A STUDY ON EXHALATION RATE OF RADON AND THORON GASES FROM KANYAKUMARI BEACH SEDIMENTS

R. T. Asher Nebin[1], A. Yardily[2]

[1]Research Scholar, Ph.D. Reg. No.20213162031004
Department of Chemistry, Scott Christian College, Nagercoil, Tamil Nadu, India
(Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli, Tamil Nadu)

[2]Research Supervisor, Assistant Professor,
Department of Chemistry, Scott Christian College, Nagercoil, Tamil Nadu, India
(Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli, Tamil Nadu)

ABSTRACT

Radon and thoron gas exhalation rate monitoring important, because radon gas is one of the major causes for lung cancer among public. Regular indoor monitoring of radon gas should be done. Outdoor gas concentrations of radon and thoron were not that much harmful because they get diluted to low concentrations by air. In, this study the exhalation rates of the radon and thoron gases from the beach sediments of Kanyakumari District were monitored. The radon mass exhalation rate ranged from 4 to 36mBq/kg/hwith an average of 10 mBq/kg/h and the thoron surface exhalation rate ranged from 106 to 11010 Bq/m^2/h with an average of 3199 Bq/m^2/h. The obtained values are compared with the world average values given by UNSCEAR, 2000

Keywords: radon, thoron, beach sediments, exhalation rates.

Introduction

The exhalation of radon and thoron gases means the release of such gases from rock or soil matrix. Measurement of exhalation rate of radon from soil and building materials, is the best way to survey environmental radon concentration. Radon and thoron exhalation rate is influenced by environmental factors, such as climatic elements, water content, and geology (Masahiro *et al*., 2004). Radon is a colorless noble gas which forms radioactive materials such as Uranium, Thorium and Radium and contaminate the soil, rocks, and groundwater. However, the concentration of radon gas outdoor is less due to air dilution, if these gases get accumulated indoor and in environments like coal mine, the concentration becomes very high and they can cause severe health impacts. On the other hand, thoron gas concentration indoors is very less due to their short half-life (55.62 s), they get decayed and diluted easily before entering buildings. Outdoor radon can influence indoor radon concentration because the half-life of this gas is longer (3.8 days) than that of thoron. If the concentrations of these gases are high, there is a risk of lung cancer to the public. Smokers are very much vulnerable to it. Considerable study has been carried out on radon and in India and abroad.

Materials and Methods

The study area chosen for this study is the coasts from Kanyakumari district which lies in the Southern part of India with high levels of natural background radiation areas i.e., High Background Natural Radiation Area (HBNRA).

Kanyakumari is the smallest district in Tamil-Nadu, guarded by Western ghats, it experiences tropical climate, with pleasant weather, it also receives rainfall during the Southwest and Northeast monsoon months. Its coastal line has high background natural radiation area because of monazite deposits. The coast is mostly rocky. Stations in HBNRA show a higher level of ambient radiation. (fig. 1.1)

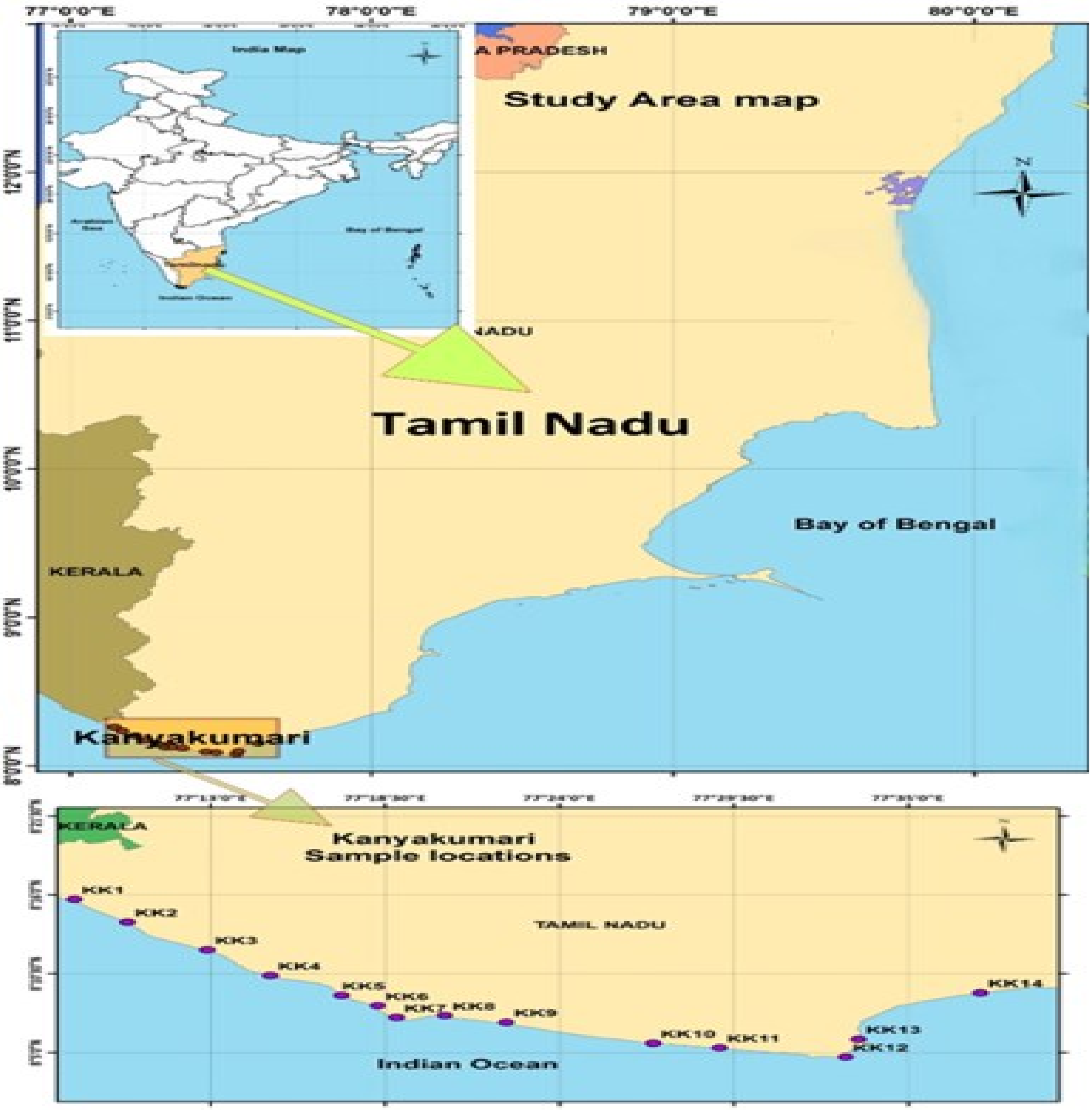

Fig. 1.1. Sampling Zones.

Radon and Thoron exhalation rates of the samples were measured using RAD 7 (Durridge make). It is a continuous monitor that measures the EPA action level of 0.148

Bq/L, with 10% standard deviation, in one hour. At the end of each run, the detector prints out a complete report. The RAD 7 is a solid-state alpha detector which measures the concentration of radon gas in the environment by indirectly measuring the daughter products ^{214}Po and ^{218}Po. It consists of a semiconducting material (Silicon) which converts radiation directly into electrical signal. The RAD 7 shows alpha spectrum of radon daughters not radon itself. It consists of a hemispherical chamber of 0.7 liters in which PIPS (Passivated Implanted Planar Silicon) detector is present. The chamber is held at negative potential. The high voltage power circuit charges the inside conductor into 2000 -25,000 V creating an electric throughout the volume of the cell. The electric field propels positively charged particles into the detector.

As soon as ^{222}Rn is converted into its daughter products ^{218}Po inside the chamber due to the negative potential inside the chamber becomes positively charged and gets attached with PIPs detector by emitting alpha particle along with energy 6 MeV. The other daughter products are not considered due to their long half-life and Bismuth is not considered as it emits β-radiation.

The collected beach sediments were dried, weighed and sealed in a SS chamber with inlet/outlet nozzles. The chamber is then connected to a closed loop configuration of the online radon/thoron monitor. The configuration is such that, the instrument draws from the chamber through an inlet filter into the measurement chamber. The air is then returned to the chamber from the RAD 7 outlet.

The radon/thoron concentration inside the exhalation chamber increases exponentially and arrives at an equilibrium value. Taking the initial radon/thoron concentration as zero, and assuming there is no appreciable leak from the chamber, the exhalation rate, J_m from the sample is expressed as:

$$J_m = \frac{C\lambda V}{M(1 - e^{-\lambda t})}$$

Where,

C - Radon/thoron concentration at time t (Bqm^{-3})
λ -Decay constant(s^{-1})
v - Effective air volume (m^3)
M- Sample's mass (kg)

For equilibrium condition, this equation reduces to,

$$J_m = C_0\lambda V/M$$

Where C_0 is the equilibrium radon/thoron concentration. Any minute leak, if present, will add to the λ value to give effective λ. It takes several days for radon to reach the equilibrium.

This difficulty is overcome by restricting the observation period to the initial linear portion of the build-up curve which satisfies the condition t << $T_{1/2}$ and E is estimated from the slope of C versus t plot.

$$\mathbf{J_m = Slope \times V/M}$$

Hence, in this case, the exhalation rate does not depend on the λ value. In case of thoron, equilibrium condition is attained within minutes. Hence, the first equation holds good for the observation period. Hence, thoron exhalation rate is estimated from the equilibrium concentration, C_0.

The minimum detectable activity (MDA)was 2 mBq/kg/h for radon and 59 Bq/m^2/h for thoron.

Results and Discussion

The results of the exhalation rates from the beach sediments inKanyakumari zone are presented in table 1.1. The world average values of radon mass and thoron surface exhalation rates are 57 mBq kg^{-1} h^{-1} and 3600 Bqm^{-2} h^{-1} respectively (UNSCEAR 2000).

Table 1.1: Exhalation rate of radon and thoron from Kanyakumari coastal sediments

S/N	Sample Location	Latiutude (North)	Longitude (East)	Radon mass exhalation rate (mBq/kg/h)	Thoron surface exhalation rate (Bq/m²/h)
1.	**Thoothoor**	8˚ 15' 26.32"	77˚ 8' 34.48"	17 ± 2	367 ± 57
2.	**Thengapattanam-(Mullorthurai)**	8˚ 14' 5.65"	77˚ 10' 21.74"	4 ± 1	106 ± 32
3.	**Karungal-(Midalam)**	8˚ 12' 9.71"	77˚ 12' 52.86"	27.2 ± 2	5785 ± 240
4.	**Colachel**	8˚ 10' 22.26"	77˚ 14' 52.15"	6 ± 1	1208 ± 130
5.	**Manavalakurichi-(chinnaviali)**	8˚ 8' 25.5"	77˚ 18' 7.76"	6.6 ± 1	1870 ± 134
6.	**Manavalakurichi (Valliyur River Mouth)**	8˚ 8' 15.9"	77˚ 33' 26.85"	8 ± 1	9896 ± 57
7.	**Kadiapattinam**	8˚ 8' 8.79"	77˚ 18' 15.6"	35.8 ± 2	11010 ± 326

8.	**Muttom- (east break water)**	8° 7' 28.2"	77° 19' 58.77"	4.2 ± 1	257 ± 53
9.	**Rajakamangalam (thurai)**	8° 7' 12.96"	77° 21' 37.65"	4 ± 1	404 ± 69
10.	**Chothavilai**	8° 5' 38.67"	77° 26' 57.45"	5.6 ± 1	878 ± 93
11.	**Manakudi**	8° 5' 19.45"	77° 29' 3.61"	7.8 ± 1	2266 ± 183
12.	**Kanyakumari- (tourist spot)**	8° 4' 40.9"	77° 33' 1.78"	3.8 ± 1	187 ± 48
13.	**Vivekanandapurambeach (Ashramam)**	8° 5' 21.69"	77° 33' 26.85"	10 ± 1	9989 ± 367
14.	**Kudankulam**	8° 9' 9.53"	77° 37' 17.33"	5.2 ± 1	576 ± 81
MDA				**2**	**59**

Radon Mass Exhalation Rate (mBq/kg/h)

In the beach sediments of Kanyakumari coast, the radon mass exhalation rate ranged from 4 to 36 with an average of 10 mBq/kg/h. The lowest rate was observed at Thengapattinam (Mullorthurai) and the highest exhalation was observed from Kadiapattinam beach sediments. It is observed that the Thengapattinam beach sediments were not dark in color which means they lack or contain less amounts of the minerals like monazite. It is observed that the dark colored sediments had high exhalation rates

Thoron Surface Exhalation Rate(Bq/m^2/h)

In the beach sediments from Kanyakumari district the thoron surface exhalation rate ranged from 106 to 11010 Bq/m^2/h with an average of 3199 Bq/m^2/h. The lowest thoron surface exhalation rate was from Thengapattinam (Mullorthurai) and highest rate was from Kadiapattinam sediments.

The high thoron exhalation rates were due to the presence of Monazite in the sand, and the thoron exhalation rate is due to the presence of Uranium-bearing minerals such as Uraninite and Carnotite in the soil.

Considerable studies on radon and thoron exhalation studies have been carried out in India and worldwide.

The average radon exhalation rates from the soil samples in Bangalore Karnataka was found as 115.64 mBq/kg/h (Poojitha *et al,* 2017). According to this study, Bangalore city has high radon exhalation rates than the present study.

Singla *et al.*, (2023) carried out a study in the Hanumangarh District of Northern Rajasthan. The radon mass and thoron surface exhalation rates are found to be 34.60

mBq/kg/h and 6.44 kBq/m^2/h respectively. The radon mass exhalation and thoron surface rate are high compared to the present study.

Alhamdi *et al;* (2021) did a study in the Duhok province - Iraq and found the mass exhalation rate of radon to be 4.2 mBq/kg/h. This is comparable to the present study.

Conclusion

From this study, it is evident that Kanyakumari coastal lines have safe levels of radon mass exhalation rates i.e., below 57 mBq kg^{-1} h^{-1}. But, the thoron surface exhalation rate from four of the sampling sites exceeds the world average of 3600 Bqm^{-2} h^{-1}, these world averages were from the guideline given by, (UNSCEAR, 2000). Hence, there is mostly no risk associated with radon mass exhalation rates.

References:

Hosoda, Masahiro, S. Michikuni, S. Masato, Y. Yuji, and F. Masahiro (2004). Radon and thoron exhalation rates and their some correlating factors. *Rn* 21: 21.

Poojitha, C. G., B. K. Sahoo, T. S. Pranesha, and K. E. Ganesh, (2017). Radon mass exhalation rate in soil samples at South Bengaluru city, Karnataka, India. In *Proceedings of the national conference on radiation physics*.

Singla, Amit Kumar, Sandeep Kansal, Supriya Rani, Salik Nazir, and Rohit Mehra. "Estimation of exhalation rates of radon/thoron in Soil in Hanumangarh district of Northern Rajasthan, India." (2023).

Alhamdi, Walat Abdulqader, and Khairi Mohammad S. Abdullah (2021). Determination of radium and radon exhalation rate as a function of soil depth of Duhok Province-Iraq. *Journal of Radiation Research and Applied Sciences,* 14(1): 486-494.