THE CONTRIBUTION OF RADON TO POPULATION DOSE FROM NATURAL RADIATION IN GHANA

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ABSTRACT

Rock samples in various parts of Ghana have long been known to contain measurable quantities of naturally occurring uranium. This study is primarily to measure the alpha-activity in dwellings due to the radioactive decay of radon, a progeny of natural uranium.

Using the closed can technique, radon levels in residential dwellings, occupational environments, and soils in Southern Ghana have been calculated from the alpha-track density on CR-39 solid state nuclear track detector. Measurements were made during the three year period from 1989 to 1992.

Such data are important because they are essential for the compilation of reliable information on the population dose to natural ionizing radiation in our country.

Keywords
radon, closed can technique, population dose, natural radiation

INTRODUCTION

In developed countries, a lot of public and media attention focuses on the possible effects of man-made sources of ionizing radiation. Although nuclear power stations are not a large exposure risk, their visibility lays them open to public and media scrutiny. In Ghana, there are no nuclear power stations. Exposure to artificial ionizing radiation is due almost entirely to diagnostic radiology. Natural sources of population exposure to radiation include cosmic rays, terrestrial gamma radiation, radioactive nuclides incorporated in the body, and exposure to radon and radon decay products.

Rock samples in various parts of Ghana have long been proved to contain measurable quantities of naturally occurring uranium [1]. This study is primarily to measure the alpha-activity in residential and occupational environments in Ghana due to the radioactive decay of radon, a progeny of natural uranium, in order to initiate the compilation of a database for natural ionizing radiation exposure in Ghana.

There is a wide variety of well established techniques for the measurement of radon and daughters [2, 3, 4, 5]. They can be divided into two broad categories:

- Active methods involving pump, filters and alpha spectroscopy. These methods are particularly useful for short-term measurements of radon daughters and for detailed investigations of individual dwellings.
- Passive methods which make use of a simple plastic foil, based on alpha-track registration. They present unique characteristics for long-term integrating measurements of radon gas for large scale surveys. Passive detectors may be of either the 'open' type or bare detector [6], or the 'closed' type [7, 8]

RADON AS A POTENTIAL HEALTH HAZARD

Radon, (^{222}Rn), is a natural radioactive gas, which has no smell or colour, and decays into other radioactive species, all of which cause human exposure to natural radiation. Radon comes from the minute amounts of uranium present in all earth material such as soils, brick and concrete, and is the decay product of ^{226}Ra in the naturally occurring radioactive series of ^{238}U, (Figure 1). Radon in the soil mixes with air and rises to the surface where it is quickly diluted in the atmosphere. Concentrations in the open air are very low, but radon that enters enclosed spaces, such as houses and mines, can reach high concentrations if its removal or dilution with fresh air is not adequate. The contribution to radon in a building could be due to either radon filtration from the ground or radon exhalation from building materials, or a combination of both sources.

The primary effect of radon is not due to the gas itself as such, since inhaled ^{222}Rn is mostly exhaled, but from the decay of its alpha-active daughters, viz. ^{218}Po and ^{214}Po see Figure 1. These are attached to aerosols which can be lodged in the lungs where inhaled.

High indoor radon gas and daughter (RnD) levels in a home expose the inhabitants to radiation dose that can increase lung cancer risks [9]. Miners exposed to high radon levels have been found to run an increased risk of lung cancer.

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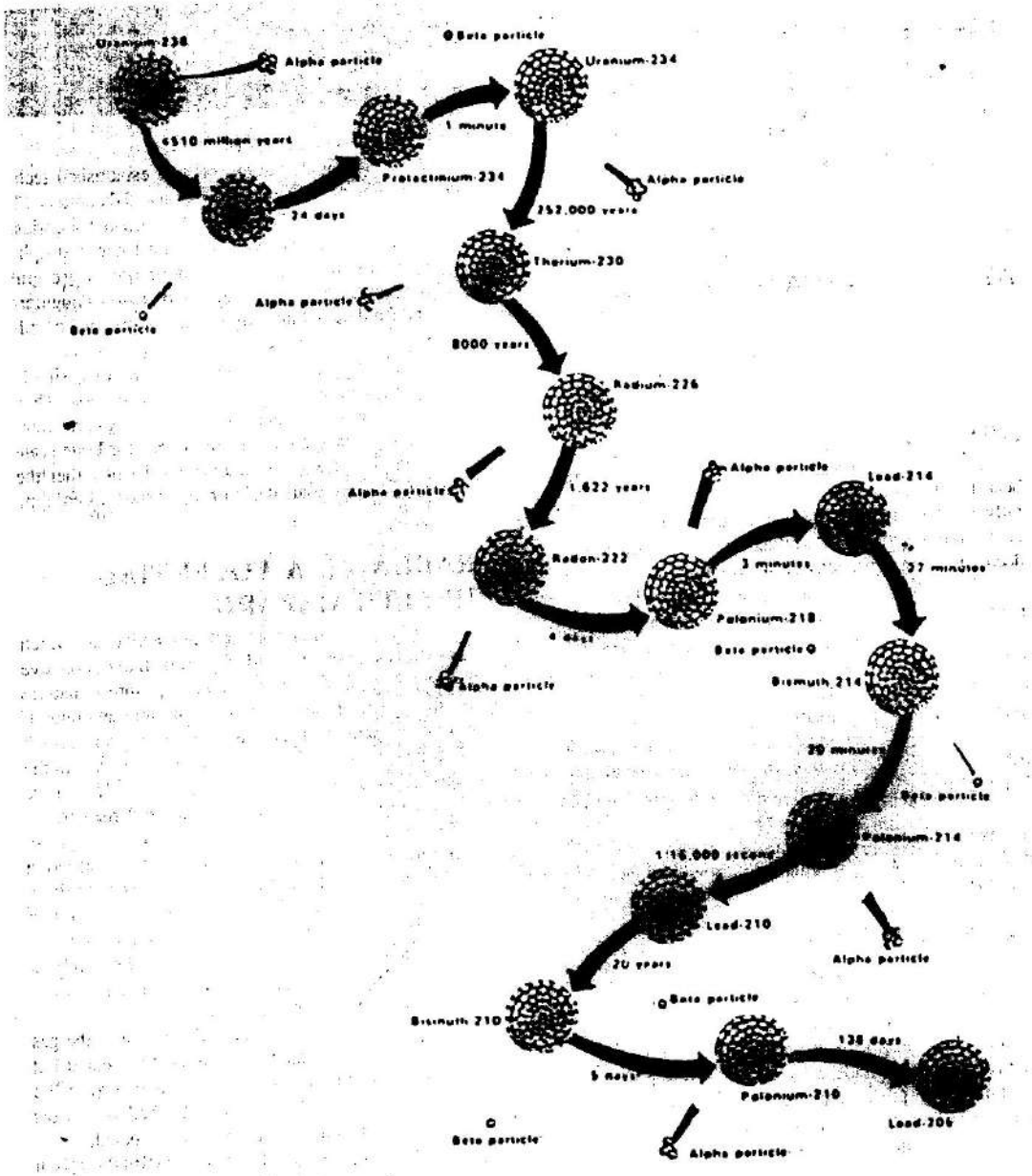


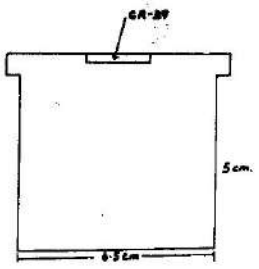
Figure 1. The radioactive decay chain (sersies) of uranium-238. The series begins with uranium-238. It goes through 15 steps and ends as lead-206. Several radionuclides of different elements, including radon, are produced in the series. The half-life and type of ionizing radiation of each change are given. *(Source: N. Ardley, Atoms and Energy. Warwick Press, 1976).*

SOLID STATE NUCLEAR TRACK DETECTION

Heavily ionizing particles (such as alpha particles) deposit energy along their trail when they travel through matter. In organic plastic materials like alkys diglycol carbonate (Columbia Resen-39 or CR-39), this energy loss creates a sub-microscopic cylinder of "damaged" molecules, the so-called latent track. This latent track is invisible. If however, one places the organic material in a suitable etchant (e.g. NaOH solution) the volume around the latent track will be attacked preferentially, so that the trail of the nuclear particle becomes visible under an optical microscope as a cylindrical cone-shaped hole of the order of 1 - 30 μm length, in the case of alpha-particles. The number of the tracks, can be used to deduce various parameters of the ionizing radiation causing the tracks.

INDOOR RADON MEASUREMENTS

For all measurements, the closed can technique was used [8]. CR-39 plastic detector was exposed to radon and radon daughters in trapped air in 5 x 6.5 cm cans with a volume of approximately 150cm^3. A 2 x 2 cm piece of the detector, stuck to filter paper was exposed by inverting the perspex lid of the can so that the sensitive area of the detector faced downward (Fig.1 a, b). The filter paper serves as an intervening barrier or membrane to cut out thoron (^{220}Rn, half life 56s), and ensure that the alpha-tracks registered are due to radon gas (^{222}Rn, half life 3.8 days), and its plateout alpha-emitter daughters, namely polonium-218 (half life 3.1 min) and polonium-214 (half life 1.6 x 10^{-6}s).



2a A 5cm Soft-drink can with CR-39 Detector placed on the topside of the lid of the can-side view for monitoring of indoor radon

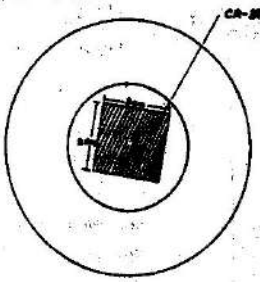


Fig. 2b The Lid used for covering the can with CR-39 attached to a White Filter Paper - Top View

Passive, time-integrated measurements were thus made of the radon which diffuses into the can over the exposure period. The cans were mounted in the following locations in the Ashanti Region:

i. Student rooms and staff homes on the campus of the University of Science and Technology, Kumasi,
ii. Homes and offices in Obuasi, the gold-mining town 50 km south of Kumasi,
iii. In the Kumasi metropolis, and
iv. In Ayeduasi, a suburb of Kumasi, where some of the houses are mud-built, "adobe" houses.

The locations for data collection in the Central Region were:
i. Cape Coast town
ii. The villages of Abandze, Biriwa and Apewosika, where measurements were made in "adobe" houses
iii. In student rooms and a laboratory on the campus of the University of Cape Coast.

IN SITU MEASUREMENTS IN SOILS

The experimental arrangement for in situ measurements of soil radon is illustrated in Figure 3.

CR-39 solid state nuclear track detector was exposed by attaching it to filter paper on the perspex lid of a 5 x 5.6 cm can. The can was placed inside a second, larger, can and suspended inside a PVC pipe and sealed at the other end to keep water out. A wire mesh was placed at the lower end of the PVC pipe to ensure a uniform soil surface and to prevent dirt and water from entering the pipe. The PVC pipe was buried at 95 cm below ground surface, and the CR-39 plastic was thus exposed for 90 days.

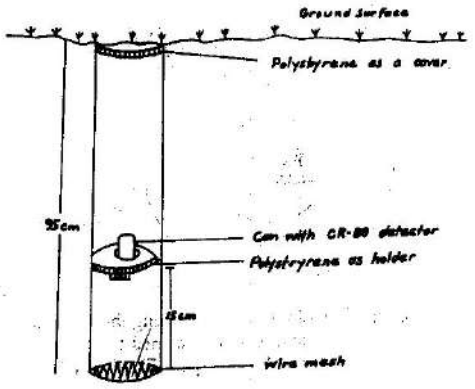


Fig 3 : EXPERIMENTAL SET-UP FOR IN-SITU MEASUREMENT OF RADON IN SOIL BELOW GROUND SURFACE

DATA ANALYSIS

After the required exposure time, all the detectors were chemically etched for 3.5 hours in 6M NaOH at a constant temperature of 70°C. The enlarged alpha-tracks were then counted under 400x magnification, using a simple optical microscope. The alpha-track density on a given plastic was converted to radon dose by using a calibration factor of 123 Bqm^{-3}/track/cm^2, obtained from plastics exposed to a known dose of radon [8].

RESULTS AND DISCUSSION

A photomicrograph of the particle tracks by alpha-particles from the radon gas is shown in Figure 4. This picture shows the typical track density registered during the *in situ* measurements.

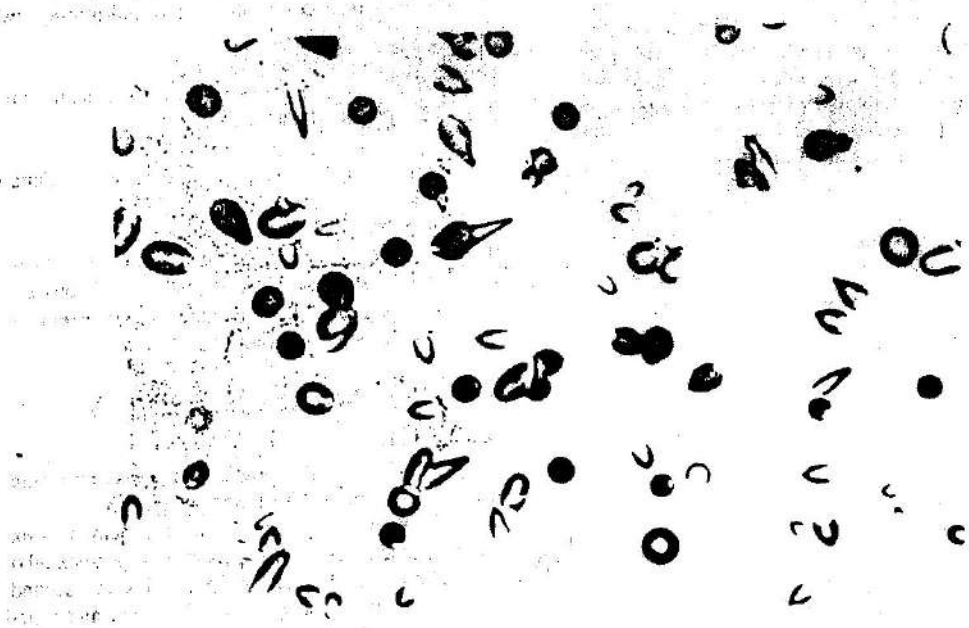


Fig.4 Photomicrograph showing typical track density for the in situ measurements. Weather station, Ashanti Goldfields Corporation premises, Obuasi

TABLE 1 : Indoor radon dose in Kumasi and neighbouring areas, Ashanti Region, Ghana. Exposure time 90 days.

	LOCATION	RADON DOSE (mSv)
1.	A staff bungalow, Univ. of Science & Technology, (UST Kumasi	2.4 ± 0.2
2.	Students' Hall of Residence, UST	2.4 ± 0.3
3.	The Shell Oil Company premises, Kumasi	
	(i) Manager's office (air-conditioned)	4.3 ± 0.4
	(ii) General office (no air-conditioner)	2.8 ± 0.3
	(iii) Workshop (no air-conditioner)	2.5 ± 0.3
4.	Premises of Ashanti Goldfields Corporation, Obuasi	
	(i) A staff member's house	2.2 ± 0.2
	(ii) An office at the ore temperature plant	3.6 ± 0.3
	(iii) An office at a mining shaft	4.5 ± 0.5
5.	Ayeduasi (adobe house)	
	(i) House 1	4.4 ± 0.4
	(ii) House 2	3.9 ± 0.4
	(iii) House 3	4.1 ± 0.4

TABLE 2 : Indoor radon doses in Cape Coast and neighbouring areas, Central Region, Ghana. Exposure time 90 days

	LOCATION	RADON DOSE (mSv)
1.	Cape Coast town	
	(i) House 1 (adobe house)	6.5 ± 0.6
	(ii) House 2	4.3 ± 0.7
2.	University of Cape Coast campus	
	(i) Students' Hall of Residence (old site)	4.8 ± 0.3
	(ii) Science laboratory (new site)	2.4 ± 0.6
3.	Biriwa - (adobe house)	
	(i) House 1	4.7 ± 0.4
	(ii) House 2	4.9 ± 0.5
4.	Abandzi (adobe house)	
	(i) House 1	4.0 ± 0.7
	(ii) House 2	4.9 ± 0.5
5.	Apewosika (adobe house)	
	(i) House 1	4.6 ± 0.4
	(ii) House 2	6.0 ± 0.4

TABLE 3 : Radon levels from in situ measurement in Kumasi and neighbouring areas of Ghana. Exposure time 20 days

	LOCATION	RADON CONCENTRATION ($kBq\ m^{-3}$)
1.	Premises of Ashanti Goldfields Corporation, Obuasi	21.0 ± 1.4
2.	Ayeduasi	
	(i) House 1	17.3 ± 1.3
	(ii) House 2	11.0 ± 0.8
3.	Students' hall of Residence Univ. of Sci. & Tech.	22.0 ± 1.6
4.	A staff bungalow Univ. of Sci. & Tech.	12.6 ± 1.0

In Tables 1 and 2 are listed the indoor radon dose measured in two regions in Southern Ghana - Central, and Ashanti Regions. In all cases, the observed alpha-track density was converted to radon concenration and radon dose, by using the track density from calibrated CR-39 plastics.

The results for indoor radon measurements show a minimum radon dose of 6.5 mSv in Cape Coast town, with an average of 3.3 mSv in the Ashanti Region and 4.7 mSv in the Central Region.

Our results represent the contribution of radon gas to the overall population dose to natural ionizing radiation in Ghana. Subsoil emanation is a key parameter in influencing the indoor radon concentration in an environment. Data from *in situ* measurements taken at the sites of some of the buildings in the survey range from 11 $kBq\ m^{-3}$ to 22$kBq\ m^{-3}$ (Table 3).

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