NATURAL RADIONUCLIDE CONCENTRATIONS OF CEMENTS IN IZMIR AND DOSE ASSESSMENTS

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ABSTRACT

The growing demand of electric power and the large domestic deposites of lignite coal have made coal-fired plants grow in number in Aegean Region of Turkey. Some of this coals like Yatağan lignites are known to have high uranium concentration (315-405Bq/kg for coal, 746-1076Bq/kg for collected fly ash). The stockpiles of fly ash of these power plants are readily available for industrial uses as in the case of cement production. Therefore to assess the doses arising from building materials especially from cement in the cities of Aegean Region a project has been started beginning from Izmir.

The traces of radium, potassium and thorium in 45 cement samples which are collected from building constructions in Izmir have been analysed by gamma spectrometry. The mean concentrations of Ra-226, Th-232 and K-40 were determined. The indoor radionuclide doses were calculated using the mean concentrations found in the measurements of this work. The results were compared with those given for other countries.

INTRODUCTION

In Turkey as well as many other countries one can observe increasing interest in industrial and extractive wastes as substitutes for natural products in building industry. They usually have higher content of naturally occuring radioactivity than traditionally applied raws.

Knowledge of the radioactivity levels of materials used in the building construction is useful in the assessment of indoor radiation exposure of the population. This is also useful for the development of standarts and guidelines for the use and management of these materials for building low background laboratories.

EXPERIMENTAL

The materials were obtained randomly from local building material suppliers and manufacturers. Different brand names were sought. All samples were oven-dried at 105° C for 16h. and then sealed in 100g. portions in cylindrical polyethylene boxes. They were kept for 1 month to attain radioactive equilibrium between radium and radon for high energy γ-spectrometric analysis. The natural radioactivity of the building materials was determined from their Ra-226, Th-232 and K-40 contents. The eU, eTh and % K contents were determined from 1.76MeV Bi-214, 2.62MeV Tl-208 and 1.46MeV K-40 lines, respectively, with a method given elsewhere (Killeen, 1979). The sample and the standard γ-spectra were taken for 4000s. with the spectrometer consisting of NaI(Tl) crystal, 4096 channel Ortec .7010 analyzer and related electronic components.

The activity concentrations of the radionuclide in the samples were given by (Chung-Keung Man et al. ,1989)

$$A_i = [(C(E_i) - B(E_i)) / (m f t P(E_i))] \qquad (1)$$

A_i : is the activity concentration of radionuclide i.
$C(E_i)$: is the net γ -counts above continum at the characteristic energy E_i
$B(E_i)$: is the background counts at E_i
m : is the mass of sample in kg.
f : is the branching ratio of the γ -emission at the energy considered.
$P(E_i)$: is the absolute efficiency at energy E_i

To compare specific activities of these materials a common index is required to obtain the total activity. This index called radium equivalent activity (Ra_{eq}) is based on the fact that 0.37Bq/g of Ra-226, 0.26Bq/g of Th-232 or 4.8Bq/g of K-40 produce the gamma dose rate (M.R. Menon et al. 1987).

$$Ra_{eq} = A_{Ra} + (A_{Th} \times 1.43) + (A_K \times 0.077) \qquad (2)$$

where A_{Ra}, A_{Th}, A_K are activities of Ra-226, Th-232, K-40 respectively in Bq/g. A criterion formula corresponding to a maximum of 0.37 Bq/g is

$$H = A_K / 4810 + A_{Ra} / 370 + A_{Th} / 259 < 1 \ (\text{A in Bq/kg}) \qquad (3)$$

If the value of H is less than 1, the result signifies that the radiation hazard is about the same as that existing in a cave in the ground. The dose rate D, within a building is estimated from the emperical relation

$$D(\text{mrem/year}) = 1.16C_K + 11.45C_{Ra} + 17.8\, C_{Th} \qquad (4)$$

where C is concentration in pci/g (K. Mamont-Ciesla et al. ,1983)

RESULTS AND DISCUSSION

The natural radioactivity in a variety of cement samples has been measured by gamma ray spectrometry . The concentrations of Th-232, Ra-226 and K-40 measured in a selection of cement samples available in İzmir are listed in table-1. The natural radioactivity of cement samples varies considerably depending on their origion. In the last columns radium equivalent concentration and dose rate are given. It can be seen that the Ra-equivalent and H values of samples measured in cement samples are lower than the limits given by Eq.2-3. The gonods, the active bone marrow, and the bone surface cells are considered by the UNSCEAR as the organs of interest. For this reason, many dosimetry models can be found in the literature for these organs. The maximum permissible gonadal dose from gama radiation due to the radioactivity in building materials amounts to 112 mrem/year. For comporison, the dose from the terrestrial radiation in İzmir (Turkey) varies from 34.41 to 89.73 mrem/year. These values can be compared with similar measurements performed by researchers other countries, they are also listed in Table 2.

Table 1. Natural Activity Concentration in Bq/kg of Cement Samples in İzmir

Sample	***eU (Ra-226)***	***eTh (Th-232)***	***%K***	***Ra_{eq}***	***$C_K/4810$ + $C_{Ra}/370$ + $C_{Th}/259$***	***Estimated gonadal dose mrem/year***
tc*	108.0	39.7	363.5	192	0.51	61.9
pc*	83.7	23.8	270.1	138	0.37	45.7
ppc*	128.2	16.9	198.9	175	0.51	56.3
wpc*	97.7	21.3	130.3	138	0.37	44.5

*tc: tras cement, pc: portland cement, ppc: portland cement with fly ash, wpc: white portland cement

Table 2. Activity Concentration in Bq/kg of Cement Samples from İzmir and Other Countries

Countries	***K-40 (Bq/kg)***	***Ra-226 (Bq/kg)***	***Th-232 (Bq/kg)***
Norway	241.7	30.0	18.5
U.K.	155.0	22.0	18.0
USSR	148.1	25.9	14.8
Germany	222.0	25.9	22.2
USA	126.0	----	14.8
Finland	241.0	44.4	26.0
India	114.2	86.0	25.6
İzmir (Turkey)	241.0	104.4	25.4

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