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Assessment of Annual Effective Dose Due to Inhalation and Ingestion of Radon in Water Samples from Some Regions of Punjab, India

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Abstract

The radon concentration has been assessed in drinking water samples collected from three regions of Punjab (Amritsar, Batala and Gurdaspur) and one adjoining area of Punjab (Kathua) by using RAD7, an electronic solid state radon monitor. The sources of collected water samples were hand pumps and submersible pumps. The overall mean values of studied areas were within the recommended limit proposed by European Commission (2001) and the range suggested by UNSCEAR (2008). The total annual effective dose was also calculated and ranged from 10-177 μSvy^{-1}. These values lie well within the safe limit prescribed by the WHO (2003) and European council (2005).The purpose of this study was to assess the radiological risk, if any, to human health due to consumption of drinking water that is available at studied areas.

Keywords: Inhalation dose, Ingestion dose, Radiological risk, Radon concentration

1. INTRODUCTION

Environmental radiation originates from a number of naturally occurring and human‐made sources. Radiation exposure can occur by ingesting, inhaling, injecting, or absorbing radioactive materials. Radiological hazards may be possible due to the presence of large content of radioactive substances in drinking water. The most common radio-nuclides in drinking water are uranium, radium and radon. Radon is a radioactive, inert gas having highest density 9.37 gl^{-1} among all noble gases. Radon

gas and its radioactive isotopes have special attention among all other naturally occurring radioactive minerals, because it has the largest amount of total annual effective dose to human [1]. Inhalation of radon gases is the second most important cause of lung cancer after smoking and the majority of radon‐induced lung cancers are caused by low and moderate radon concentrations rather than by high radon concentrations because in general, less people are exposed to high indoor radon concentrations [2]. It has been measured in water in many parts of the world, mostly for the risk assessments due to consumption of drinking water [3-6]. People who are exposed to proportionally high levels of radio-nuclides in drinking water for long periods may germinate serious health problems such as stomach and gastrointestinal cancer [7], lung cancer, anaemia, osteoporosis, cataracts, bone growths, kidney diseases, liver disease and impaired immune system.

In the present study, the water samples were taken from three regions of Punjab i.e. Amritsar, Batala and Gurdaspur and adjoining area of Punjab i.e. Kathua to see the variation of the radon concentration in water samples taken from Punjab plains to Siwalik Himalayas. The objective of the study is to calculate inhalation and ingestion doses in the drinking water samples used by inhabitants of the study area for health hazards point of view.

2. GEOLOGY

The area of present study is Amritsar, Batala and Gurdaspur regions of Punjab and Kathua district of Jammu & Kashmir, India as shown in fig 1.

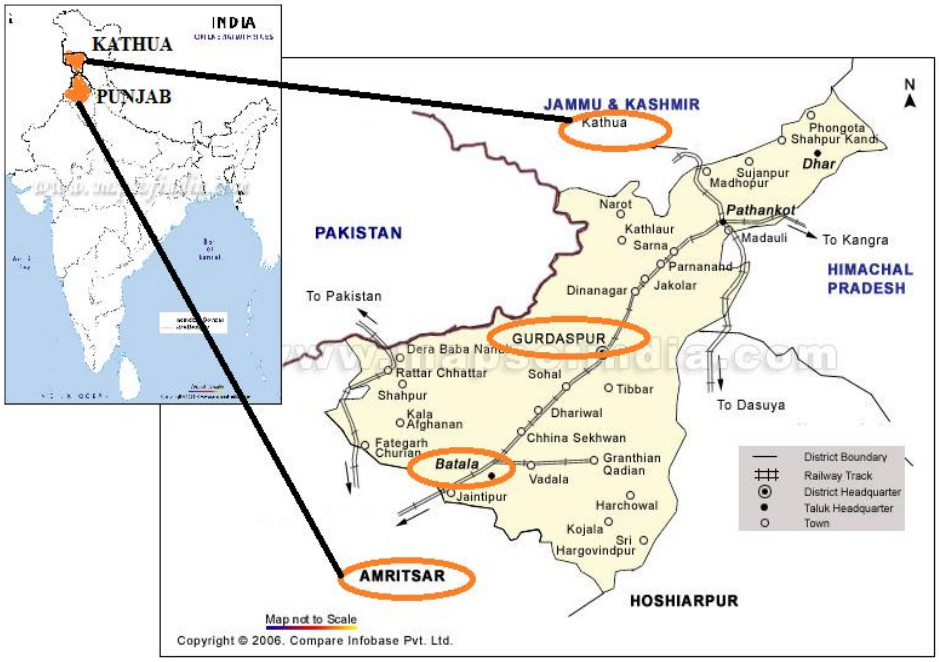

Figure 1.Geological map of surveyed areas of Punjab state and Kathua district of Jammu & Kashmir, India.

The Punjab is situated in northwest India. The Indian state borders the Pakistani province of Punjab to the west, Jammu and Kashmir to the north, Himachal Pradesh to the northeast, Chandigarh to the east, Haryana to the south and southeast and Rajasthan to the southwest. Kathua is one of the prominent district of Jammu provinces and is often referred as the "Gateway of J&K". It lies at the southernmost end of the State and is located between 34°16'00" to 32°55'00" North Latitude and between 75°06'00" to 75°54'00" East Longitude. It is bounded by Gurdaspur district of Punjab in the South-East, Chamba district of Himachal Pradesh in North-East, District Doda and Udhampur in North and North-West, Jammu in the West and in South-West by international border with Pakistan. The southern and south-western parts of the district are covered by gentle terrain called as Outer Plains whereas the northern and north-eastern parts are hilly and mountainous with intermountain valleys called as Dun belt.

3. METHODOLOGY AND THEORETICAL CALCULATION

Radon concentrations in the collected samples were analysed by RAD7 (Durridge Company) (fig 2.)

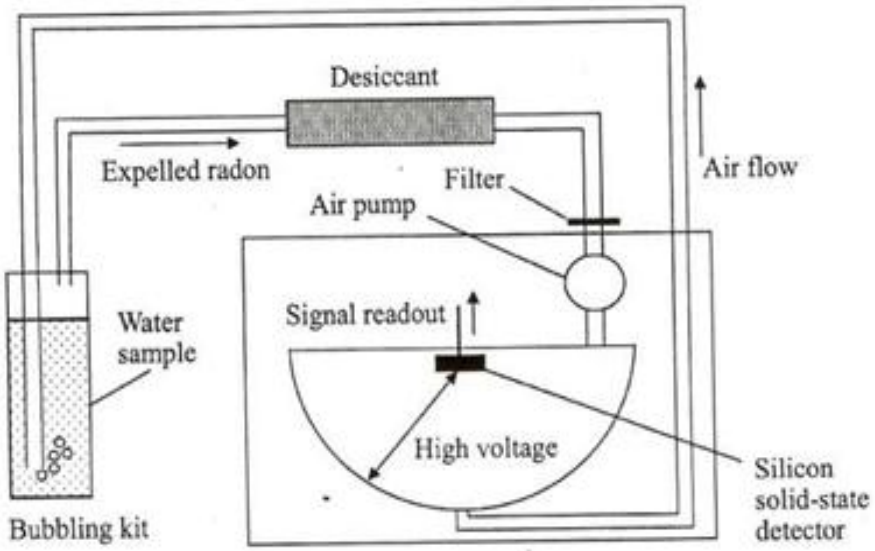

Figure 2.Schematic diagramof RAD H20 assembly.

which is an online radon monitor. RAD7 is a continuous radon gas monitor. It is based on Solid State Silicon Detector. It contains a hemisphere dome in the middle of device, called internal cell [8]. The detailed procedure of RAD7 has been explained elsewhere [3, 4]. The dose due to radon can be divided into two parts, first is dose from ingestion and second is dose from inhalation. The annual mean effective dose

for ingestion and inhalation were calculated according to parameters introduced by UNSCEAR report [1] as below:

$\mathbf{E_{ing}\ (\mu Svy^{-1})} = Rn^{222}$ conc. $(Bql^{-1}) \times W_{in} \times DCF_{ing}$ (1)

$\mathbf{E_{inh}\ (\mu Svy^{-1})} = Rn^{222}$ conc. $(Bql^{-1}) \times R_{aw} \times F \times O \times DCF_{inh}$ (2)

Where E_{ing} is the effective dose of ingestion (μSvy^{-1}), W_{in} is the ingestion intake rate ($730\ ly^{-1}$), DCF_{ing} is the ingestion dose conversion factor (3.5×10^{-9} Sv Bq^{-1}), E_{inh} is the effective dose of inhalation (μSvy^{-1}), R_{aw} is the ratio of Rn in air to Rn in water (10^{-4}), F is the equilibrium factor between Rn and its decay products (0.4), O is the average indoor occupancy time per person ($7000hy^{-1}$) and DCF_{inh} is the inhalation dose conversion factor ($9nSv\ h^{-1}\ (Bq/m^3)^{-1}$). The annual doses to lung and stomach was calculated by multiply the ingestion and inhalation doses with tissue weighting factor for lungs and stomach i.e. 12. [9].

4. RESULTS AND DISCUSSION

The range of radon concentration in water samples from Amritsar region has been varied from 4-16 Bql^{-1} with an average value of 10±5 Bql^{-1} as shown in Table 1.

Table 1. Range, Average and S.D. for radon concentration in water samples and their annual effective doses for studied regions.

Regions	No. of Villages	Statistical factor	Rn conc. (Bql^{-1})	Annual effective dose equivalent (μSvy^{-1})			Doses to organs of body (μSvy^{-1})	
				Ingestion	Inhalation	Total	Stomach	Lungs
Amritsar	5	Range	4-16	10-41	10-40	20-81	123-491	121-484
		Average ± S.D.	10±5	25±11	25±11	50	301±137	296±135
Batala	5	Range	2-17	5-43	5-42	10-85	61-521	60-514
		Average ± S.D.	10 ±6	26 ±14	25 ±14	51	313±171	308 ±168
Gurdaspur	5	Range	10-14	26-36	25-35	51-71	307-429	302-423
		Average ±S.D.	12±1	30±4	30±4	60	362±45	357±44
Kathua	5	Range	11-35	28-89	27-88	55-177	337-1073	333-1058
		Average ±S.D.	21±10	55±25	54±24	109	656±296	647±293

S.D. = Standard deviation

The annual effective dose due to ingestion of radon in water samples of Amritsar region is varied from 10-41 μSvy^{-1} with an average value of 25±11 μSvy^{-1} and due to inhalation of radon in water samples is varied from 10-40 μSvy^{-1} with an average value of 25±11 μSvy^{-1}, respectively. The total annual effective dose of radon concentration in water samples is 50 μSvy^{-1}. The average value of annual dose to

stomach and lungs is 301±137 μSvy^{-1}and 296±135 μSvy^{-1}, respectively as shown in fig 3.

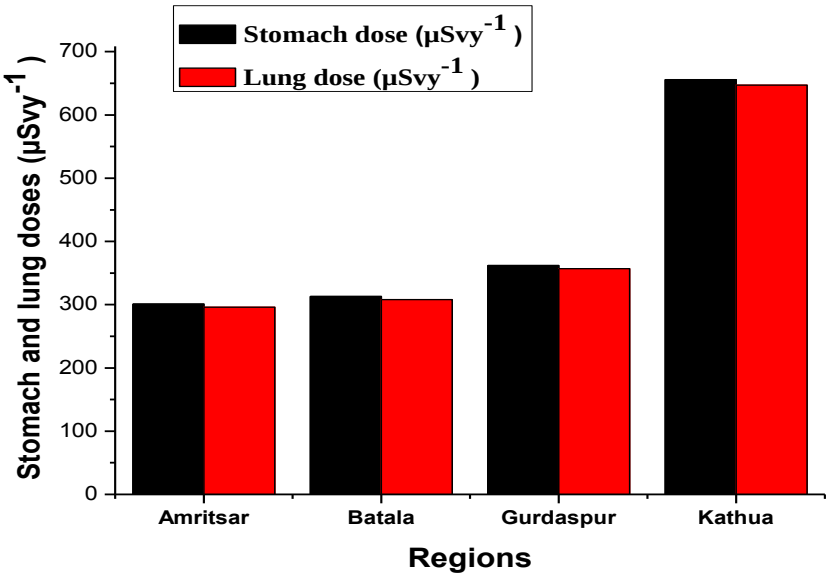

Figure 3. Variation of doses to stomach and lungs (μSvy^{-1}) for different regions .

The range of radon concentration in water samples from Batala and Gurdaspur regions have been varied from 2-17 Bql^{-1} with an average value of 10±6 Bql^{-1} and 10-14 Bql^{-1} with an average value of 12±1 Bql^{-1}, respectively as shown in Table 1. The total annual effective dose of radon concentration in water samples is 51μSvy^{-1} for Batala and 60 μSvy^{-1} for Gurdaspur, respectively. The average value of annual dose to stomach and lungs is 313±171 μSvy^{-1} and 308±168 μSvy^{-1} for water samples of Batala region and the average value of annual dose to stomach and lungs is 362±45 μSvy^{-1} and 357±44 μSvy^{-1} for Gurdaspur region, respectively as shown in fig 3.

The range of radon concentration in water samples from Kathua region has been varied from 11-35 Bql^{-1} with an average value of 21±10 Bql^{-1} as shown in Table 1. The annual effective dose due to ingestion of radon in water samples of Kathua region is varied from 28-89 μSvy^{-1} with an average value of 55±25 μSvy^{-1} and due to inhalation of radon in water samples is varied from 27-88 μSvy^{-1} with an average value of 54±24 μSvy^{-1}, respectively. The total annual effective dose of radon concentration in water samples is 109 μSvy^{-1}. The average value of annual dose to stomach and lungs is 656±296 μSvy^{-1}and 647±293 μSvy^{-1}, respectively as shown in fig 3.

All the values of radon concentration in water samples for Amritsar, Batala, Gurdaspur and Kathua region is found to be well within the range suggested by UNSCEAR [1] and limit suggested by European Commission [10]. The minimum value of radon concentration is 10 Bql^{-1} for Amritsar and Batala and the maximum value of radon concentration is 21 Bql^{-1} for Kathua region as shown in fig 4.

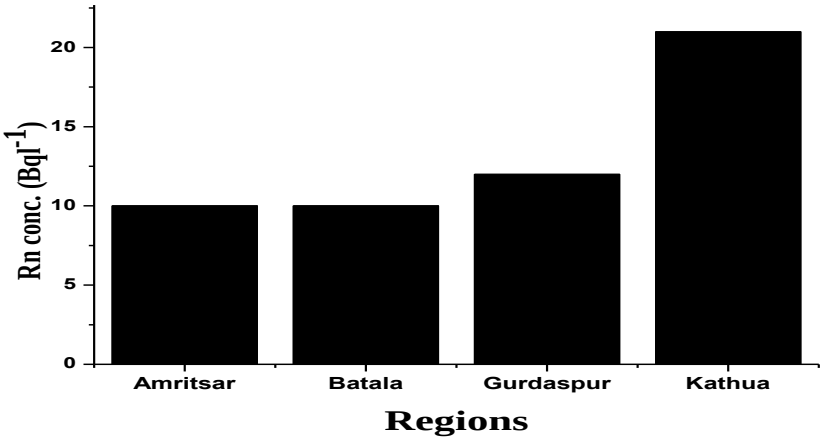

Figure 4. Variation of radon concentration (Bql^{-1}) in water samples for different studied regions.

The values of radon concentration in water samples increases as one move from Punjab plains to Shiwalik Himalayas [4] due to the presence of uranium mineralisation in shiwalik himalayas as reported earlier by Kaul et al.1993 [11].

Moreover, the total annual effective dose of all regions is found well within the recommended limit of 100 μSvy^{-1} suggested by the WHO [12] and European council [13]. However, the value of total annual effective dose in Kathua region is higher as compared to other regions which may be due to the occurrence of radon in groundwater is reasonably related to the uranium content of the bedrocks and it can easily enter into the interacting groundwater by the effect of lithostatic pressure. Since the values of annual effective dose in all regions are found below the recommended limit, hence it can be concluded that the areas are safe for health hazard point of view.

5. CONCLUSIONS

The values of radon concentration from water samples in all four regions were well below the range prescribed by the UNSCEAR [1] and the limit recommended by European Commission [10]. The total annual effective dose due to inhalation and ingestion of radon from drinking water samples were below then 100 μSvy^{-1} suggested by the WHO [12] and European council [13]. Hence the drinking water of the studied areas is not dangerous for the inhabitants of those areas.

6. ACKNOWLEDGMENTS

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