



Measurements of Radon Gas (^{222}Rn) Concentration in Ground Water in Shahjahanpur City of Uttar Pradesh by Using Radon Emanometer Technique

Dr. Mohd. Salim Ahmad Khan
Department of Physics G.F. (P.G.) College
Shahjahanpur-242201(U.P.) India

Abstract: The measurements of radon (^{222}Rn) gas concentration in groundwater were carried out in Shahjahanpur city of Uttar Pradesh. The measurements were performed by analyzing the different ground water samples collected from different location, using Radon Emanometer Technique (RET). From the result it is found that the concentration of radon in hand pump water samples varies from 11.27 Bq/L to 7.29 Bq/L with an average value of 8.74 Bq/L. The concentration of radon in boreholes water samples varies from 13.25 Bq/L to 8.75 Bq/L with an average value of 11.02 Bq/L where as the radon gas concentration in well water samples varies from 9.94 Bq/L to 6.63 Bq/L with an average value of 7.82 Bq/L. The value of annual effective dose ($\mu\text{Sv/y}$) from ^{222}Rn ingested with water varies from 0.13 $\mu\text{Sv/y}$ to 0.27 $\mu\text{Sv/y}$ with an average value of 0.19 $\mu\text{Sv/y}$.

Keywords: Radon, Radon, Ground water, Annual effective dose, Emanometry technique.

I. Introduction

Radon is a naturally occurring radioactive gas that is part of the uranium decay series. Its presence in the environment is associated mainly with trace amounts of uranium and its immediate parent, radium-226, in rocks and soil. Because of its gaseous nature, radon can move freely through porous media such as soil or fragmented rock. Radon may permeate from rocks and soil into buildings through cracks in floors or gaps around pipes or cables. Where pores in rock and soil under the water table are saturated with water, radon can be dissolved into the water and transported with it. Consequently domestic water supplies may have elevated concentrations of dissolved radon. This can give rise to a radiation dose as a result of either inhalation or ingestion. Radon can be released from the water into the air and, when inhaled, results in radiation exposure of the lungs. The organ at greatest risk from the ingestion of water containing radon is considered to be the stomach. Radon concentrations in water depend largely on the source of radon emanation, which may be the result of natural processes, industrial or agricultural activities and human activities in the area where the wells are located. Attention has been focused on the issue of radon in drinking water by a European Commission Recommendation proposing that surveys should be undertaken in Member States to determine the scale and nature of exposures caused by radon in domestic drinking water supplies [1]. The radon present in the underlying rocks and soil may also become dissolved in the groundwater resulting in elevated radon activity concentrations in groundwater supplies. When radon accumulates in indoor air may represent an increased health risk, especially lung cancer. However, the risk from radon released from water use is less than the risk due to indoor accumulated radon. If the ground water is used as drinking water it must be taken into account the water radon content. According to the EPA reports the radon in drinking water caused 168 cancer deaths per year of which 89% lung cancer caused by indoor radon released from water and 11% of stomach cancer caused by drinking water containing radon. The United States Environmental Protection Agency (EPA) proposed a National Primary Drinking Water Regulation for ^{222}Rn with a maximum contaminant level (MCL) of 11.1 Bq L⁻¹ or 300 pCi L⁻¹ ([2], [3]). The amount of radon released indoor due to water usage is much lower compared to the radon amount that accumulates indoor from the soil. Radon gas released from water will contribute to the total concentration of indoor air with about 1-2%. It is remarkable that if the amount of radon in water is reduced only 40 to 50 percent before is delivered to users, it causes that the respiratory and gastrointestinal cancers reduced about 30 to 35 percent and in long term is very important for decreasing remedial cost.

II. Brief geography of the study area

Shahjahanpur district is one of the historical districts in the republic of India. It is a part of Bareilly division which is situated in south-east of Rohilkhand division. It was established in 1813 by the British Government. Previously it was a part of district Bareilly. The main town is Shahjahanpur city which is its

headquarters. Geographically, it is situated at 27.35 N latitude and 79.37 E longitudes. Its geographical area is 4575 sq. kilometers with an elevation of 472 feet above sea level .There exists an army cantonment, and a major clothing factory for defence forces called Ordnance Clothing Factory. Recently a thermal Power Plant is established in Shahjahanpur.

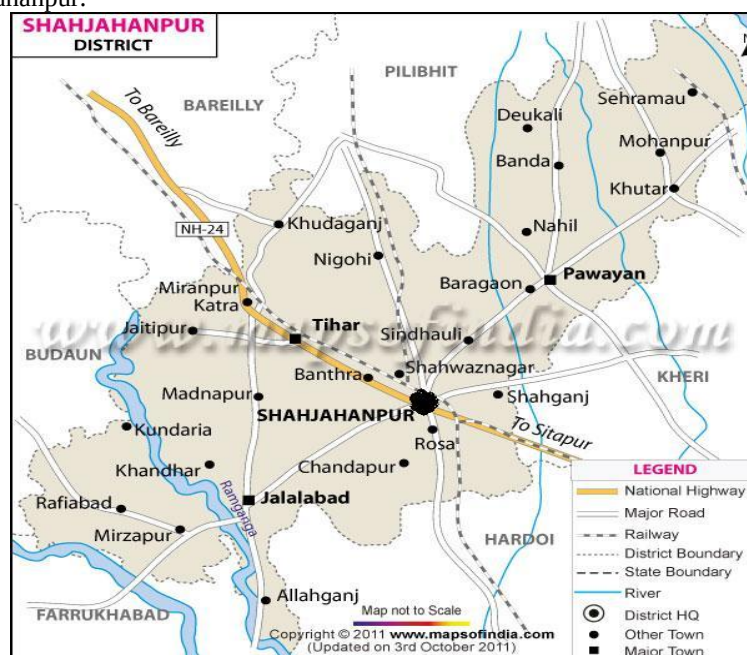


Figure1: District map of Shahjahanpur

III. Methodology

In the present study radon (^{222}Rn) gas concentration in ground water was measured by “Radon Emanometer Technique”. It consists of a one litre radon-tight reagent bottle connected in a closed circuit with glass vessel internally coated with activated zinc sulphide (ZnS), will be used as a scintillation material through a hand operating pump and a glass bulb containing calcium chloride (CaCl_2) to absorb the moisture. The glass vessel is transparent and coupled to a photomultiplier (PMT). It can be any shape depending on the type of photomultiplier employed to count the scintillation produced but used shape is cylindrical about 5 cm in diameter and 20 cm in height. Water sample of 750 ml is used in the bottle and after that air is then circulated in the closed circuit for 15 minutes until the radon formed a uniform mixture with the air. When radon decays alpha-particles, it produces scintillations on the ZnS (Ag) which are sensed by photomultiplier and the resulting alpha activity is recorded (Alpha counts). The recorded alpha counts is converted in to Bq/L by using appropriate calibration factor. The calibration factor 1 count/min. = 0.663Bq/L was used to convert recorded alpha counts to Bq/L [4]. The block diagram for measurement of radon in water is shown in figure.

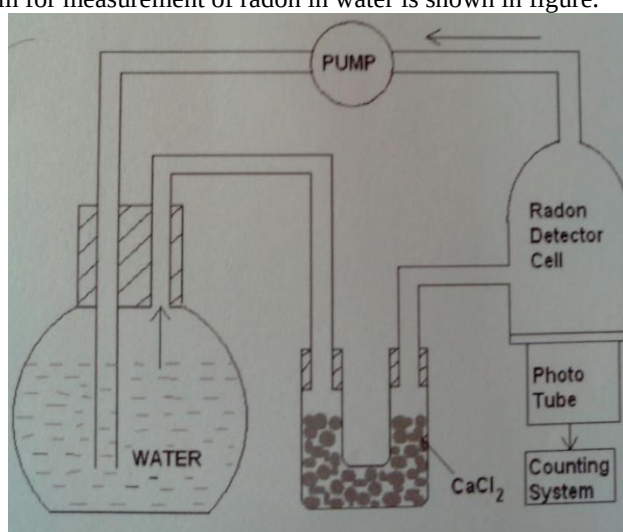


Figure 2: Block diagram for radon measurement in water

The annual effective dose ($\mu\text{Sv/y}$) from ^{222}Rn ingested with water was calculated by taking in account the activity concentration of radon (Bq/L), the dose coefficient (Sv/Bq) and the annual water consumption (L/y) according to the relation

$$D_{\text{ing}} = C_{\text{Rn}} \cdot I_F \cdot E_D$$

Where D_{ing} is the committed effective dose from ingestion (Sv), C_{Rn} is the concentration of ^{222}Rn (Bq/L), I_F is the ingesting dose conversion factor of ^{222}Rn (10^{-8} Sv/Bq for adults, and 2×10^{-8} Sv/Bq for children [5]). E_D is the water consumption (2 L/day) [6]. For the dose calculations, a conservative consumption of 2 L/day per year for “standard adult” drinking the same water and directly from the source point was assumed [7]. The annual effective doses for ingestion were estimated according to parameters introduced by UNSCEAR report [8].

IV. Result and discussion:

The measured values of radon concentration in ground water and annual effective dose from radon ingested with water are shown in table 1. The summarized result are shown in table 2. Three categories of water samples all of which are ground water (hand pumps, boreholes and wells water) from the city of Shahjahanpur were collected and analyzed. The wells water has depths of about 8-13 m while the boreholes have depths of 50–150 m. A total of 15 samples were collected and analyzed. Four samples from each i.e. from hand pumps, boreholes and wells water are taken. The summarized result is shown in table 2. As the results show, most of the values are below 11 Bq/L and only about 20% of the samples are above 10 Bq/L and 11 Bq/L, the standard set for radon in water. The radon concentration in water for hand pumps varies from 7.29 Bq/L to 11.27 Bq/L with an average value of 8.74 Bq/L. The radon concentration in water for a borehole varies from 8.75 Bq/L to 13.25 Bq/L with an average value of 11.02 Bq/L. The radon concentration in water for wells varies from 6.63 Bq/L to 9.94 Bq/L with an average value of 7.82 Bq/L. The annual effective dose due to ingestion of ^{222}Rn with hand pumps water varies from $.15 \mu\text{Svy}^{-1}$ to $.23 \mu\text{Svy}^{-1}$ with an average value of $.19 \mu\text{Svy}^{-1}$. The annual effective dose from ^{222}Rn ingested with boreholes water varies from $.18 \mu\text{Svy}^{-1}$ to $.27 \mu\text{Svy}^{-1}$ with an average value of $.22 \mu\text{Svy}^{-1}$. The annual effective dose from ^{222}Rn ingested with wells water varies from $.13 \mu\text{Svy}^{-1}$ to $.20 \mu\text{Svy}^{-1}$ with an average value of $.16 \mu\text{Svy}^{-1}$. The mean values of radon concentration for hand pumps water, boreholes water and wells water wells are lower than the Maximum Concentration Limit (MCL) of 11.1 Bq/L set by the USEPA and the world average value of 10 Bq/L set by World Health Organization ([9], [10]). Higher concentrations of radon were recorded in borehole samples compared with wells and hand pumps samples. This is because boreholes are deeper and closer to surface sub soil, which is underlain by the older granite. The lowest radon concentration was recorded with hand pumps water samples. The generally low levels of ^{222}Rn concentration in hand pump and well water samples could be attributed to the shallowness of most of the wells and boreholes, which would allow much of the ^{222}Rn to escape. The overall average value of annual effective dose is $.189 \mu\text{Svy}^{-1}$. It is also noted from the results that among the 15 samples analysed, the borehole samples recorded higher ^{222}Rn concentrations and higher annual effective doses compared with hand pumps and well water samples. In each of the samples collected, though the activity concentration varied, the geological content was almost the same. This similarity in geological content could result from the ground water formation, discharge rate and the radon emanation rate from the parent nuclide uranium or radium. The effective doses are also within the World Health Organisation (WHO) recommended reference level of 0.1 mSv/y [11] for intake of radionuclides in water. It is observed that our results are less than the maximum contaminant level for the US Environmental Protection Agency 11.1 Bq/L or 300 pCi/L and thus are within the safe limit. The graphical variation of radon gas concentration and annual effective dose ($\mu\text{Sv/y}$) from ^{222}Rn ingested with water are shown in figures 3a & 3b.

Table 1: Observed radon gas concentration for different types of ground water samples collected from different locations.

Sample ID	No. of count/min.	Radon concentration (Bq/L)	Annual effective dose (μSvy^{-1})
HP1	13	8.61	.17
HP2	11	7.29	.15
HP3	17	11.27	.23
HP4	14	9.28	.19
HP5	11	7.29	.15
BH6	17	11.27	.23
BH7	16	10.60	.21
BH8	20	13.25	.27
BH9	20	8.75	.18
BH10	17	11.27	.23
WW11	10	6.63	.13
WW12	12	7.95	.16
WW13	11	7.29	.15
WW14	15	9.94	.20
WW15	11	7.29	.15

Table 2: Summarized result of radon gas concentration for different types of ground water sampled collected from different locations.

Type of water used		Hand pumps	Boreholes	Well water
Radon concentration (Bq/L)	Maximum	11.27	13.25	9.94
	Minimum	7.29	8.75	6.63
	Average	8.74	11.02	7.82
Annual Effective Dose(μSv^{-1})	Maximum	.5	.18	.13
	Minimum	.23	.27	.20
	Average	.19	.22	.16

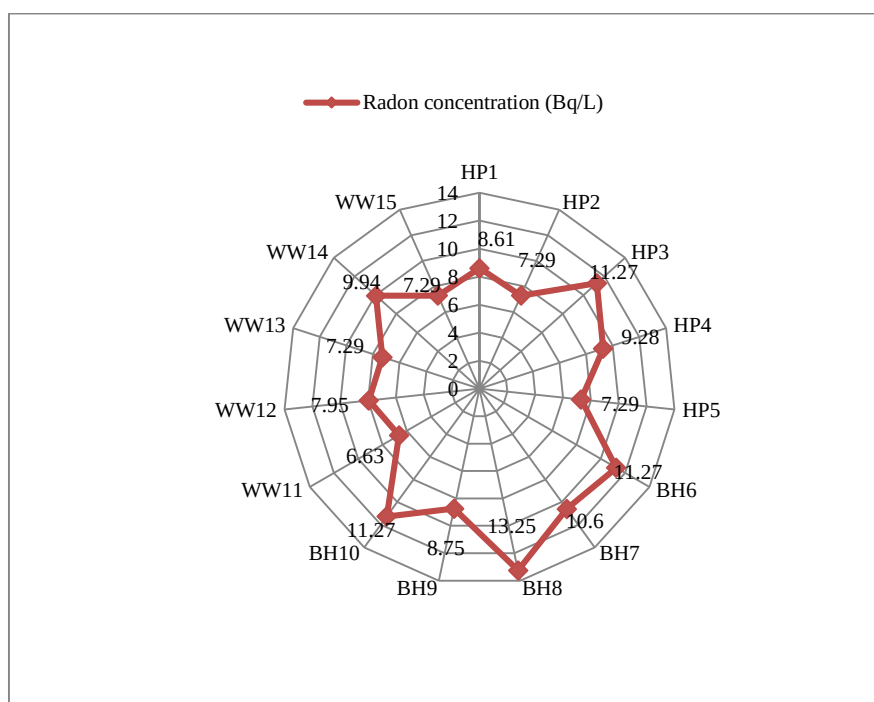


Figure 3a: Variation of radon gas concentration of water from different location

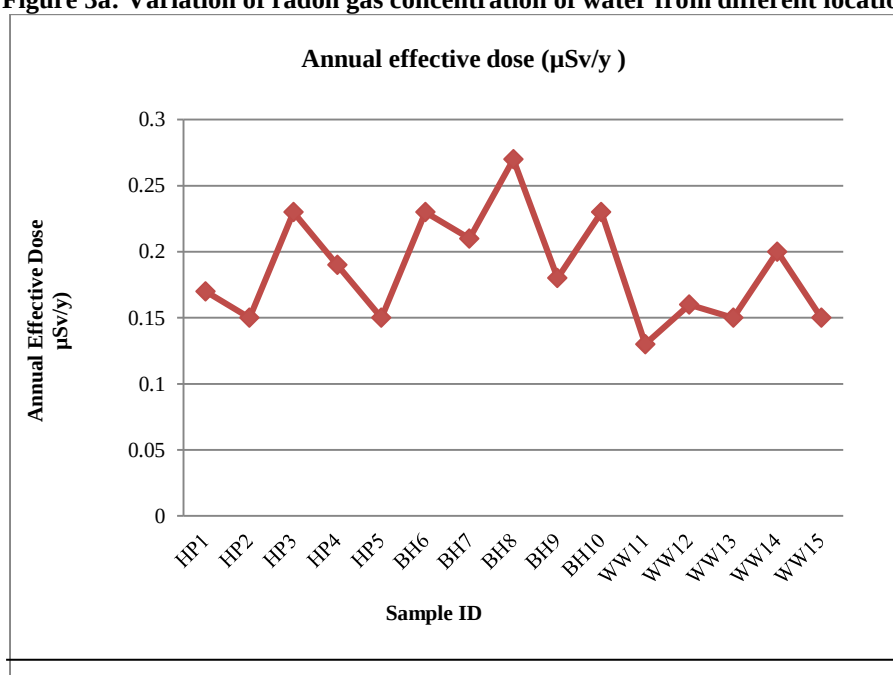


Figure 3b: Variation of annual effective dose (μSv/y) from radon ingested with water

V. Conclusions

Measured values of radon concentration in three types ground water (i.e. hand pumps, boreholes and hand-dug wells) are shown in tables 1&2. From the measured value of radon gas concentration the annual effective doses received by the inhabitants of the surveyed area have been estimated. From the result it is found that the concentration of radon in hand pump water samples varies from 11.27 Bq/L to 7.29 Bq/L with an average value of 9.11 Bq/L. The concentration of radon in boreholes water varies from 13.25 Bq/L to 8.75 Bq/L with an average value of 10.96 Bq/L where as the radon gas concentration in hand-dug well water samples varies from 9.94 Bq/L to 6.63 Bq/L with an average value of 7.95 Bq/L. The average value annual effective dose ($\mu\text{Sv/y}$) from ^{222}Rn ingested with water varies from $16\mu\text{Sv/y}$ to $223\mu\text{Sv/y}$. From the results it is concluded that the average value of radon concentration for hand pump water samples, boreholes water samples and hand-dug well water samples are lower than the Maximum Concentration Limit (MCL) of 11.1 Bq/L set by the USEPA [2]. The effective doses are also within the World Health Organization (WHO) recommended reference level of 0.1 mSv/y [11] for intake of radionuclides in water and are within safe limits.

VI. Acknowledgement

The author is grateful to Dr. R.B.S. Rawat and Dr. Anil Kumar Singh Department of Physics S.S. (P.G.) College Shahjahanpur for providing all necessary facility to carried out this work.

VII. References

- [1]. IAEA (International Atomic Energy Agency), "Water for people and water for life" The United Nation World Water Development Report, 2001. <http://www.unesdoc.unesco.org/images/0012/001295/129556e.pdf>.
- [2]. USEPA (United States Environmental Protection Agency), "National Primary Drinking Water Regulations" Radionuclides Proposed Rule, Federal Register 40, Parts 141 and 142. U.S. Government Printing Office, Washington, DC, 1991.
- [3]. M.A. Same, R.H. Rima, Y.N. Rida, C. Malek and K.Gabriel "Radon measurements in well and spring water in Lebanon" Radiation Measurements, vol. 42, pp. 298–303, 2007.
- [4]. V.M.Choubey, S.K. Bartaya and R.C. Ramola, "Radon in Himalayan Spring" A Geographical Controle, Environment Geol., vol.39, pp.523-530, 2000.
- [5]. UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation), "Sources and Effects of Ionizing Radiation" Report to the General Assembly with Scientific Annexes. New York: United Nations, 1993.
- [6]. WHO (World Health Organization): Guidelines for Third Edition Recommendation Drinking water Quality Geneva, 2004.
- [7]. L.M. Galan, S.A. Martin and E.V. Gomez, "Estimates of the dose due to ^{222}Rn concentrations in water" Radiation Protection Dosimetry, Vol. 111, no.1, pp 3-7, 2004.
- [8]. UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation), Annex E. United Nations, New York, 2006.
- [9]. I.P. Farai, and A.O. Sanni, "Yearly variability of radon in a groundwater system in Nigeria" J. Afr. Earth Sci., vol.15, no.314, pp.399-40, 1992.
- [10]. A.O. Mustapha, J. P. Patel & I.V.S. Rathore "Preliminary report on Radon concentration in drinking water and indoor air in" Kenya. Environ. Geo.chem. Health, vol. 24, pp.387–396, 2002.
- [11]. K.Somlai, S.Tokonami, T.Ishikawa, P.Vancsura, M.Gaspar, V.Jobbery, J.Somlai and T.Kovacs "Rn concentration of water in the Balaton Highland and in the southern Part of Hungary and the assessment of the resulting dose" Radiation Measurements, vol.42, pp .491- 495, 2007.