Asian Journal of Chemistry Vol. 21, No. 10 (2009), S052-055

Measurement of Alpha Radioactivity in Some Building Construction Materials

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Natural radioactivity is wide spread in the earth's environment and it exists in various geological formations in soils, rocks, plants, water and air. The growing worldwide interest in natural radiation exposure has lead to extensive surveys in many countries. The building materials like bricks, concrete, sand, cement etc. are earth based, containing uranium and thorium in varying amounts which are the biggest inescapable sources of natural ionizing radiation for human exposure. In the present investigation, the alpha radioactivity from radon emanated from some building construction materials viz; stones, soil, cement and fly ash has been estimated using alpha sensitive LR-115 type II plastic track detectors. Based upon the data, the mass and the surface exhalation rates of radon emanated from them have also been calculated.

Key Words: Alpha Radioactivity, Radon, Exhalation rates, Building materials.

INTRODUCTION

All organisms like bacteria, plants and animals including humans in this universe are exposed everyday to varying amounts of radiation since the beginning of their existence. The majority of exposure to radiation comes from natural sources which may be terrestrial and extra terrestrial. Extra terrestrial radiation originates in outer space as primary cosmic rays and reaches the atmosphere. Terrestrial radiation is emitted from radioactive nuclides present in trace amounts throughout the earth's crust including soils and rocks which exposes the organisms and hydrosphere. Such types of radiations are also emitted from those nuclides which get transferred to human beings through food chains or by inhalation and get deposited in their tissues. Human population is always exposed to ionizing radiation from natural sources[1]. Natural radioactivity is widespread in the earth's environment and it exists in various geological formations that makes up our planet, in water, oceans and in our building materials. They are even found in us; we ingest and inhale radio nuclides in our air, food and water. Natural radioactivity in soils comes from ^{238}U and ^{232}Th series and natural ^{40}K. Uranium is a naturally occurring radioactive element

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present in trace amounts throughout the earth's crust which gets decayed continuously giving rise to one of its decay products radon as its progeny in the environment. The concentration of radioactive elements in the building materials is most important in the assessment of population exposure to radiations.

The exposure of population to high concentration of alpha radioactivity mainly from radon for a long period leads to pathological effects like the respiratory functional changes and the occurrence of lung cancer[2]. Knowledge of radioactivity present in building materials enables one to assess any possible radiological hazard to mankind by the use of such materials. In the light of the above-mentioned facts, it is therefore, important to assess the radioactivity in common building construction materials. The measured values of radon concentration and radon exhalation rates for building materials are important from radiation protection point of view.

EXPERIMENTAL

For the measurement of radon concentration, we have used canister technique[3]. A known amount (0.10 kg) of stone and soil samples (crushed, filtered through a sieve and oven dried) were placed in plastic cans. LR-115 type-II plastic track detectors were fixed on the bottom of the lid of each can with tape such that sensitive side of the detector faced the specimen. The cans were tightly closed from the top and sealed. The geometrical parameters of the detectors were: LR-115 type- II plastic track detectors (1cm×1cm).

The exposure time of the detectors was 100 days. At the end of the exposure time, the detectors were removed and subjected to a chemical etching process in 2.5N NaOH solution at 60^0C for one and half-hour. The detectors were washed and dried. The tracks produced by the alpha particles, were observed and counted under an optical Olympus microscope at 600X. The measured track density (Track/cm^2/day) was converted into radon concentration in Bq/m^3 using calibration factor[4-5] 0.02 tracks/cm^2/day Bq m^{-3}. The calibration factor used for the present study is for a similar set and the detectors were calibrated through Inter-laboratory calibration exercises carried out by BARC (Bhabha Atomic Research Centre), Mumbai, India at the National level. The equations used for exhalation rates are[6-7].

$$E_x = \frac{CV\lambda/M}{T+1/\lambda(e^{-\lambda T}-1)} \quad (\text{Bq Kg}^{-1}\,\text{h}^{-1}) \text{ for mass exhalation rate} \qquad (1)$$

$$E_x = \frac{CV\lambda/A}{T+1/\lambda(e^{-\lambda T}-1)} \quad (\text{Bq m}^{-2}\,\text{h}^{-1}) \text{ for surface exhalation rate} \qquad (2)$$

Where C = Integrated radon exposure (Bq m^{-3} h^1), M = Mass of sample (Kg),
V = Volume of air in can (m^3), T = Time of exposure (hrs),
λ = Decay constant for radon (h^{-1}), A = Surface area of the sample (m^2).

RESULT AND DISCUSSION

The Radon levels and exhalation rates in some building construction materials varied appreciably as shown in the table. The levels of radon in stone samples varied from 518 Bqm^{-3} to 941 Bqm^{-3} with an average of 731 ± 54Bqm^{-3}.

TABLE

RADON CONCENTRATION AND EXHALATION RATES IN VARIOUS SAMPLES USED AS BUILDING MATERIALS.

Samples	Sample codes	Radon conc. (Bqm^{-3})	Mass exhalation rates ($mBq\ kg^{-1}\ hr^{-1}$)	Surface exhalation rates ($mBqm^{-2}\ hr^{-1}$)
Stone	ST-1	941	34.4	746
	ST-2	691	25.3	548
	ST-3	768	28.0	609
	ST-4	729	26.7	578
	ST-5	518	18.9	411
	ST-6	857	31.3	679
	ST-7	614	22.4	487
AM ± SE*		731 ±54	26.7 ± 2.0	580 ± 43
Soil	S-1	538	19.6	426
	S-2	499	18.2	396
	S-3	614	22.4	487
	S-4	461	16.8	365
	S-5	433	15.8	343
	S-6	354	12.9	281
	S-7	473	17.3	375
	S-8	316	11.5	250
	S-9	1382	49.5	1083
	S-10	1075	37.8	828
	S-11	1190	41.9	984
AM ± SE*		667 ± 111	23.9 ± 3.8	529 ± 88
Cement	C-1	461	16.8	366
	C-2	518	18.9	412
	C-3	538	19.6	427
	C-4	442	16.1	351
	C-5	403	14.7	320
	C-6	480	17.5	381
AM ± SE*		474 ± 19	17.3 ± 0.7	376 ±15
Fly Ash	FH-1	729	27.6	609
	FH-2	845	31.3	685
	FH-3	614	22.0	481
	FH-4	1421	68.4	1197
	FH-5	1036	38.8	849
	FH-6	1190	43.2	946
AM ± SE*		973 ± 114	38.5 ± 6.2	795 ± 98

- SE (standard error), AM(arithmetic mean)

The levels are found to be higher in some black coloured granite and slate stones (ST-1, ST-6) as compared to other stones. In similar studies chauhan and chakarvarti, 2002[8], reported some higher levels of radon emanated from these stones. The levels of radon in soil samples varied from 316 Bqm^{-3} to 1382Bqm^{-3} with an average of 667 ± 111 Bqm^{-3}. The levels of radon in some soil samples collected from the vicinity of shivalik range of hills (S-9, S-10, S-11) are found to be higher compared with other soil samples collected from northern Haryana. In similar studies[9] the average radon levels in Indian soil samples have been reported as 515.6 Bqm^{-3}.

The levels of radon in some cement samples varied from 403 Bq m^{-3} to 538Bqm^{-3} with an average of 474 ± 19 Bqm^{-3}, while the levels of radon in some fly ash samples varied from 614 Bqm^{-3} to 1421 Bqm^{-3} with an average of 973 ± 114 Bq m^{-3}. In similar studies the average levels in cement samples have been reported[10] to be 905 Bqm^{-3} and in fly ash samples the average levels reported[11] are 1214 Bqm^{-3}. The levels in fly-ash are higher compared with other building materials. It is due to that fly-ash obtained from coal burning contains concentrated amount of radionuclides[12]. From the present investigations we can conclude that some building materials may enhance levels of alpha radioactivity indoors due to emanation of radon and its progeny.

ACKNOWLEDGMENTS

The authors are thankful to Chairman Department of Physics and Director National Institute of Technology, Kurukshetra for providing necessary facilities.

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