Primary Drinking Water Regulations; Radionuclides: Proposed Rule. U.S. Government Printing Office Washington, DC, 1991.
[21] Ajay Kumar, Amanjot Kaur, Advances in Applied Science Research, 2014, 5(1):43-4.
[22] Duggal V, Mehra R, Rani A, Radiat. Prot. Dosim., 2013 1-7.
[23] Rani A, Mehra R, Duggal V, Radiat.Prot. Dosim, 2013, 153, 496.
[24] Navjeet Sharma et al Advances in Applied Science Research, 2011, 2 (3):186-190 Adv. Appl. Sci. Res., 2011, 2 (3):186-190.
[25] S.Kalia, J.J. Mahindroo, Neerja, N. Gupta, Int. Jour. of Envt. Sci. Development & Monitoring, 2(2011), pp. 97-101.
[26] United Nations Scientific Committee on the effects of Atomic Radiation. Sources and effects of Ionizing Radiation, United Nations, 2008.
[27] EUROPEAN COMMISSION, Commission recommendation of 20th December 2001 on the protection of the public against exposure to radon in drinking water. 2001/982/Euratom, L344/85, 2001.

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