Preliminary studies on radon/thoron and their daughter products in few dwellings of KGF mining area during 2007

[1]H S Prakash, [2]M D Lakshmana
[1]Assistant Professor, [2]Assistant Professor
[1]kgf first grade college, oorgaum,kgf,
[2]sheshadripuram degree college, bengaluru

Abstract **- great amount of research in the field of radiation hazard conducted since 1942 has been directed towards understanding the mechanism of radiation injury as well as the ecological relationship that exists in an environment contaminated with radioactive material. Study of Radon / Thoron and its daughter products in the environment has always been an important aspect of such studies. Extensive studies have been carried out by various researchers on the concentration of Radon / Thoron and their daughter products in different types of buildings, floorings, walls and ventilations. In the present paper, an attempt has been made to measure the indoor concentration of Radon and Thoron and their products using solid state nuclear track detector (SSNTD) techniques carried out in few dwellings of K.G.F mining area.**

keywords **- solid state nuclear track detector**

Introduction

Ever since human is bon on this earth, he is bombarded by radiation Everybody on this earth, irrespective of his place of stay and occupation he is getting some dose of ionizing radiation, which exists all around us. This is called natural background radiation. About 82% of total human exposure to radiation is from natural sources. Manmade sources such as medical exposures, Phosphate fertilizers and consumer products etc. and about 18% of the total exposure, which is known as Technologically enhanced natural radioactivity (1,2). The global average equivalent effective dose from all sources per year is 24 navy out of which a 50% of radiation is due to radon and its daughter products (2) The measurement of concentration of radon and its decay products in indoor and outdoor air and soil has been the interest of many research scientists all over the world.

Numerous studies have been carried out on radon emanation, exhalation and transport (Schery et al, 1982; Rogers and Nickson, 1991, Kemski et al. 1992), in order to understand the source of radon, and ultimately for better mitigation of the hazards associated with radon in dwellings. The studies show that the concentration of radon in soil & air varies over time, and that Variations often are associated with the physics nature of the soil and the environment, such as changes in air pressure and temperature, and wind moisture patterns (Duenas and Fernandez, 1987: Washington and Rose. 1990: Hubbard et al. 1992; Washington and Rose, 1992: Hubbard, 1996: Hubbard and hagberg, 1996). Studies have also shown that radon emanation, transport rate and exhalation vary between soils with different physical and chemical properties, such as grain composition (Markkanen and Arvela, 1992; Morawska and Phillips, 1993), grain size (Megumi and Mamuro, 1974). compaction, porosity and permeability (Holkko and Liukkonen, 1992), petrography, radium distribution, weathering and soil horizon formation (Landa, 1984; Greeman et al., 1990; Greeman and Rose, 1996: Ek and Ek 1996; Hogue et al., 1997; Greeman et al, 1999).

The prediction of radon concentrations in a given dwelling is extremely difficult. The main sources of indoor radon concentrations are the soil – gas, building materials. tap water and natural gas used for cooking. The topography, house construction type. soil characteristics, ventilation rate, wind direction, atmospheric pressure and even the lifestyle of the habitants are also having significant influence on indoor radon concentrations (Ramachandran et al., 1990; Jonsson, 1991; Mishra and Ramachandran 1995).

One of the major factors affecting the radon concentration in dwellings is the lithology of the underlying strata. Mining in the vicinity may intensify the influence of the geological structure. The presence of a shallow, abandoned working near the surface as well as a big number of faults enables easier migration of different gases and of course, migration of radon.

Exposure of person to high concentration of ^{222}Rn and the short-lived progeny for a long period leads to pathological effects live the respiratory fundamental changes and the occurrence of lung cancer (10, 11). ^{222}Rn and its daughter product present in natural environment can causes radiation hazard if such sources are concentrated in enclosed areas such as underground mines, caves cellars of poorly ventilated houses. They can also give rise to significant radiation exposure in open spaces, if their concentrations are very high either due natural causes or manmade causes.

A new analysis of published results also shown a slightly increased risk of lung cancer from household ^{222}Rn consistent with the level of risk that has been estimated based on the studies of underground mines (11, 12, 13). Ever since studies on uranium mines established the presence of a positive risk coefficient for the occurrence of lung cancer in mines exposed to evaluate levels of ^{222}Rn and the progeny, there has been a great upsurge of interest in the programming conceded with measurement of ^{222}Rn

in the environment. This interest was accentuated by these observations of elevated ^{222}Rn level in the indoor environment in many countries that led to the realization of residential Rn as being a possible public health issue in the realization for residential ^{222}Rn as being a possible health issue in the Western world. It was also hoped that in conjunction with epidemiological studies large-scale indoor Rn surveys lead to qualitative understanding the dose effects of ^{222}Rn exposure (2)

Besides its negative effects on the health of living organisms, Radon monitoring has several other advantages. The main other applications of radon are mineral exploration based on radon measurements, Earthquake predictions, Hydrogeology, Rock bursts, Predictions of Volcanic Eruptions and Medical Application.

In the objective of the present study is the measurement of Radon/Thoron and their daughter products, estimation of effective equivalent population dose and comparison of concentration of radon / thoron and their daughter products to Indian average value and global average value.

A survey of the earlier work shows that the work on indoor ^{222}Rn and ^{220}Rn studies have become prominent only after 1980's. Marvin Wilkening (30) has made an extensive study on seasonal variation of Rn at location in the southwestern part of United States and reported high ^{222}Rn concentration during winder and low concentration during summer and he has measured room wise Rn concentration and reported high concentration of indoor ^{222}Rn in bedroom and kitchen which are due to poor ventilation.

Ramola (31) studied the variation of Rn concentration in the interior parts of Guru Nanak campus using LR-115 Solid State Nuclear Track Detectors. The ^{222}Rn concentration measured in different rooms ranged from 36.3 to 305.6 Bq. m^{-3} the variation of ^{222}Rn concentration with respect to height i.e., in ground floor, first floor and second floor has been studied and an exponential decrease in the ^{222}Rn concentration was observed with height. In addition to these, the investigators studied the variation of ^{222}Rn concentration with respect to ventilation conditions, types of materials present and the direction of airflow.

Subharamu (32) have made a qualitative study of the seasonal variation in the indoor concentration of ^{222}Rn and its progeny and reported that both Rn and its daughter projects are highest during winter and minimum during summer.

Ramachandran (33) has studied the seasonal variation in concentration of ^{222}Rn and its progeny inside houses in Bombay. Here the progeny concentrations were measured using grab sampling method and indoor ^{222}Rn using SSNTD technique. The average ^{222}Rn concentration reported was 103 Bq. m^{-3} and average potential alpha energy exposure were 0.79 mWL, (grab sampling) and 1.53 m WL (SSNTD). The estimated average dose were 0.2 and 0.48 mSvy^{-1} respectively. In this measurement a pacific trend in the seasonal variation of the indoor Rn concentration was observed.

Segovia (34) measured concentration of ^{222}Rn concentration both in indoor and outdoor using LR 15 type II Solid State Nuclear Detector in Mexico city as part of the survey of natural radioactivity in local environment. Low ^{222}Rn concentration of about 40 Bq.m^{-3} were found. The highest ^{222}Rn concentration of his Bq m^{-3} was found inside a house having walls of concrete blocks, dirt floor and no plaster on the walls. Soil ^{222}Rn concentration up to 1500 Bq. m^{-3} was found. No correlation has been observed between atmospheric ^{222}Rn and subsoil structural Zone.

Mahal et al (35) have carried out an extensive study on diurnal variation of Rn concentration in Malaysia and reported that the Rn level is found to be maximum just before sunrise and minimum just before sunset.

Jatinder Kumar et al(36) have measured the ^{222}Rn concentrations in dwellings of radioactive areas in Himachal Pardesh using LR 115 type II Solid State Track detectors and observed that the maximum ^{222}Rn concentration due to the presence of ^{238}U prospects beneath the soil and the average value of ^{222}Rn concentrations in the villages Aghar, Chakmoh, Gallot, Khain and Rachaon were found to be 0.73, 0.66, 1.06, 0.88 and 0.71 KBq. m^{-3} respectively.

Ameer Azam et al (37) made an extensive study of monthly variation of indoor Rn in Aligarh using LR 115 type I Solid State Nuclear Track Detectors and reported that the indoor Rn concentration is maximum during winter and minimum during summer. The reported value of effective dose equivalent varies from 0.40 mSv.y^{-1} with a mean value of 0.80 mSv.y^{-1}

Ramola (31) estimated the annual dose from exposure to ^{222}Rn and its daughters in the indoor and outdoor using LR 115 type II Solid State Nuclear Track Detectors method in Garhwal area in the Himachal region. He reported outdoor Rn daughter exposures as 0.078 mWLy^{-1} and in indoor mud houses 0.54 mWLy^{-1} and 0.43 mWLy^{-1} in cement houses. The annual geometric mean value of ^{222}Rn concentration was 104 Bqm^{-3} in cement houses and 124 Bq. m^{-3} in mud houses.

Selcuk et al (38) have measured the Rn concentration in elazig houses and factorial in Istanbul, Turkey and reported the measured Rn concentrations had a mean value of 47 Bq. m^{-3} and the value of the concentration ranged from 17 to 184 Bq. m^{-3} and reported that the ^{222}Rn concentration decreases as the floor number increases.

Tetsuya Hanada et. al. (39) have carried out the measurement of nationwide indoor ^{222}Rn concentration in Japan and the reported that arithmetic mean, median and geometric mean values for ^{222}Rn concentrations are 15.5, 11.7 and 12.7 Bq. m^{-3} respectively. Vaupotic et. al. (40) attempted a systematic study on indoor ^{222}Rn and gamma radiation level in Slovenian schools

and reported that for ^{222}Rn values of 168 and 82 Bq. m^{-3} for arithmetic mean and 890 Bq. m^{-3} geometric mean respectively. Similarly, they have reported gamma levels to vary from an arithmetic mean of 102 $Gy.h^{-1}$ and geometric mean of 95 $Gy.h^{-1}$.

Rajesh Kumar et al (41) have made an extensive study of the measurement of ^{222}Rn and its daughters in thermal power station using LR 115 type II Solid State nuclear Track Detectors and observed that the indoor ^{222}Rn levels are found to be in the range of 52.2 to 444.8 Bq. m^{-3} with an average ^{222}Rn activity concentration of 228.9 Bq. m^{-3}, resulting into the effective dose equivalent of 8.6 $mSv.y^{-1}$ and reported that the higher ^{222}Rn levels may be attributed due to the power plant areas and the utilization of coal enhancing the alpha activity and also due to the poor ventilation.

Sanam et. al. (42) have means the ^{222}Rn level in Madurai, India, using LR - 115 Solid State Nuclear Track Detectors and reported the value for ^{222}Rn concentration as 5 $Bq.m^{-3}$ concentration and maximum and minimum value as 184 Bpm. The average ^{222}Rn

Concentration in summer is 38.5 $Bq.m^{-3}$ and in winter 69.9 Bqm^{-3} and yearly average is 57.6 $Bq.m^{-3}$. Further the average concentration in winder is higher by a factor of 1.8 as compared to that summer. The yearly average of ^{222}Rn concentration in Madurai is 57.6 $Bq.m^{-3}$ which is comparable with autumn, i.e., 54.6 $Bq.m^{-3}$. He has reported that the higher ^{222}Rn concentration is because of the type of the building materials used for the construction and the temperature variation.

Kheral et. al. (43) have measured the indoor ^{222}Rn concentration in some villages of Chhattisgarh, India by using LR 115 type II Solid State Nuclear Track Detector and obsessed the average level vary from 233 - 335 $Bq.m^{-3}$ and average annual ^{220}Rn level vary from 29.3 to

35.5 $Bq.m^{-3}$. They could not establish the direct correlation between the ^{222}Rn concentration and the gamma level and reported that the reason for the relatively low indoor ^{222}Rn concentration is due to good ventilation and higher indoor concentration is due to the Houses having mud walls and mud flooring.

Neg a al (44) have made an extensive comparative study of ^{222}Rn, ^{220}Rn levels in Garhwal and Kumaun homes of Uttaranchal, India and reported that the concentration of ^{222}Rn and ^{220}Rn vary from 11.3 Bq. m^{-3} – 129.7 $Bq.m^{-3}$ and 1 Bqm^{-3} to 97.7 $Bq.m^{-3}$ respectively in Garwal homes whereas they vary from 6.7 $Bq.m^{-3}$ to 63.5 $Bq.m^{-3}$ and from l $Bq.m^{-3}$ to 156 $Bq.m^{-3}$ respectively in Kumaun homes The levels of ^{222}Rn and ^{220}Rn daughters found to vary from 1.00 mWL to 17.2 m WL and 12 m WL to 210.6 mWL respectively. He has reported that the elevated level is mainly due to the building materials and type of construction of houses

Ameer Azam et al (45) have carried out the measurement of monthly variation of ^{222}Rn and its progeny in Aligarh using LR 115 type II Solid State Nuclear Track Detectors and reported that the value of indoor Rn concentration varies from 28.6 Bq. m^{-3} to 48.6 Bq. m^{-3} with a mean value of 36.2 Bq. m^{-3}. The maximum value of PAEF has been found during winter months and minimum during summer months.

Sreenath Reddy et al (46) have carried out an extensive study of indoor ^{222}Rn and its progeny concentration levels in the surrounding areas of Hyderabad, India, by using LR - 115 Solid State Nuclear Track Detectors and estimated that Rn and progeny levels in different types of dwellings vary from 3 to 47 Bq. m^{-3} and 0.04 to 3.5 mWL with an average of 11 Bq. m^{-3} and 0.9 mWL. And the dose due to ^{222}Rn and its progeny is found to vary from 0.01 to0.20 $\mu Sv.h^{-1}$. They have reported the higher concentrations of ^{222}Rn and its progenies in winter and lower in rainy season, the ratio of concentrations from winter to rainy season is 1.6 and whereas from winter to summer it is 1.3. They have reported the higher concentration of ^{222}Rn and its progenies in winter and lower in rainy season, the ratio of concentration from winter to rainy season is 1.6 and whereas from winter to summer it is 1.3. They have reported the higher concentration of ^{222}Rn and its progeny during winter season, and also in the houses having poor ventilation, mud walls mud flooring and tiled roofs.

Andreja Popit et al (47) have carried out a systematic study of indoor ^{222}Rn concentration in relation to geology in Slovenia and reported the relation between indoor ^{222}Rn concentration, rock type, tectonic faults and age of buildings.

Birk et al (48) have carried out an extensive study on indoor ^{222}Rn / ^{220}Rn concentration in Hamirpur and Una districts of Himachal Pradesh Seasonal variation of $^{222}Rn/^{220}Rn$ concentration were reported in this study and observed maximum concentration during winter and minimum concentration during summer and rainy season. The mean value of ^{222}Rn and ^{220}Rn

concentrations during these seasons are 81.6 Bq m^{-3} and 39.0 Bq. m^{-3}.

Deka et al (49) have measured indoor ^{222}Rn, ^{220}Rn levels in different arcas of Brahmaputra valley of Assam, India and estimated that indoor ^{222}Rn. ^{220}Rn levels varied from
101.1 to 238.5 Bq. m^{-3} respectively and in hilly region of Guwahati and in Namrup region it varies from 132.9 to 197 Bq. m-3 and 5.4 to 2311 Bq. m^{-3} respectively and the reported estimated inhalation dose for hilly region of Guwahati vary from 0.43 to 1.07 μSvh^{-1} whereas for Namrup it varies from 0.54 to 0.79 μSvh^{-1}. They have reported that higher concentration during winter is because of the poor ventilation, use of electronic devices and coal fires. He has also reported that the strongest influence on ^{222}Rn and ^{220}Rn levels is that of ventilation.

Khokhar et al (50) have studied the seasonal variation of ^{222}Rn and ^{220}Rn concentration in dwellings of Bilaspur by using LR 115 Solid State Nuclear Track Detectors and estimated that the ^{222}Rn concentration in the surveyed houses varied between 49.5 to 7.9 Bq. m^{-3} with the overall mean 23.4 Bq. m^{-3} and the ^{220}Rn concentration varied from 103 to 0.62 Bq. m^{-3} with arithmetic mean of 18.5 Bq. m^{-3} and the annual effective dose in different types of houses vary from 3 to 10 $mSvy^{-1}$. They have reported that the indoor ^{222}Rn /^{220}Rn levels is maximum during winter and minimum during summer and the higher concentration of ^{222}Rn, ^{220}Rn in the houses are due 10 higher ^{238}U and ^{232}Th concentration in mud and stones and also reported that the higher concentration of ^{222}Rn, ^{220}Rn in houses because they are all old.

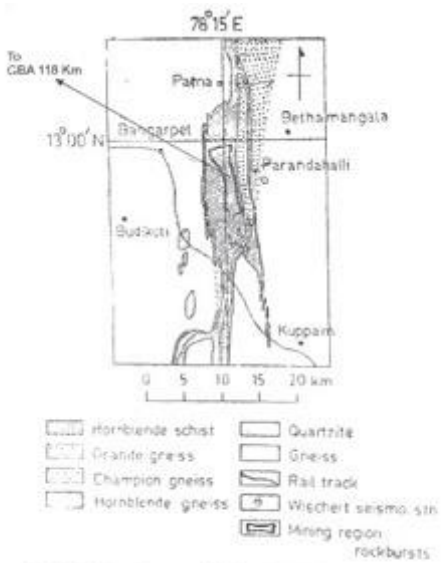
Sreenivas Reddy et al (51) have studied the concentration of indoor radioactivity levels by using LR-115 Solid State Nuclear Track Detectors and reported that the concentration levels of ^{222}Rn and ^{220}Rn vary from 13 to 110 Bq. m^{-3} and 1 to Bq. m^{-3} respectively. The reported average levels of ^{222}Rn and ^{220}Rn are 24 Bq. m^{-3} and 17 Bq. m^{-3} respectively.

Vinay Kumar et al (52) have carried out extensive baseline studies of $^{222}Rn/^{220}Rn$ concentration levels in Nalgonda District by using LR-II5 Solid State Nuclear Track Detectors and reported the ^{222}Rn / ^{220}Rn concentration levels very from 15 to 461 Bq. m^{-3} respectively and the natural background radiation very from 720 to 399 $\mu Gy.y^{-1}$ in the spatial distribution. They have reported that the higher concentrations of ^{220}Rn was due to the presence of relatively higher concentration of ^{232}Th in the granites formation of the area and also due to ventilation condition and the type of the materials used for the construction of the houses.

Study Area Kolar Gold Fields

The area of the present study is the Kolar field, situated at 12^0 57' N and 78^0 16' E in the South-East corner of Karnataka state near Bangalore city in India and lies at an altitude of 900 m above mean sea level. There is an indication that some of the ancient working are more than 1,000 years old. However, the Bharat Gold Mines started in 1880 by M/s. John Taylor & sons. The deepest mining, they have gone up to 3200 meters. In the year 2001 all the mining activities have been stopped. Approximately 49 million tons of ore have been mined, yielding 793 tons of Gold. Around 6000 people were working at the time of closure of mine [5]. There mine were operating and the workings are spread over a strike length of 8 Km. The problems of ground control and rock bursts have been serious in the mines of Kolar Gold Fields [20] & [23].

The problem of ground control and rock bursts associated with hard rock has been bursts have occurred at all depths under different mining conditions. The high strength and brittleness of rock is a main reason for these rock bursts. Whenever rock burst takes place there is an ejection of rock mass from the working site accompanied by explosive noise and followed by a blast. In olden days they mined out the gold and left the void in the underground without hack filling and good support. As virgin rock is mined out the natural stability of rock mass is disturbed then the stress increases beyond the elasticity of rock resulting in the rupture of rocks. This causes rock bursts. However, the problem become more serious as mining reached greater depths. One of the mines has reached a depth of over 3.2 Km (Champion Red). Rock burst have caused large-scale damage to underground working including loss of shafts traveling and haulage roadways pumping and winding installations. Surface buildings have also been Extensive damaged. Fatalities are generally associated with rock burst has been lost forever. Valuable proved ore reserve has been lost forever. However, the problem of rock burst, has been considerable reduced by introduction of better mining by the introduction of better mining methods, based on studies of rock mechanics [21].



A Geological map of Kolar Gold Field region.

Figure shows a geological map of the Kolar Gold Fields region. The host for Gold is Hornblende schist. The mines of K.G.F occupy strike length of approximately 8 Km and trends almost north-south and is nearly parallel to the axis of the schist belt. It is at a distance of about 118 Km from gauribidanur seismic array station (G B A) near Bangalore, where a large number of rock bursts been recorded. The lodes dip towards the west at 400 to 450 near the surface, gradually changing to nearly vertical at depth. The maximum depth to which mining operation in this region is approximately 3.2 Km (10, 500 ft). A map of mining areas of Kolar Gold Fields showing seismogenic features is as shown.

There are three significant geologic faults, viz. Mysore North fault, tenants fault and Giffords fault, all striking NE-SW these faults are nothing but plane of weakness in whose vicinity many rock bursts tend to occur. The extraction of lode is generally done as per standard of metal mining practice. Shafts of depth are usually supported by a brick (or) reinforced, concrete lining and levels are supported by steel rods sets. lagged and packed (20)

Instrumentation for Radon Detection

The basic principles of operation of nuclear radiation detectors are identical. The radiation enters the detector, interacts with the atoms of the detector material loosing part or whole of its energy and releases a large number of relatively low energy electrons from their atomic orbits. The process by which the electrons are released may differ from detector to detector. To discuss the fundamental mechanisms involved in the process of radiation detection, it is convenient to divide radiations into two broad groups, namely, charged particles (a, B- B+, etc.) and neutral radiations (x-rays gamma rays neutrons). While the charged particles release electrons by direct interaction, the neutral radiations do so indirectly. These electrons are then collected and formed into a voltage or current pulse for analysis by electronic circuitry. The method of measurement of radon and their progeny may be based on active technique, which involves the pumping indoor air containing radon and its progeny into or through detecting system or a passive technique where the concentrations are measure under natural conditions by simply exposing the detectors indoors. A no. of techniques are available. Frequently used techniques for radon and its progeny measurements are

1. Collection Technique
2. Solid State Nuclear Track Detector (SSNTD)

Collection Technique is an active technique while, the SSNTD is a passive technique. In the present study SSNTD method is used.

In the present study to determine concentration of radon/thoron and their daughter products solid-state nuclear track detector method is used. This is the most accurate method to determine the concentration of radon / thoron and their daughter products. Solid state nuclear track detectors are thin plastic dielectrics sheets of materials such as cellulose nitrides and poly carbonates. They are sensitive to alpha but not to beta & gamma radiations. Also they are unaffected by humidity, low temperature, moderate heat and light. They are passive detectors and do not require energy to operate as their detecting property is an intrinsic quality of the material they are made of. For indoor measurements, normally the CN films are used as they very specific alpha radiation detectors. The schematic diagram of double dosimeter cup used for monitoring radon, thoron & their progeny is shown in fig. 4.1 and its full view is as shown in plate 4.1. Each chamber has a length of 4.5 cm and radius of 3.1 cm. The SSNTD's used are 12um thick. The SSNTD one placed in compartment measures only radon, which diffuses into it from the ambient air through a semi permeable membrane. These membranes have permeability constants in the range of the 10^{-8} to 10^{-7} cm^{-2} s^{-1} (28, 29) and allow more than 95% of the radon gas to diffuse and suppress thoron gas to less than 1%. The glass fiber filter paper in compartment 2 allow both radon and thoron gas to diffuse in and hence the tracks on SSNTD, are related to the concentration of both the gases. The SSNTD placed on the outer surface of the dosimeter. exposed in the bare mode, registers alpha tracks attributable to the air borne concentrations of both the gasses and their progenies.

The dosimeters are suspended from the mid point of the house at a height of 2 m. from the ground level. At the end of the stipulated period of exposure usually about 100 days the dosimeters are retrieved, and all the three STDs are etched with 10% of NAOH solution for on hour at a bath temperature of about 60 °C. The procedure for the film etching is as follows. A stainless-steel vessel of capacity 3.5 liters is used as the etching bath. The filmstrips are mounted on a circular stainless-steel plate, having provision for holding the film (18 at a time) and kept inside the etching bath. The plate is mounted on a stainless-steel rod. Water isheated up to slightly higher (63°C.) than the required temperature (60°C.) ina temperature-controlled water bath. The etched films arc washed in distilled water dried using a soft tissue paper, which does not adhere to the film. The sensitive film is peeled off from the base material. An experiment with varying etching time shows that 60 to 75 minutes of etching time is the optimum period required for track development. The radon / thoron levels and their progeny working level concentration are calculated by the following relations (28, 29);

$C_r(Bq.\ m^{-3}) = T_m/DS_m$ $C_t(Bq.\ m^{-3}) = T_f\ C_rDS_{rf}/DS_{tf}$

$R_n(m.\ WL) = C_rF_r/3.7$ $R_t(m.\ WL) = C_tF_t/.275$

Where Cr is Radon Concentration (Bq. m^{-3}), Ct is Thoron Concentration (Bq. m^{-3}), Tm is Track density of the film in membrane compartment, T_f is Track density of the film in filter compartment Period of exposure (days), S_m is Sensitivity factor of membrane compartment, S_{rf} is Sensitivity of radon in filter compartment, S_{tf} is Sensitivity of thoron in filter compartment R_n is Radon progeny concentration (m. WL) R_t Thoron progeny concentration (m, WL) F_r is Equilibrium factor for radon progeny and F_t is Equilibrium factor for thoron progeny

The sensitivity factors of the membrane compartment for individual gas WL concentrations measurements are given by (29),

S_m = 0.019+ -0.003 Tem-2 d^{-1} /Bq. m^{-3} for ^{222}Rn gas membrane cup S_{rf} = 0.020+0.004 Tem-2 d^{-1} /Bq. m^{-3} for ^{222}Rn gas in filer cup

S_{tf} = 0.016+-0.005 Tem-2 d^{-1} /Bq. m^{-3} for ^{222}Rn gas in filer cup S_{da} = 0.3+0.058 Tem-2 d^{-1} /Bq. m^{-3} for ^{222}Rn daughters

S_{dt} = 0.3+-0.06 Tem-2 d^{-1} /Bq. m^{-3} for ^{222}Rn daughters

The equilibrium factors for radon and thoron progeny may be expressed as follows :

$F_R = 0.104\ f_{RA} + 0.518\ f_{RB} + 0.37\ f_{RC}$ $F_T = 0.91\ f_{TB} + 0.09 f_{TC}$

Where f_{RA}, f_{RB}, f_{RC} and f_{TC} are activity fraction with respect to parent gas F_R and F_T are the equilibrium factors for radon and thoron progeny respectively, corresponding to the extracted ventilation rate. From the equilibrium factors, working level concentrations are calculated. The inhalation dose due to radon and thoron has been calculated by using conversion coefficient 9 nSv and 32 nSv and equilibrium factor 0.4 and 0.1 for radon and thoron respectively. Finally, an estimation of the inhalation dose may be provided using the formula (2).

$D = \{(0.17 + 9F_R)C_R + (0.11 + 32\ F_T)\ C_T\} \times 7000 \times 10^{-6}\ (mSvy^{-1})$

Results and Discussion

Radon / Thoron and their daughter products were measured during summer season (11/04/2007 to 11/07/2007) in KGF mining area, using solid state Nuclear track detector technique. The results of measurements are given in table 1 and 2. they are classified by the types of construction, Floorings, roofs and ventilation conditions.

Table 1 Average concentration of Radon (^{222}Rn) and its daughter products.

Location	**Concentration of Radon ^{222}Rn (Bq. m^{-3})**	**Concentration of ^{222}Rn Daughters (mWL)**
Shanthinagar, Bangarpet Mosaic Flooring	50	3
Oorgaum, KGF Cement	45	8
Oorgarm, KGF Red Oxide	170	21

Location	Concentration of Radon ^{222}Rn (Bq. m^{-3})	Concentration of ^{222}Rn Daughters (mWL)
Robertson pet, KGF Mosaic	150	9
Championreef, KGF Asbestos	100	6
Championreef, KGF Cement	35	5
Championreef, KGF Granite	65	4
Mean Value	87.85	8

Table 2 Average concentration of Thoron (^{220}Rn) and its daughter products.

Location	Concentration of Thoron ^{220}Rn (Bq. m^{-3})	Concentration of ^{220}Rn Daughters (mWL)
Shanthinagar, Bangarpet Mosaic Flooring	30	5
Oorgaum, KGF Cement	26	7
Oorgarm, KGF Red Oxide	76	12
Robertson pet, KGF Mosaic	65	4
Championreef, KGF Asbestos	43	3
Championreef, KGF Cement	15	9
Championreef, KGF Granite	35	5
Mean Value	40.57	6.4285

Table 3 Average concentration of Radon, Thoron and the equivalent effective dose

Location	Concentration of Thoron ^{220}Rn (Bq. m^{-3})	Concentration of Thoron ^{220}Rn (Bq. m^{-3})	Effective Equivalent Dose ($mSvy^{-1}$)
Shanthinagar, Bangarpet Mosaic Flooring	50	30	2.0146
Oorgaum, KGF Cement	45	26	1.7899
Oorgarm, KGF Red Oxide	170	76	6.2472
Robertson pet, KGF Mosaic	150	65	5.4645
Championreef, KGF Asbestos	100	43	3.5658
Championreef, KGF Cement	35	15	1.2016
Championreef, KGF Granite	65	35	2.5263
Mean Value	87.85	40.57	3.5285

The data from the Table 1 shows that the concentration of Radon in indoor atmosphere ranges from 170 Bq. m^{-3} to 35 Bq. m^{-3} with mean value 87.35 Bq. m^{-3}. The concentration of daughter products varies from 3 mWL to 21 mWL with mean value of 8 mWL. The indoor Radon /Thoron sources are ^{226}Ra, ^{232}Th present in soil beneath ground and building materials. The building materials used are mostly bricks, cement marbles, granites etc.

Higher concentrations of indoor Radon and its daughter products have been observed in KGF Mining Area, The Bedrocks in these areas have high content of radium. Thoron these gases can diffuse into dwellings through the structure of bedrocks along with different layers and cracks Hence we observed high concentration of Radon and Thoron The slightly low concentrations of

Radon and daughter products were obtained in Bangarpet. These buildings are old, and floorings is made up of Mosaic and Red Oxide. The house in Oorgaum have slightly higher concentration compared to Robertson pet and Bangarpet. The houses are actually are newly constructed and floorings are made up of tiles. Tiles may be containing high radon activity.

The table 2 gives the concentration of thoron and its daughter products. The data shows the concentration of thoron in indoor atmosphere ranger from 12 to 76 Bq. m^{-3} with a mean of 40.57 Bq. m^{-3}. The concentration of daughter ranges from 3 to 12 with mean value of 6.248 mWL. The concentration of thoron and the decay products depends on construction of building materials, ventilators and activity of the present in the building materials.

Higher concentration of indoor thoron and the daughter products have been observed in Oorgaum, KGF. This may be due to the concentration of the building and ^{232}Th present in building materials and ventilation rates. The lower concentration of thoron and the daughter products was obtained in Robertson pet and Champion, KGF.

The Table 3 gives Radon / Thoron concentrations and inhalation dose to the population due to these gases in KGF mining area. The inhalation dose due to radon and thoron was calculated by using conversion coefficients 9 nSv and 32 pSv an equilibrium factor 04 and 0.1 for radon and thoron respectively. The occupation factor 7000 hours was used. The inhalation dose is calculated by using the formula

$$D = \{ (0.17 + 9F_R) C_R + (0.11 + 32 F_R) C_T \} \times 7000 \times 10^{-6} \text{ mSvy}^{-1}$$

The inhalation dose due to radon and thoron gases vary from 1.2016 to 6.2472 $mSvy^{-1}$ with an average of 3.5285 $mSvy^{-1}$. The houses need mining area and having granite and tiles Morning show higher values of inhalation dose than other types of houses.

Conclusion

An attempt has been made to measure the concentration of Radon and Thoron and their products in few dwellings of KGF Mining Area. The mean values of Radon and Thoron Concentrations in KGF are 87.85 Bq. m^{-3} and 40.57 Bq. m^{-3} respectively, The Radon Concentrations are higher than Indian average valne (255 Bq. m^{-3}) and higher to the global average value (40 Bq. m^{-3}) The mean value of Thoron Concentration in KGF is higher than the Indian average value (17 Bq. m^{-3}) and world average value (10 Bq. m-3). The Average value of Radon and Thoron and their daughter products depends on concentration of Radon and Thoron Gases. The daughter products are higher than global average value. Radon and Thoron and their daughter products in indoor atmosphere vary with ventilation conditions, types of buildings and materials used for construction. Higher concentration of Radon and Thoron and their daughter products are observed in poorly ventilated houses, houses with granite and tiles floorings.

The dose rates recorded during this study are due to the concentration of natural background radiation and did not show any abnormal rates in the radiation level at any place. The total dose due to Radon and Thoron and their daughter products in KGF is higher than the global average values.

In the present work the measurements of indoor Radon and Thoron and their daughter products concentrations have been carried out only in a few limited dwellings of mining area of KGF. For the point of health risk, this data is not adequate. More number of measurements in different type of houses to cover larger areas in and around KGF should be carried out. The present work provides a base line data for further studies related to the concentration of indoor Radon and Thoron and their daughter products, equilibrium factors, ventilation rates, gamma radiations.

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