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ORIGINAL ARTICLE

Effective Dose Measuremets from Radon Ingestion and Inhalation in Driking Water

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ABSTRACT

Radon and its decay products are the main source of natural radiation exposure. Alpha particle emissions of radon in drinking water increase the absorbed dose by the respiratory and gastrointestinal systems, which can lead to cancer. The present study is aimed to determine the effective dose from radon ingestion and inhalation in drinking water sources. Radon concentrations in water samples from different locations of the Shahjahanpur city were measured by portable radon gas surveyor SILENA (PRASSI) system. The results showed that about 48% of water samples had radon concentration greater than 11Bq/l the level recommended USA environmental protection agency (EPA). The annual effective dose to stomach and lungs per person was calculated according to parameters introduced by the United Nations Scientific Committee on the Effects of Atomic Radiation. According to the results, the average radon concentration in drinking water was 10.19 Bq/L. The annual effective dose to adults due to waterborne radon was estimated to be about 7.4±2.4 Sv/y for lungs and 0.20 Sv/y for stomach. This study showed that the concentration of radon in drinking water used by people in various locations of the city is lower than the recommended values. The results show no significant radiological risk related to waterborne radon for the inhabitants of the studied regions

Key words: *Radon concentration, Effective Dose, Drinking Water*

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INTRODUCTION

Radon (^{222}Rn) is a naturally occurring, radioactive noble gas with a half-life of 3.82days, and it is a member of the ^{238}U decay series [1]. Radon and its short-lived decay products such as ^{218}Po, ^{214}Pb, ^{214}Bi, and ^{214}Poat indoor places are recognized as the main sources of public exposure by natural radioactivity, contributing to nearly 50% of the global mean effective dose to the public [1, 2, 3]. The type of soil, building materials, and water used for drinking and other household usages can make various contributions to the indoor radon level. The available data indicate that the main source of the indoor radon is the soil underlying a building [2]. However, certain building materials with high concentrations of radium, and even domestic water with high concentrations of radon can make major contributions to the indoor radon exposure [4, 5]. The most important aspect of radon in high concentrations can be health hazard for human, and they are the cause of lung cancer [6, 7]. However, a very high level of radon in drinking water can also lead to a significant risk of stomach and gastrointestinal cancer [8, 9]. Knowledge of the level of radon in each source, including household water, particularly water from groundwater sources, is necessary to protect the public from consequences of excessive exposure to radiation, the risk of lung cancer in specific. Radon can enter a home from the soil below your home and/or the tap water. Groundwater (well water) poses a greater risk for radon contamination than surface water. Airborne radon is a much greater health risk than ingested radon. Waterborne radon poses the greatest health risk when the radon is released to the air through household uses of water such as showering, laundry and dishes. Radon is formed by the decay of uranium, which is present in small amounts in soil and water. There are uranium deposits in the soil that can contribute significant amounts of radon gas to the soil and groundwater [10]. Radon gas can seep into cracks in a foundation or be introduced to the building via well water. Radon in water could pose a risk for health by inhalation and ingestion. Radon is released from the water to the air by showering or other household uses. Airborne radon is the second leading cause of lung cancer in the United States. Radon in drinking water is associated with stomach cancer, contributing up to 30 deaths per year. In this study, the result of radon measurements in 25 water samples, sources and tap water, actually used for drinking and other household in city are presented.

EXPERIMENTAL TECHNIQUE

The Portable Radon Gas Surveyor SILENA (PRASSI) system was used for radon concentration measurement in the water samples which were, particularly, well suited for the type of measurement which must have been performed in closed loop circuit. The system had a built-in detector suitable for radon measurement based on a broadly-accepted technique. It consisted of a 1830 ml cell coated with zincsulphide, activated with silver AnS (Ag) coupled with a low-gain-drift photomultiplier. The cell characteristics provided the detection of very low radon concentration levels in the sampled air. The PRASSI pumping circuit operated with constant flow rate at 3 liters per minute for degassing the water sample properly.

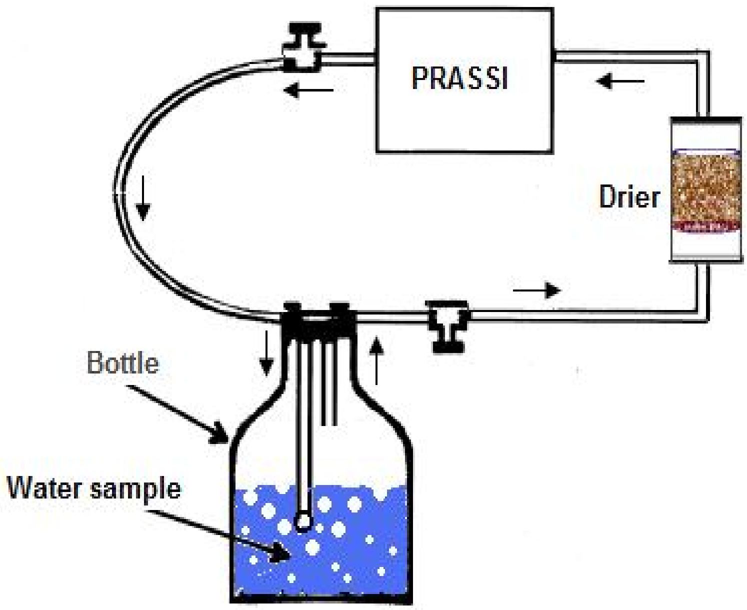

Fig. 1: Portable radon gas surveyor (PRASSI) system

The sensitivity of the system in continuous mode was 4 Bq/m^{3}during 1 hour integration time. The system was set up of a measurement including bubbler and drier column is shown in Fig. 1. To measure the content of radon in water, we considered Vsample =150 ml of the water sample in bubbler and the PRASSI will read a concentration of:

$$C_{PRASSI}\,(Bq/m^3) = A_{Rn}\,(Bq)/V_{TOTAL}(m^3)$$

Where V_{TOTAL} is the total volume of system equal to 2.4×10-3 m^3 and A_{Rn} is the radon activity. It follows that the concentration of radon in water is:

$$C_{Rn}\,(Bq/m^3) = A_{Rn}\,(Bq)/V_{sample}\,(m^3) = C_{PRASSI}\,[V_{TOTAL}\,(m^3)/\,V_{sample}\,(m^3)]$$

The average value of three measurements was considered as the radon concentration in the water sample.

RESULT AND DISCUSSION

In the present research, 25 water samples from groundwater of deep wells, surface water of rivers; tap water were collected and analyzed for radon concentrations. The radon concentration in various samples of water is presented in the Fig. 2. The measured values of radon concentration and annual effective dose from different location of the study area and the mean radon concentration & annual effective dose data of surface, well and tap water samples with advice andaction level of EPA are given in table 2 &3. The arithmetic mean radon concentration of all samples was 10.19 Bq/L. Compared to advise contaminant level of 11 Bq/L for radon in public drinking water, suggested by the EPA [11, 12], the radon concentrations in most of the drinking water samples in the study area was not so high, and they were lower than the action level. In addition, the EPA requires that action must be taken to reduce radon levels above an alternative maximum contaminant level of 148 Bq/L.

Table 1: Measured values of radon concentration and annual effective dose

No. of samples	Radon Concentration (Bq/L)	Annual effective dose (Svy^{-1})
SW1	7.56	0.15
SW2	6.12	0.12
SW3	9.25	0.19
SW4	11.12	0.22
SW5	8.66	0.17
SW6	5.46	0.11
WW7	11.23	0.22
WW8	9.17	0.18
WW9	10.15	0.20
WW10	12.34	0.25
WW11	14.20	0.28
WW12	12.02	0.24
WW13	10.45	0.21
WW14	9.19	0.18
WW15	13.15	0.26
WW16	11.10	0.22
TW17	10.12	0.20
TW18	10.50	0.21
TW19	8.40	0.17
TW20	9.67	0.19
TW21	10.65	0.21
TW22	12.43	0.25
TW23	11.05	0.22
TW24	10.96	0.21
TW25	9.87	0.20
Average	**10.19**	**0.20**

Table 2: Summarized result of radon concentration and annual effective dose

Types of samples	No. of samples	Mean radon Conc.(Bq/L)	Annual effective Dose (Svy^{-1})	EPA advice level (Bq/L)	EPA action level (Bq/l)
Surface water	6	8.02	0.16		
Well water	10	11.30	0.22	11	148
Tap water	9	10.40	0.21		

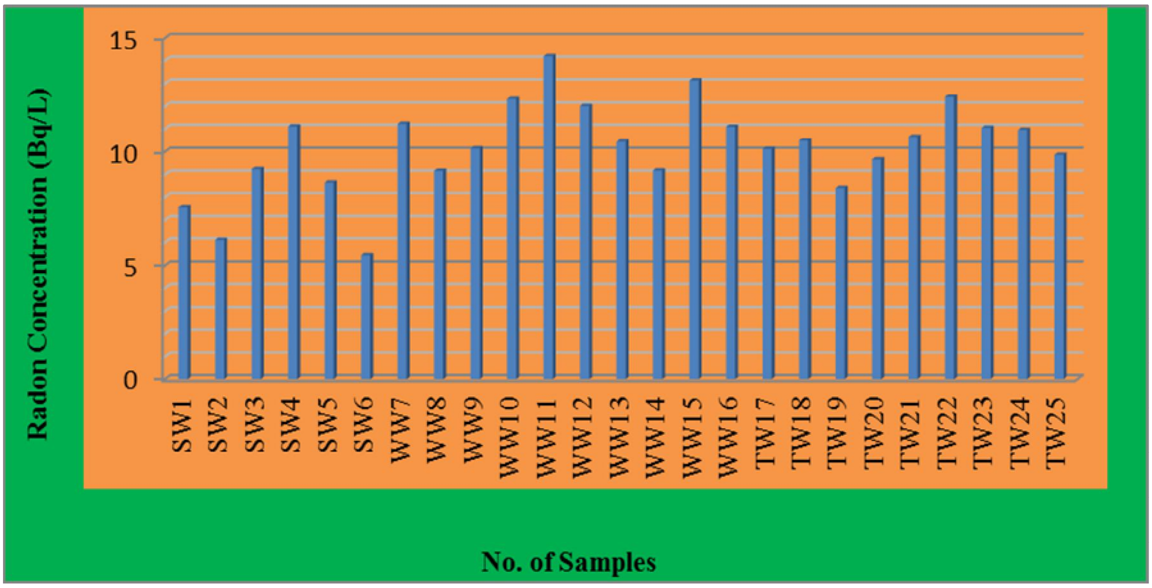

Fig. 2: Radon concentration in various samples of water

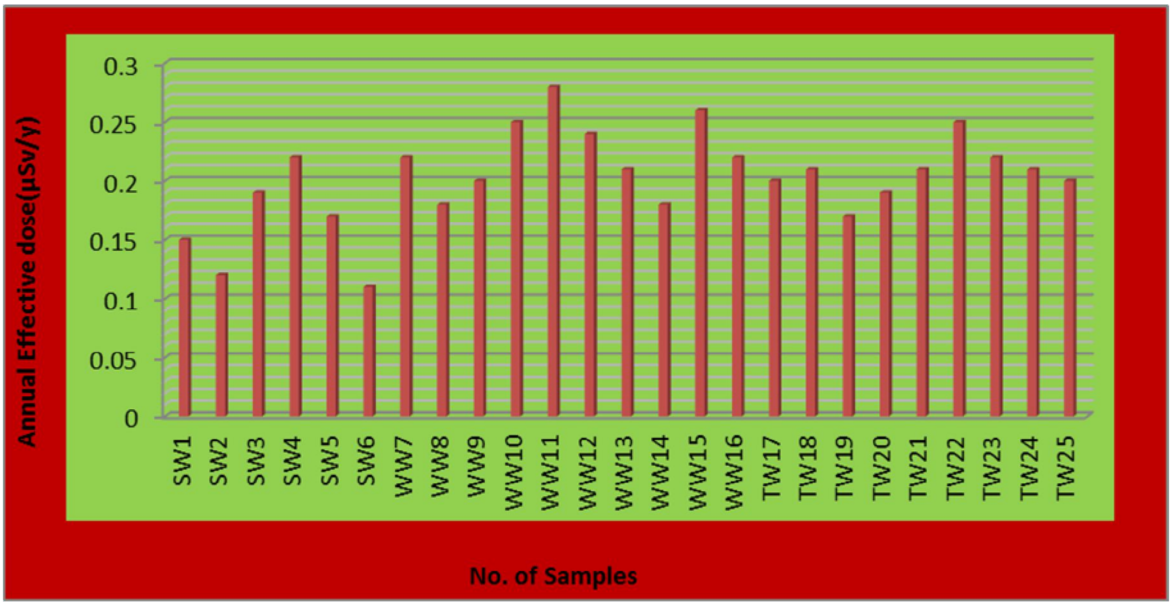

Fig. 3: Annual effective dose in various sample of water

The radon concentration of drinking water is an important issue from dosimetry aspect, since more attention is paid to control of public natural radiation exposure [13-16]. Regarding radiation dose to public due to waterborne radon, it is believed that waterborne radon may cause higher risks than all other contaminants in water [15, 16]. Radon enters human body through ingestion and inhalation as radon is released from water to indoor air. Therefore, radon in water is a source of radiation dose to stomach and lungs. The annual effective doses for ingestion and inhalation were calculated according to parameters introduced by UNSCEAR report. The annual effective dose (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-

$$D_{ing} = C_{Rn}.\ I_F.\ E_D$$

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). E_D is the water consumption (2 L/day). 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. The annual effective doses for ingestion were estimated according to parameters introduced by UNSCEAR report.

The annual effective dose due to inhalation corresponding to the concentration of 1Bq/l was 0.16 Sv/y, in surface water, 0.22 Sv/y in well water and 0.21 Sv/y in tap water respectively. Therefore, waterborne radon concentration of 1 Bq/l caused total effective dose of about 2.68 Sv/y for adults. The effective doses and radon concentration are within the World Health Organization (WHO) recommended reference level of 0.1 mSv/y 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 11Bq/L or (300 pCi/l) and thus are within the safe limit. The graphical variation of radon concentration and annual effective dose (Sv/y) from ^{222}Rn ingested with water are shown in Fig. 2 & 3.

CONCLUSION

Observed values of radon concentration in three types of water samples i.e. surface water, well water and tape water 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. The average value of radon concentration was found to be 8.02 Bq/l in surface water, 11.30 Bq/l in well water and 10.40 Bq/l in tap water respectively. The total average value of radon concentration in water samples was found to be 10.19Bq/l. The average value annual effective dose from ^{222}Rn ingested was found to be 0.16 Sv/y in surface water, 0.22 Sv/y in well water and 0.21 Sv/y in tape water respectively. From the results it is concluded that the average value of radon concentration in three different water samples are lower than the Maximum Concentration Limit (MCL) of 11.1Bq/L set by the USEPA .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. The results of this study indicated that the radon concentration in public drinking water samples of the study area were mostly low enough, and below the proposed concentration limits. The results of this study show that there is no significant radiological risk related to waterborne radon for the inhabitants of the studied regions

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