^{226}Ra, ^{232}Th and ^{40}K concentrations in Brazilian wall paints

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Abstract. Geological materials used as building materials act as a source of radiation due to primordial radionuclides as the single radioactive isotope of potassium ^{40}K and radioisotopes from the uranium ^{238}U and ^{232}Th series. Wall paints are one of the building materials to be considered for dose rates evaluation, as, beside other components, contain pigments, mainly titanium dioxide. As titanium dioxide is obtained from minerals as rutile and ilmenite, with thorium and uranium traces, the activity concentration of natural radionuclides in wall paints should be determined, for further annual effective dose assessment in a construction. In this work, activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K were determined by high-resolution gamma-ray spectrometry in 50 commercial brazilian white latex wall paints samples. The activity concentration values for ^{226}Ra ranged from 1.41 Bq.kg^{-1} to 38.7 Bq.kg^{-1}, for ^{232}Th from 0.9 Bq.kg^{-1} to 101.2 Bq.kg^{-1} and for ^{40}K from 5.9 Bq.kg^{-1} to 256 Bq.kg^{-1}. The results show that the activity concentrations of the wall paints studied in this work are in a safe range for use for all the 50 samples.

INTRODUCTION

Naturally occurring radionuclides with half-lives of the same order that the age of the earth, like ^{40}K and the radionuclides from the ^{238}U and ^{232}Th series, are the major source of exposure for mankind [1,2]. Buildings and houses are very important in human life, cause quite a lot of the lifetime is spent at home and/or office. Virtually, every building material contains the natural radionuclides ^{226}Ra, ^{232}Th and ^{40}K. Knowledge of the levels of natural radioactivity in building materials is important for the assessment of population exposure to natural radioactivity, since most passes 80% of your life in the residences.

Several studies over the world have been conducted to evaluate natural radioactivity in building materials such as rocks, granites, marbles, sand, etc. [3-7], however, to date, there are no studies concerning the natural radioactivity that eventually the wall paints used internal or externally in buildings and houses used could contain.

The basic raw materials for the production of almost all kinds of paints are made up of resins, pigments, solvents and additives. The pigments give the paint color, solvents make it easier to apply resins help it dry and additives serve as everything from fillers to antifungicidal agents. The basic pigment is titanium dioxide, providing the whiteness and opacity of paints. Titanium dioxide is a simple inorganic compound, processed from ilmenite minerals, representing 92% of the world demand of titanium minerals [8]. As monazite, the main ilmenite radioactive contaminant [9], contains 1 to 20% thorium dioxide and also some uranium traces, it is easy to assume that wall paints, as other construction materials, could contain natural radioactivity [10].

Several studies have been conducted to evaluate the occupational exposure of titanium production industry workers [11-13], but the natural radioactivity effect to the humans from the wall paints used in the buildings and houses.

The use of titanium dioxide in Brazil is divided by 85.5% for paints, 8.6% for steel industry, 6.4% for iron alloys, 1.6% for electrodes and 0.8% for floors and tiles [14].

Brazil is one of the world top five markets for coatings, manufacturing paints in a variety of applications. There are hundreds of large, medium and small manufacturers spread throughout the country. The top ten manufacturers account for 75% of total sales [15].

EXPERIMENTAL

Fifty different brands of tin can wall paints, from different manufacturers, were acquired from a donation made by the Brazilian Coatings Manufacturers Association (ABRAFATI) and National Service for Industrial Training (SENAI). Each sample was tightly sealed in a 100-mL HDPE flat-bottom cylindrical flask with screw cap and bubble spigot and stored for approximately 4 weeks, in order to ensure radioactive secular equilibrium [16].

All samples were measured during 150000 seconds with a coaxial extended range high-purity germanium detector (HPGe) of 25% relative efficiency, with conventional electronics and an EG&G ORTEC Spectrum Master 919 4-k multichannel analyzer. The spectra were analyzed with the WinnerGamma software [17]. The background radiation was determined by measuring an ultra-pure water sample and the detector efficiency curve was determined with a multi-element standard aqueous radioactive solution sample, both in the same geometry of the samples.

The activity concentration of ^{40}K was calculated by its single gamma transition of 1461 keV. The activity concentration of ^{226}Ra was determined by the weighted mean of the ^{214}Pb and ^{214}Bi gamma transitions activity concentrations and the activity concentration of ^{232}Th by the weighted mean of the ^{212}Pb, ^{212}Bi and ^{228}Ac gamma-ray transitions activity concentrations [16]. All activities concentrations were determined with self-attenuation corrections [18], as The aparent densities of the studied samples varied from 0.97 ± 0.03 g.cm^{-3} to 1.46 ± 0.04 g.cm^{-3}.

RESULTS AND DISCUSSION

Activity concentration values for all natural radionuclides considered are shown in Fig. 1 for each wall paint sample.

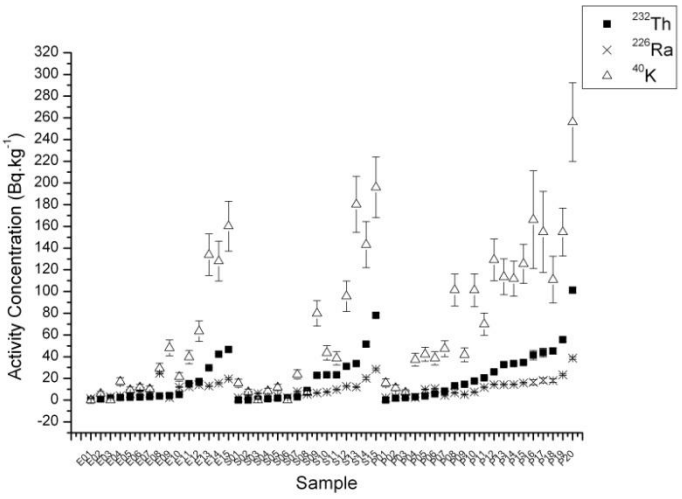

Fig. 1: Natural radionuclides activity concentration values, assessed for 50 different samples of wall paints. The wall paints are labelled as E for Economic quality, S for Standard quality and P for Premium quality.

Activity concentrations of ^{232}Th are, generally, higher than activity concentrations of ^{226}Ra to the samples, this is expected because of the origin of the material as ilmenite and rutile.

Correlation between ^{232}Th and ^{226}Ra in the samples are shown in Fig. 2 for each wall paint sample.

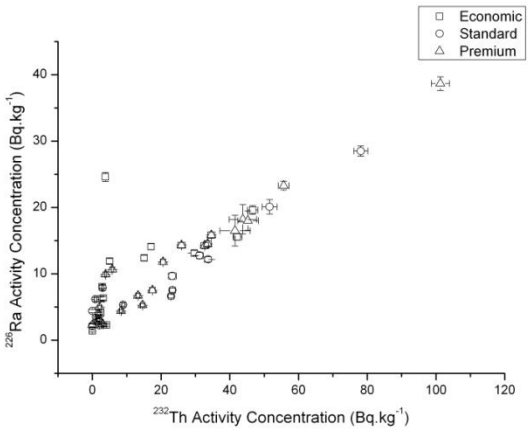

Fig. 2: Correlation between ^{232}Th and ^{226}Ra activity concentrations for all samples.

The sample E08 (the outlier point at Fig. 2) shows a different behavior from all the others samples, sugesting that this sample has other component as well as titanium dioxide influencing in its ^{226}Ra activity concentration.

CONCLUSIONS

Activities concentrations of ^{226}Ra, ^{232}Th and ^{40}K in 50 samples of wall paints show that, as expected, for the majority of samples, the thorium content is higher, since the titanium dioxide is produced from ilmenite and were found to be normal. The authors find that these results are exclusives and since this kind of data were not found in the literature by the authors, they can not be contrasted.

All samples presented values considered safe for use in constructions. The maximum activity concentration for ^{226}Ra, ^{232}Th and ^{40}K are, respectivily, 38.7 ± 1.0 Bq.kg^{-1}, 101.2 ± 2.6 Bq.kg^{-1} and $26\times10^{1} \pm 4\times10^{1}$ Bq.kg^{-1}, all from sample P20.

No correlation between the activity concentration and the wall paint type (Economic, Standard or Premium) was observed.

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