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An Experimental Investigation of Radon Concentrations in Groundwater along the Coast of Chennai City with Ingestion Dose

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Abstract

Radon has become one of the major problems in radiation protection since it cause lung cancer. It is radioactive, odorless, colorless, water soluble and the heaviest noble gas. Since rocks and soil contains radium that decays to form dissolved ^{222}Rn which dissolved into underground water and surface water. The concentration of ^{222}Rn in underground water depends on the concentration of its parent ^{226}Ra in the underlying rock. In this study, the result of systematic measurement of activity concentration of ^{222}Rn in ground water along the coastal regions of Chennai City is discussed. The ^{222}Rn concentration in water was measured using the radon emanometry method. The associated effective doses were computed.

Keywords: *222Rn concentration, Drinking water, Chennai City, Radon emanometry, Effective dose*

INTRODUCTION

Naturally occurring ^{222}Rn, belonging to the uranium-238(^{238}U) decay series, is the most abundant and has the longest half-life among the noble gas. Radon is a natural isotope. It is produced after three alpha and two beta disintegrations following the initial ^{238}U alpha decay. ^{222}Rn is efficiently transferred from the solid matrix to the water-filled pore and fracture space by alpha recoil and associated effect.[1] The ^{222}Rn activity concentration in water sources depends not only on the concentration of uranium in certain types of rocks and soils, but also on the

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distribution of the parent radium-226 (^{226}Ra) inside the solid grain, degree of rock weathering, the disequilibrium state of the uranium series inside the solid grain, adsorption of radium in the rock grain and fracture surfaces, and on the effective rock surface exposed to ground water contact.[2] Although ^{222}Rn may present in considerable activity concentration within the sources of water, most of the gas is lost before the water is consumed. As ^{222}Rn is more soluble in other gases than in water, it is easily transferred to the atmospheric air. Surface waters typically contain very low concentrations of ^{222}Rn[3] than ground waters.

In recent years, concern has grown about the potentially hazardous effects of the continuous exposure of the general public to low-level radioactivity environments. The ^{222}Rn in water can be ingested or inhaled during consumption of water and will result in exposure of human organs to radiation, primarily the lungs. Thus, assessing ^{222}Rn in water, in addition to that in air, is an important step in reducing the potential exposure to it .On the other hand, the use of water in dwellings may result in 'enhanced' indoor concentration levels of ^{222}Rn. Such an increase in the indoor levels of ^{222}Rn depends on the total consumption of water in the dwelling, the size of the dwelling, and the rate of air ventilation.[4] the present study was carried out to measure ^{222}Rn activities in natural water samples from coastal areas of Chennai city.

MATERIALS AND METHODS

i.Sample collection

Sampling stations were identified in selected locations for collecting drinking water. In this present study, all the drinking water samples were collected from different sources such as Bore wells, open wells, tap water and lake water. The map showing the sampling stations is shown in Fig. 1. About 1 L of water was collected from each sampling station in airtight bottles. The bottles were filled completely to minimize loss of ^{222}Rn during sample collection. The samples were brought to the laboratory with minimum delay and were analyzed immediately.

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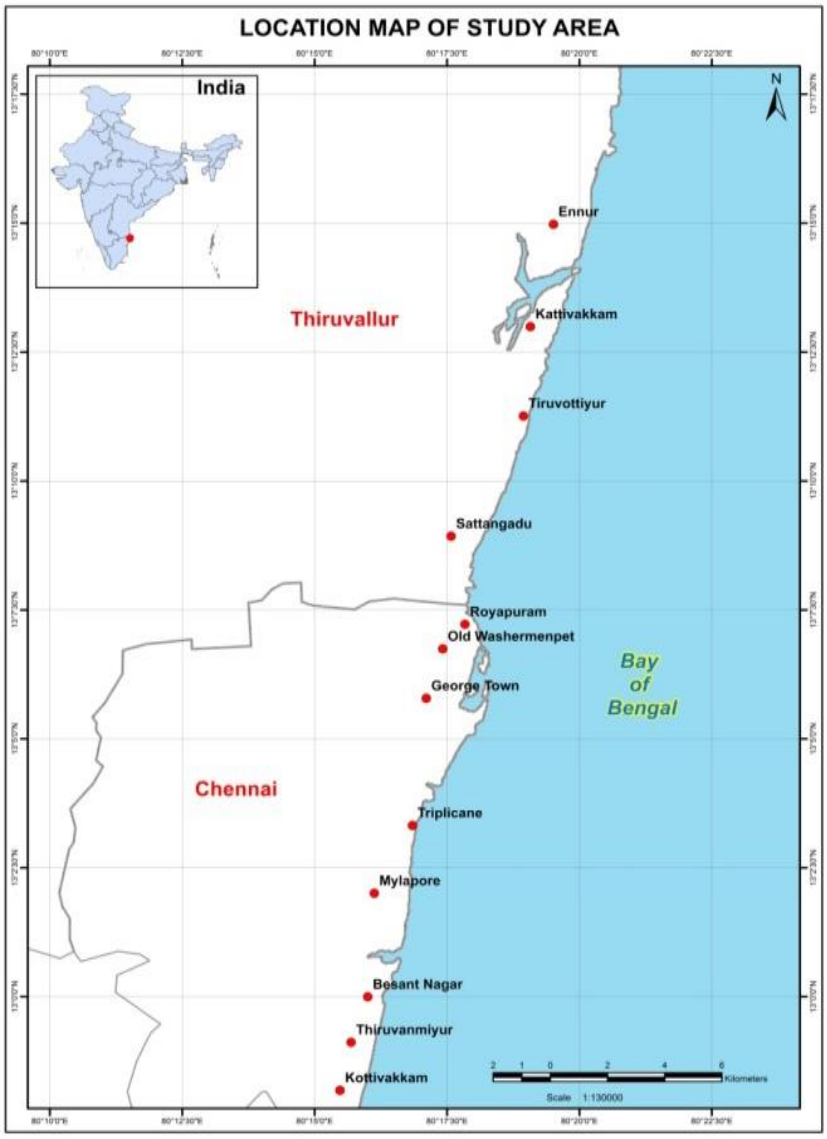


Fig. 1: Sampling station in coastal area of Chennai city

ii.Activity determination

The concentration of ^{222}Rn in aqueous samples was determined by the emanometry method. [5] In this method, about 60 ml of the water sample was transferred into the bubbler by the vacuum transfer technique. The dissolved ^{222}Rn in the water was transferred into a pre evacuated and background-counted scintillation cell. The scintillation cell was stored for 180 minutes to allow ^{222}Rn to attain equilibrium with its daughters and then it was coupled to photomultiplier and alpha-counting assembly and the activity was counted. The overall efficiency of this setup was found to be 74%.

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iii. Assessment of effective dose

The effective dose for an individual via ingestion of drinking water is calculated using the formula $\mathbf{D_{ing}=Cr\times I_f\times E_d}$[6] where, D_{ing} is the annual effective dose for an individual due to ingestion of the radionuclide (Sv y^{-1}),C_r is the concentration of the radionuclide in ingested drinking water (Bq l^{-1}), I_f is the annual in takeoff drinking water containing the radionuclide (ly^{-1}), and E_d is the ingestion dose conversion factor for the radionuclide(Sv Bq^{-1}).The effective dose due to the intake of ^{222}Rn was assessed using the measured activity of ^{222}Rn and dose per unit activity of radon ingested.

EXPERIMENTATION

i. Concentration of ^{222}Rn in water

The results of the concentration of ^{222}Rn in drinking water are presented in Table 1 and Figure 2.

Table 1: Mean ^{222}Rn concentration and effective dose value of different areas in coastal area of Chennai city

Area	**^{222}Rn range in water (Bq l^{-1})**	**^{222}Rn mean value in water((Bq l^{-1})**	**Ingestion dose value for calculated ^{222}Rn concentration (mSv y^{-1})**
Kovalam	3.2 – 7 (closed) & 1.5 – 2 (open)	5.3	0.0193
Muttukadu	2.5 – 3.0 (closed)	2.8	0.0102
Uthandi	1.0 -1.7 (closed)	1.2	0.0043
Panaiyur	2.3-2.6 (closed)	2.5	0.0091
Karapakkam	2.0 – 2.5 (closed) & 1.2 – 1.5 (open)	2.1	0.0077
Injambakkam	2.6 - 3.0 (closed)	2.9	0.0159
Neelankarai	2.0 – 2.5 (closed)	2.3	0.0084

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Palavakkam	4 – 4.5 (closed)	3.5	0.013
Kottivakkam	3.2 – 3.6 (closed)	4.3	0.016
Thiruvanmiyur	1.6 – 5.3 (closed)	3.2	0.012
Besant nagar	1.5 – 3.6 (closed)	3.2	0.012
Adyar	1.5 – 3.6 (closed)	3.2	0.012
Ra puram	3.2 - 4.5 (closed)	3.7	0.014
Mylapore	2.5 – 3.6(closed)	3.0	0.011
Triplicane	1.6 – 3.5(closed)	2.6	0.009
Chepauk	1.0 – 3.3 (closed)	2.3	0.008
Chennai beach station	3.0 – 6.3 (closed)	4.3	0.016
Royapuram	4.0 – 5.0 (closed)	4.5	0.016
Old washermanpet	3.5 – 6.2 (closed)	4.7	0.016
Thiruvotriyur	1.0 – 3.2 (closed)	2.04	0.007
Ennore	3.0-6.0 (closed)	5.3	0.019

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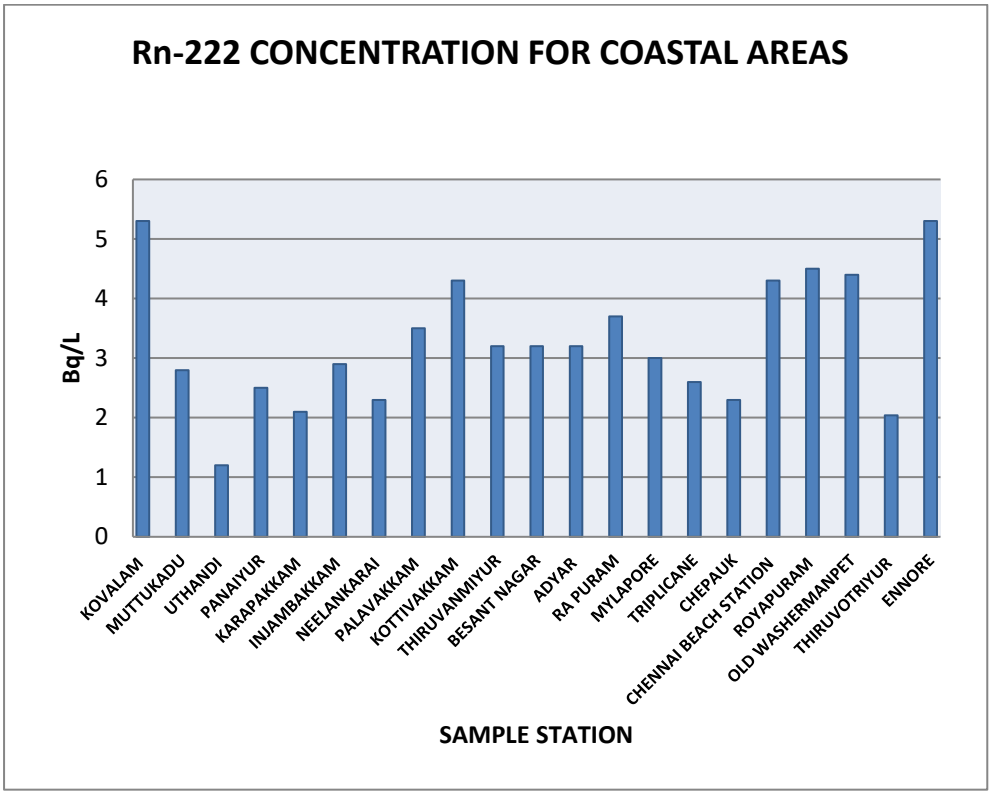


Fig. 2: Graph representing mean ^{222}Rn concentration

i.Dose due to dissolved 222Rn

Using the measured concentration of ^{222}Rn in drinking water, the effective doses were estimated and represented in Table 1 and figure 2. The conversion factor used for the calculation of effective dose for the stomach is 14.4 μSv Bq^{-1}.[8] The mean daily intake of water is assumed to be a minimum of 2 L per person.[9] The effective dose receive by the population of the region was found to vary from 0.001 to 0.167 Sv y^{-1} with a mean value of 0.044 Sv y^{-1} for closed well, 0.022 Sv y^{-1} and 0.001 for metro water.

RESULTS AND DISCUSSION

The results obtained in this study indicate that the ^{222}Rn concentration was in the range of 1.2 to 5.3 Bq l^{-1} with the mean value of 4.3 Bq l^{-1} for closed well and 2.1 Bq l^{-1} for open well from the 100 samples collected over different areas of Chennai City. While the average values are within the maximum concentration limit of 11.1 Bq/l set by USEPA and world average value of 10 Bq/l set by WHO, several incident values from well and borehole sites exceeded these values. The effective dose receive by the population of the region was found to vary from 0.004 to 0.019 Sv y^{-1} with a mean value of 0.044 Sv y^{-1} for closed well and 0.022 Sv y^{-1} for open well.

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