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INDOOR RADON (^{222}RN) LEVELS IN COASTAL AND RIFT VALLEY REGIONS OF KENYA

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Abstract

Measurements of indoor radon levels by electret technique in Coastal and Rift Valley Region of Kenya are reported. The results indicate a large variation in the concentrations (5 - 704 Bq m^{-3}) and that remedial action is necessary in some dwellings. The geological formations and the manner in which the houses have been constructed have a bearing on these radon levels. Most of the houses were made of mud bricks. The radon levels (43-704Bq^{-3}) were found higher in Taita and Taveta regions. This is because the house construction procedures in these regions minimize the natural ventilation. This is in contrast with Soi region where temperatures range 24 to 32°C throughout the year and the houses had more natural ventilation with radon concentration levels being less than 100Bqm^{-3}. This was a factor of three lower compared to the levels of ^{222}Rn (mean = 199 Bq^{-3}) in the stone houses at Soi because they were more air tight than the mud houses. The annual effective dose varied from 0.4 to 3.6 mSv y^{-1}.

1. Introduction

There is natural radiation all around us. The major contributors are cosmic radiation and terrestrial radionuclides. Among the terrestrial radionuclides, the radon isotopes are of particular importance because of the proportion of dose that they produce. The average effective dose to adults from natural sources of ionizing radiation is reported as 2.4 mSv (UNSCEAR, 1993) and inhalation of radon isotopes contributes over 50 % of this total dose. These isotopes are produced in the decay of uranium and thorium: ^{222}Rn (radon) from the ^{238}U decay series; ^{219}Rn (actinon) from the ^{235}U decay series; and ^{220}Rn (thoron) from the ^{232}Th decay series. Their half-lives are 3.82days, 4.0 seconds, and 55.6 seconds respectively. Uranium and thorium are present in soils and rocks and as such their isotopes will be detected wherever these minerals are found. The short half-life of ^{219}Rn and the fact that ^{235}U makes up only 0.71 % of natural uranium makes this decay product of little concern compare to the other two.

Early in the last century, it was observed that the incidences of lung cancers among uranium miners were higher than the rest of the public. In the ICRP report (ICRP, 1977) results of the epidemiological studies of not only cancers among uranium miners but also among fluorspar and other non-uranium miners are discussed in detail. In all cases, it is observed that the high incidences of lung cancer are correlated to high levels of radon and its decay products. Nationwide surveys of radon in the human environment have been undertaken in many countries (Cliff et al, 1983; UNSCEAR, 1988; UNSCEAR, 1993). The results obtained vary from country to country due to differences in geological formation as well as climatic conditions. Most countries have set levels above which the national government should take action (Ahmed, 1994) with most adopting a value of 200 Bq m^{-3}. In UNSCEAR report (1993), it is pointed that there is no data on the radon levels in a large part of the African continent. This is probably due to the general assumption that radon is not a serious problem in tropical climates. In addition, the African way of constructing houses in the rural areas is quite different from that of the developed countries.

In most rural African areas, mud bricks are used as wall materials for constructing the houses. This is mainly because they are less expensive to use than stone or concrete blocks. The bricks are made from the available ground materials and if the materials contain ^{226}Ra, then the walls will act as sources of radon. Furthermore, if the floor of the house is bare, as it is in most cases, then with the exception of the roofing material, the door and the windows, the rest of the house will also act as sources of radon. Another important aspect of the house is the level of ventilation; this is governed by the climate of the area. In this paper, we report data on indoor ^{222}Rn concentrations in Taita, Taveta, Olkaria, and Soi regions in Kenya. The first two regions are at the Coast whereas the latter two are in the Rift valley.

2. Experimental Methods

Electret ionization chambers were used to determine the indoor radon concentrations. The scientific and technical basis of the technique is previously described by Kottrappa et al (1988, 1990, 1993). Briefly, the ionization chamber consists of an electret loaded into a chamber. Both the electret and the chamber are made from electrically conducting plastic. The electret holds a charge that provides the necessary electrostatic field; it also acts as a sensor. Radon diffuses into the chamber and the alpha particles that are produced due to its decay and that of its decay products ionise the air in the chamber. The electrostatic field created by the electret allows the negative ions to be collected on the electret, thereby reducing the charge on it. Therefore, a measurement of the decrease in the potential on the electret is a measure of the radon concentration.

For each measurement, the initial voltage (V_i) on the electret was measured followed by its placement in the chamber. The chamber was then placed inside the house in a place where there would be no disturbance and left for a period of two (2) to thirty (30) days. At the end of this period, the final voltage was measured (V_f). The voltage drop on the electret is proportional to the ionization that has taken place over the period that the electret ion chamber was exposed. The radon concentration is calculated as:

$$Radon = \frac{V_i - V_f}{TxCF} - BG$$

where the radon concentration is in Bq m^{-3}, T is the exposure period in days, CF is the calibration factor in V per Bq m^{-3} day , and BG is the radon equivalent of natural γ radiation background.

3. Results and Discussion

Radon

The results (table I) indicate that there is a large variation in the indoor radon concentrations (5 – 704 Bq m^{-3}) This could be due to the geological differences and the manner in which the houses are constructed. Most of the houses in which radon was measured were made of the mud bricks. The radon levels in the mud constructed houses (n = 42) of Soi region were all below the action level of 200 Bq m^{-3} that has been suggested by the IAEA (Ahmed, 1994). On the contrary, over 50 % of similarly built houses (n = 54) in Taita and Taveta regions exceeded this limit and a further 13 houses had values which exceeded the UNSCEAR (1993) recommended action level of 400 Bq m^{-3}. This is because, these regions tend to be very cold in the night and therefore the construction procedure is to minimize natural ventilation. This is in contrast with Soi region where temperatures range from 24 to 32 °C throughout the year, which means that the houses will require as much natural ventilation as possible. Results of radon measurements in the offices ranged from 100 to 573 Bq m^{-3} with an average of 276 Bq m^{-3}. Since this is a fluorospar mining company then this may be the reason why the radon levels in the offices are high since the materials used for building are from the region. Radon measurements were carried out in a small number of stone houses (n = 12), which are built in a similar manner as the offices, and it was observed that the levels were higher by a factor of three when compared to the mud houses. This is because they are more air tight than the mud houses. Although owning a stone house is a measure of affluence in the society, it is evident that it has an associated radiation risk. It is interesting to note that the workers in the fluorospar Company would be the ones capable of owning these houses and therefore would be exposed to high levels of radon both in the offices and at home.

Table I. Mean indoor radon (^{222}Rn) concentrations and the annual effective dose (Range values are in parenthesis)

Region	Sampling Area	Wall Material	Radon Concentration (Bq m^{-3})	Annual Effective dose (mSv y^{-1})
Coast	Taita District	Mud bricks	278 (65 – 704)	3.0[a]
				3.6[b]
	Taveta District	Mud bricks	240 (43 – 618)	2.5
				3.1
Rift Valley	Soi Division	Mud bricks	67 (14 – 161)	0.7
				0.9
		Stone	199 (70 – 312)	2.1
				2.6
	Olkaria	Wooden	60 (49 – 81)	0.6
				0.8
		Concrete	37 (5 – 83)	0.4
				0.5

[a] Indicates an occupancy factor of 0.5.

[b] Indicates an occupancy factor of 0.6 .

Areas having geothermal activity are expected to have high radon levels (UNEP, 1991). However, it was observed that the radon values in this region were low when compared to other two regions. This was probably because the offices had extraction fans to remove hydrogen sulphide gas and this increased air exchange. The wooden houses had floors made of concrete floors, which minimized the radon emanation from the ground. In addition, the houses were built in manner to allow high levels of air exchange. Therefore, as a result of the offices being well ventilated, the workers are not exposed to radon as much as in their houses. This means that there is need to improve the construction of their houses.

4. Annual Effective Dose

In rural Africa, people spend more time outdoors as compared to the developed countries. But the women, due to cultural norms, in addition to going to cultivate the fields they prepare meals for their families. Therefore, they spend more time indoors. In calculating the annual effective dose, occupancy factors of 0.5 and 0.6 have been used for women and men respectively. This is different from the 0.8 that is recommended by UNSCEAR (1993) and ICRP (1993). In addition, the equilibrium factor of 0.4 (ICRP, 1993) has been used The residents of Taita, Taveta and the occupants of stone houses in Soi region are exposed to higher annual effective dose values than the world average of 1.0 mSv y^{-1}, that is the estimate of UNSCEAR (1993). In general women will have a higher risk of indoor radiation exposure.

5. Conclusions

The indoor radon levels in rural areas have been observed to vary from those requiring no action to those which are high enough require remedial action. The nature of constructing houses plays a significant role in either reducing or enhancing the levels. In some regions, the estimated annual effective dose is higher than the ICRP estimate of 1 mSv y^{-1}. Therefore, further studies aimed at designing rural houses that conform to the cultural norms as well as minimize radon exposures should be carried out. This data will be useful to the Kenya Radiation Protection Board in developing national guidelines for radon protection.

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