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ORIGINAL ARTICLE

Radon Concentration in Natural Water of Chamarajanagar District, Karnataka State

M.S. Chandrashekara
Department of Studies in Physics, University of Mysore, Manasagangtri, Mysuru
Email: msc@physics.uni-mysore.ac.in

ABSTRACT

Radionuclides are present everywhere in the earth's crust and also in the surrounding atmosphere. Among all the natural sources of radiation, radon and its progeny in the environment contribute maximum radiation dose to the world population. Hence study of the radon concentration in natural water is necessary from the point of radiation protection. The results of measurement of ^{222}Rn concentration in natural water samples of Chamarajanagar District are presented in this paper. The ^{222}Rn concentration in water samples was determined by the method of radiation emanometry. Emanation technique is bubbling air through the water followed by transferring gas to the Lucas cell. The effective dose due to ingestion and inhalation of radon was also estimated. The ^{222}Rn concentration in natural ground water is found to vary from 8.8 Bql^{-1} to 44.5 Bql^{-1} with an average of 17.4 Bql^{-1}. The concentration levels of ^{222}Rn are compared with the standard safe limits of WHO and EPA. The effective dose due to ingestion and inhalation of radon from drinking water varies from 44.5 to 225.8 Sv y^{-1} with an average of 88.2 Sv y^{-1}.

Key words: *Radon, ingestion dose, inhalation dose*

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INTRODUCTION

Radionucleides are found everywhere in different levels on the earth which humans inhale and ingest leading to health risks. The measurement of the concentrations of radioactive elements in soil, air and water and their health risks have been the interest of many researchers all over the world. About 87% of the radiation dose received by human being is due to natural radiation sources (UNSCEAR 2000). Radon is a natural radioactive noble gas that is present in trace amounts almost everywhere on the earth, being distributed in the soil, groundwater and in the lower atmosphere. Exposure to radon accounts for more than 50% of the annual effective dose of natural radioactivity. The origin of radon in the earth's crust stems directly from the radium isotopes and their decay products distributed in minute quantities in the ground within a few meters of the below the Earth's surface (Hussain, *et al.,* 1999). Radon gas can dissolve in groundwater and released into the indoor air during household activities such as bathing, dish and cloth washing. When radon accumulates in indoor air, it can cause health risk. Thus, exposure to waterborne radon may occur through ingestion and inhalation. Presence of radon in water and air contribute to significant dose to human beings, through intake of water in to the human body. Measurement of on radon concentration in drinking water samples and assessment of inhalation and ingestion dose is of primary importance from the point of health risks associated with radon concentration. When the groundwater originates from rocks containing higher amounts of radioactive elements, the radioisotopes leach with water and get dissolved in it contributing to the dose. The measurement of the concentrations of radioactive elements in soil, air and water and their health risks have been the interest of many researchers all over the world.Radon, a radioactive gas, decaying through alpha emission is soluble in water. Radon in drinking water causes lung cancer, from inhalation radon stomach cancer from ingestion (USEPA, 1991). Groundwater normally contains higher radon which may lead to the need for water treatment or limitations in its use for drinking purpose (Yoon, *et al.,* 2013).

STUDY AREA

The Chamarajanagara district is located in the southern tip of Karnataka state and lies between North latitude (11º 40' 58" and 12º 6' 32") and East longitude (76º 24' 14" and 77º 64' 55"). The geographical area is about 5,000 square km and has an average elevation of 662 m. The study area with its four taluks is shown in below in figure 1.Granites rocks are found in most parts of Kollegala taluk, whereas Gneiss rocks are found in eastern parts of Kollegala taluk. The southern part of this taluk surrounded by M.M. Hills. This district is endowed with rich mineral resources including both metallic and nonmetallic minerals. Major mineral available is black granite (Radhakrishna and Naqvi 1986) The B.R. Hills in Yelandurtaluk, is mainly surrounded by gneiss rock (Radhakrishna and Vaidyanadhan 2011).

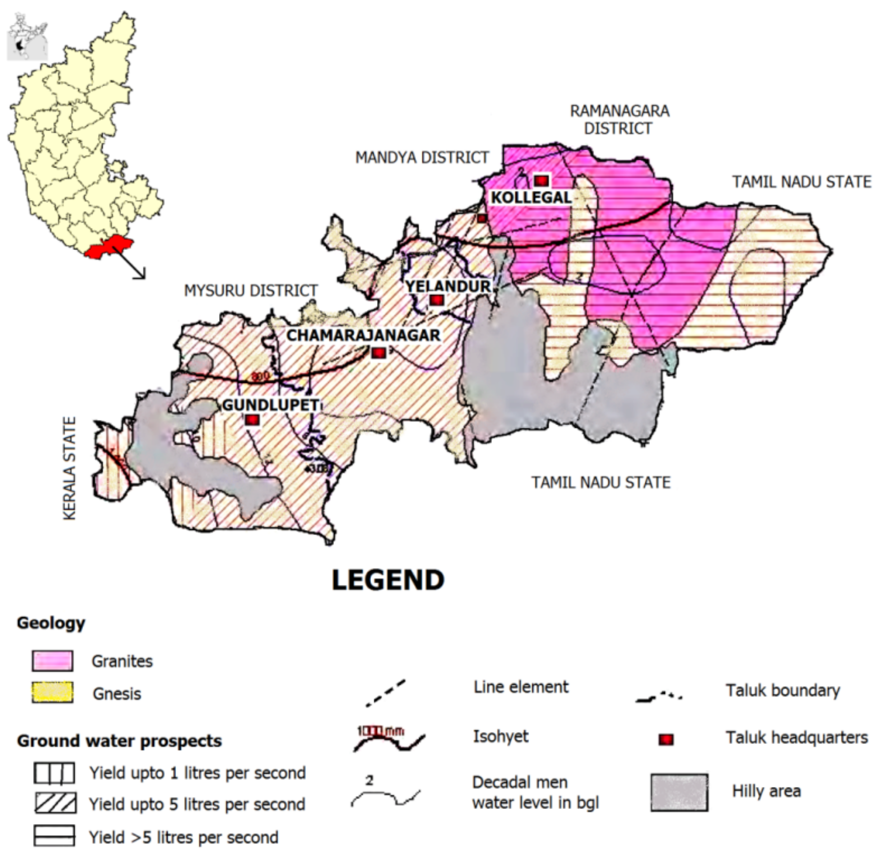

Fig. 1: Chamarajanagar district

The concentration of radionuclides on earth varies from place to place which mainly depends on type of soil and rocks in the study area. Monazite and granites rocks are known to contain higher levels of radionuclides. In Chamarajanagar, geological survey has revealed the presence of granitic gneiss rocks that has higher concentration of Uranium

(Radhakrishna B.P. and Vaidyanadhan 2011). Ground water which originates from granitic rocks that leach and dissolve radioisotopes is the main source of water, resulting in higher dose to the local population. Therefore distribution of radioactive elements in the groundwater and its relation to geological features of the area are studied.

ATERIALS AND METHODS

ESTIMATION OF ^{222}RN BY EMANOMETRY:

Emanometry is one of the most accurate and feasible techniques used by many researchers for the measurement of ^{222}Rn concentration in liquid samples. Radon emanation technique uses bubbling of air through the sample solution and transferring gas to the Lucas cell. Radon bubblers, made of corning glass, have airtight joints and stop cocks. Leak proof couplings are provided for degassing the samples as well for transferring radon gas into Lucas cells. Ball joints are provided for coupling the Lucas cell to the bubbler for collecting radon gas (Raghavayya, *et al.*, 1980). Schematic diagram of radon bubbbler in shown in the figure 2.

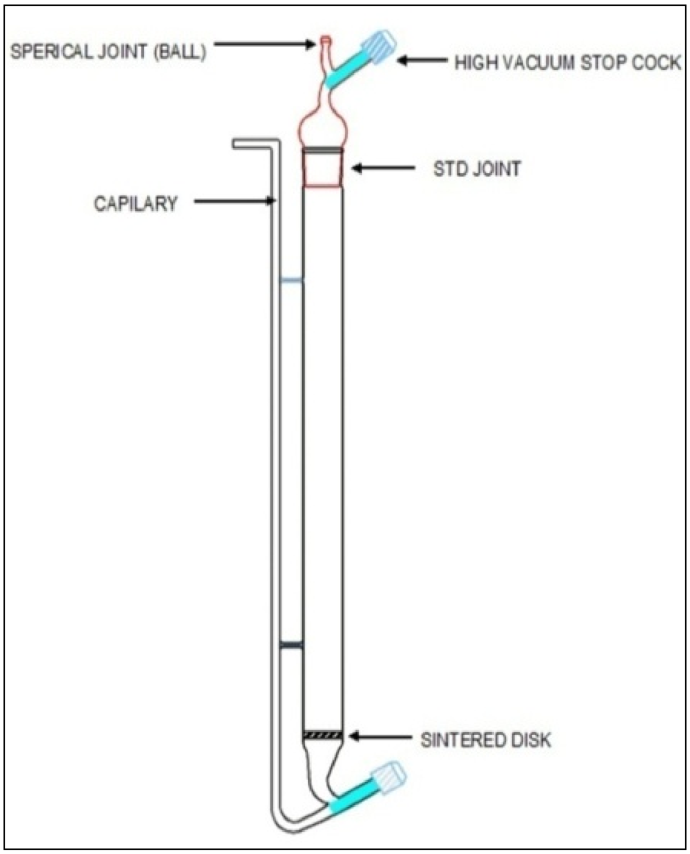

Fig. 2: Schematic diagram of Radon Bubbbler

Lucas cell, coated with ZnS(Ag) scintillator, is a cylindrical vessel of 150 cc volume fitted with a Swagelok connector on one side for evacuation and sampling and a glass window on the other side which produces scintillations on interaction of alpha particle emitted by radon and its progeny. These scintillations pass through the glass window and fall on the photocathode of a photomultiplier when coupled to photomultiplier assembly. The schematic diagram of Lucas cell is shown in figure 3. The pulses produced by the PM tube are processed inside the assembly to enable them to be counted by a programmable counting system. The background counts of the detector were recorded every day.

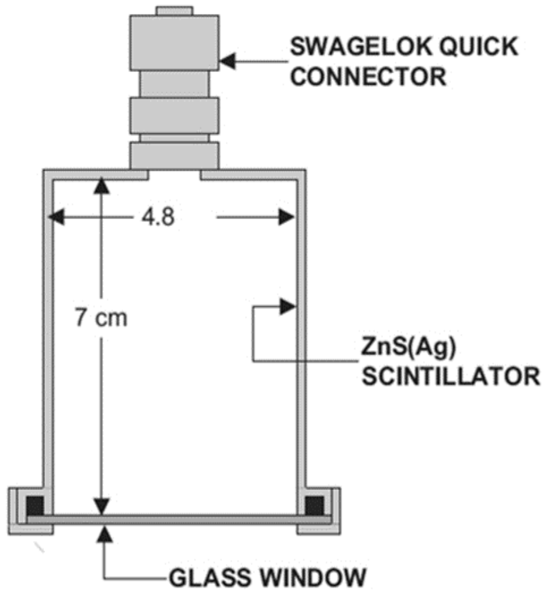

Fig. 3: The schematic diagram of Lucas cell.

ESTIMATION OF RADON CONCENTRATION IN WATER

About 100 ml of water sample was collected from each location in the study area with minimum disturbance after pumping out water for 5 minutes with zero headspace so that no air bubbles are present inside the container to avoid aeration. The samples collected from the bore well brought to the laboratory and concentration of ^{222}Rn in water was estimated by the emanometry where about 70 ml of the water sample is transferred into the bubbler by the vacuum transfer technique. The dissolved radon in the water was transferred into a pre-evacuated and background counted scintillation cell and stored for 180 minutes to allow radon to attain equilibrium with its daughters and then it was coupled to a alpha counting assembly.

The concentration was calculated using the relation (1)

$$^{222}Rn\left(BqL^{-1}\right) = \frac{6.97\times10^{-2}\times(D\pm SD)}{V\times E\times\left(e^{-\lambda T}\right)\times\left(1-e^{-\lambda t}\right)} \quad \text{-----------(1)}$$

Where, D = Sample counts – Background counts, V = Volume of water (70 ml),
E = Efficiency of the scintillation cell (74 %), t = Counting duration
λ = decay constant for radon (2.098 x 10^{-6} s^{-1}), T = Counting delay after sampling.

Radon Dose Assessment:

The annual effective dose due to inhalation and ingestion of ^{222}Rn were calculated using equations (2) and (3) using the parameters given in UNSCEAR.

Inhalation Dose:

$^{222}Rn\ (BqL^{-1}) \times 10^{-4} \times 7000\ h \times 0.4 \times 9\ nSv\ [L\ 10^{3}\ (Bq\ h)^{-1}]$ -----------(2)

Ingestion Dose:

$^{222}Rn\ (BqL^{-1}) \times WI\ (L\ a^{-1}) \times 10^{-3}\ m^{3}\ L^{-1} \times DCF\ (n\ Sv\ Bq^{-1})$ -----------(3)

Table 1: ^{222}Rn concentration in natural bore well water of Chamarajanagar district.

Sl.No.	Locations	Radon (Bql^{-1})	Ingestion dose due to Radon (Svy^{-1})	Inhalation dose due to Radon (Svy^{-1})	Total dose (Svy^{-1})
Chamarajanagar Taluk					
1	Amachavadi	11.6	29.7	29.3	59.1
2	Badanaguppe	17.9	45.8	45.5	91.0
3	Basavapura	8.8	22.4	22.1	44.5
4	Chamarajanagar	29.0	74.2	73.2	147.4
5	Ganaganur	9.0	23.0	22.7	45.8
6	Venkataiahna Chatra	14.6	37.4	36.9	74.3
Yelandur Taluk					
7	Ambale	19.4	49.5	48.8	98.4
8	Ganiganur	16.7	42.7	42.1	84.8
9	Gowdahalli	9.7	24.8	24.4	49.2
10	Gumballi	17.4	44.4	43.8	88.2
11	Kesthur	28.7	73.3	72.3	145.7
12	Yelandur	18.6	47.6	46.9	94.5
Gundlupet Taluk					
13	Begur	26.9	68.8	67.9	136.7
14	Bheemanabeedu	9.8	25.0	24.7	49.7
15	Gundlupet	13.8	35.2	34.7	69.8
16	Hangala	12.6	32.2	31.8	63.9
17	Kabbahalli	14.3	36.5	36.0	72.6
18	Terakanambi	10.2	26.1	25.7	51.8
Kollegal Taluk					
19	Ajjipura	16.3	41.6	41.1	82.7
20	Bandalli	11.3	28.9	28.5	57.3
21	Cowdalli	31.7	81.0	79.9	161.0
22	Gopinatham	14.3	36.5	36.0	72.6
23	Kollegal	9.9	25.4	25.0	50.4
24	Sathegala	44.5	113.7	112.1	225.8
Minimum		8.8	22.4	22.1	44.5
Maximum		44.5	113.7	112.1	225.8
Average		17.4	44.4	43.8	88.2
Standard deviation		8.9	22.6	22.3	44.9

RESULTS AND DISCUSSION

The activity concentration of ^{222}Rn in ground water of Chamarajanagar district is studied. The effective dose due to ingestion and inhalation of radon in water was estimated from the measured concentration of radon. The activity of radon is measured and their concentrations of are estimated in the water samples collected from different locations of the study area using emanometry method. Bore well water from 24 villages/towns of Chamarajanagara District and the results are shown in tables 1. The ^{222}Rn concentration in natural water is found to vary from 8.8 Bql^{-1} to 44.5 Bql^{-1} with an average of 17.4 Bql^{-1}. ^{222}Rn concentration in ground water sources is higher due to water from drilled holes in rocks, which have higher concentration than the average bedrock and sub soil that are underlain by the older granite (IAEA 2011). The WHO guideline for drinking water quality recommends repeated measurements to be implemented if radon in public drinking water supplies exceeds 100 Bql-1 (WHO. 2011). Bore well water samples were collected from 24 villages/towns of the study area from which water is commonly used by the general public for drinking purposes. At each location about 3-6 samples were collected and analysed and ^{226}Rn concentration is measured. When ground water flows across the radon (or uranium) bearing rocks, soils and minerals, it interacts with these natural sources. As a result radon content may arise in ground (bore well) water (Institute of Medicine 2005). Utilization of radioactive minerals can also increase the radon levels in ground water (Hess, *et al.,* 1989). The specific levels radioactivity of radon is related to the type of rock from which the soil originates. Higher radiation levels are associated with igneous rocks such as granite and lower levels with sedimentary rocks. There are exceptions, however, as some shales and phosphate rocks have relatively high content of radionuclides (Yoon, *et al*., 2013). The effective dose due to radon in water varies from 44.5 to 225.8 Svy^{-1} with an average value of 88.2 Svy^{-1}, which is less than the guide line value prescribed by World Health Organization (WHO. 2011). The Total dose of radon concentration in various locations of study area is shown in figure 4.

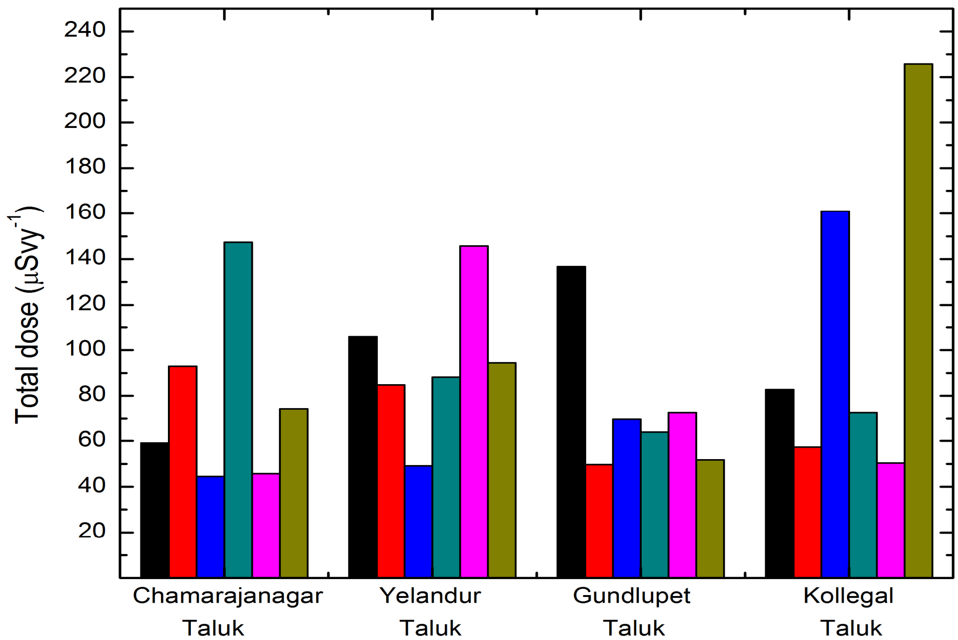

Fig. 4: Total dose of Radon-222 in different taluks of Chamarajanagara district

CONCLUSIONS

The ^{222}Rn concentration in natural water is found to vary from 8.8 Bql^{-1} to 44.5 Bql^{-1} with an average of 17.4 Bql^{-1}. Radon concentration in all the drinking water samples is well below the safe limit recommended by various health and environmental protection agencies. The safe limit recommended for the radon concentration is about 100 Bql^{-1} which is prescribed by WHO. Maximum value of radon concentration is observed in Kollegala Taluk. This region is characterized by granite racks. As granite rock contains higher radium concentrations, when ground water originates from granite formations, radionuclides leach out with ground water. Due to this, the higher radon concentration in bore well water samples has been observed. The effective dose due to radon in water varies from 44.5 to 225.8 Svy^{-1} with an average value of 88.2 Svy^{-1}, which is less than the guide line value prescribed by World Health Organization (WHO).

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