Assessment of radioactivity level in granite stones sold to ornamental and building purposes in Brazilian Amazon region (Belém, Pará): a cross sectional study

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Abstract: The aim of this work was evaluate the level of radioactivity in granite sold in the region of Belém (Pará, Brazil) using a Geiger-Müller detector. The results showed that only 5 from 57 samples of 35 types of granite evaluated had count rates above that measured in the Background. However, the counting statistics suggests that the measured radiation values in these 5 samples are not due random fluctuations inherent in such measures.

Keywords: granite; radiation; building material; Geiger-Muller.

1. INTRODUCTION

In Brazil, granite is one of the materials most frequently used in the ornamentation of buildings` structure [1,2]. But depending on its geological origin, granite may be associated to elements with high levels of radioactivity, as ^{238}U, ^{232}Th and ^{40}K, the leading isotopes associated with this material [3]. This might explain the high prevalence of cancer found in some regions of the State of Pará where high levels of radiation were found at homes ornamented with granite [4,5]. Thus, a strict control of the levels of radioactivity associated with the granite sold for ornamental purposes in the Amazon region is necessary.

In this context, the aim of this work was to evaluate the level of radioactivity in granite samples obtained as available in the local market of the city of Belém, Pará, the most populated city in the Brazilian Amazon.

2. METHODS

Samples of 35 types of granite used in home decoration were obtained. Samples were acquired on 10 granite stores in the city of Belém. Samples were in the form of polished plates without resin, measuring 10 x 10 cm. Measurements of radioactivity levels in these samples were performed using a portable Geiger-Muller Detector (MIR 7028 model, MRA, São Paulo, Brazil) with a pancake-coupled probe. The equipment was calibrated by the manufacturer using the Known Radiation Field method and sources of Cs-137, Am-241, C-14, Pm-147, Cl-36 and Sr-90 + Y-90. All measurements were performed at UNAMA`s Radiology Laboratory. This work was approved by UNAMA`s Ethics Committee (CAAE: 17826113.4.0000.5173).

The significance of the radioactivity measured in the granite samples was evaluated by a simple analysis based on the Poisson distribution: counting statistics. Radioactive decay is a random event registered in counts per minute. If this event is measured only once, as it was in this work, the best estimate of the value of this event (in counts per minute) is :

$$n \pm \sqrt{n} \qquad (1)$$

being **n** the amount of counts per minute and $\sqrt{n}$ the standard deviation (s.d.) of this value. Thus, the best estimate of the rate of counts per minute is:

$$\frac{n}{t} \pm \frac{\sqrt{n}}{t} \qquad (2)$$

being **t** = 1 minute. On the other hand, being **nt** the total count of radioactive decay events in a minute, the **nt** value contains both the **nf** value (decay events counts occurring in the radioactive source under study) and the **nb** value (decay event counts due the Background):

$$n_t = n_f + n_b \qquad (3)$$

Thus, in terms of counts per minute rate, we have:

$$\left(\frac{n_t}{t}\right) = \left(\frac{n_f}{t}\right) + \left(\frac{n_b}{t}\right) \qquad (4)$$

Accordingly, the rate of counts per minute due only to the source being studied is:

$$\left(\frac{n_t}{t}\right) = \left(\frac{n_f}{t}\right) - \left(\frac{n_b}{t}\right) \qquad (5)$$

And, to calculate the level of accuracy of the rate of counts per minute due only the source under study, we used the error propagation rule, using the following notation:

$$\sqrt{\left(\frac{n_f}{t}\right)^2} = \sqrt{\left(\frac{n_t}{t}\right)^2 + \left(\frac{n_b}{t}\right)^2} \qquad (6)$$

Thus, it was possible to assess whether the negative standard deviation of the rate of counts per minute due only to the source under study was equal, smaller or greater than the value of the rate of counts per minute due only to the Background.

3. RESULTS

Figure 1 shows the levels of radioactivity for each granite sample compared to Background radioactivity levels (Background, 76.4 c.p.m.). Radioactivity measurements revealed that 5 from the 57 granite samples analyzed (Marfim, Preto, Laranjeira, Amêndoa and Ceará) showed radioactivity levels above the Background levels. Table 1 shows the radioactivity values measured in all samples (see Appendix).

4. DISCUSSION

Radioactivity levels found for most of the 57 samples of granite rocks used in this study were within acceptable levels, i.e. below the Background level. However, this is not always the case. For example, while in the city of Gramado (Brazilian south), low levels of radiation were found in samples of 3 granite types (Crema Bordeaux, Mombassa and Golden) [2], levels of radiation higher than the recommended as acceptable by the National Nuclear Energy Commission (1mSv / y) were found in 1 from 5 granite samples (Red Rose, Rosa Imperial, Marrom Imperial, Relic and Quinágua) in Recife (Brazilian northeast) [1]. The results of the present study also revealed that only 5 from 57 samples analyzed granites (Marfim, Preto, Laranjeira, Amêndoa and Ceará) had radiation levels above that in the Background.

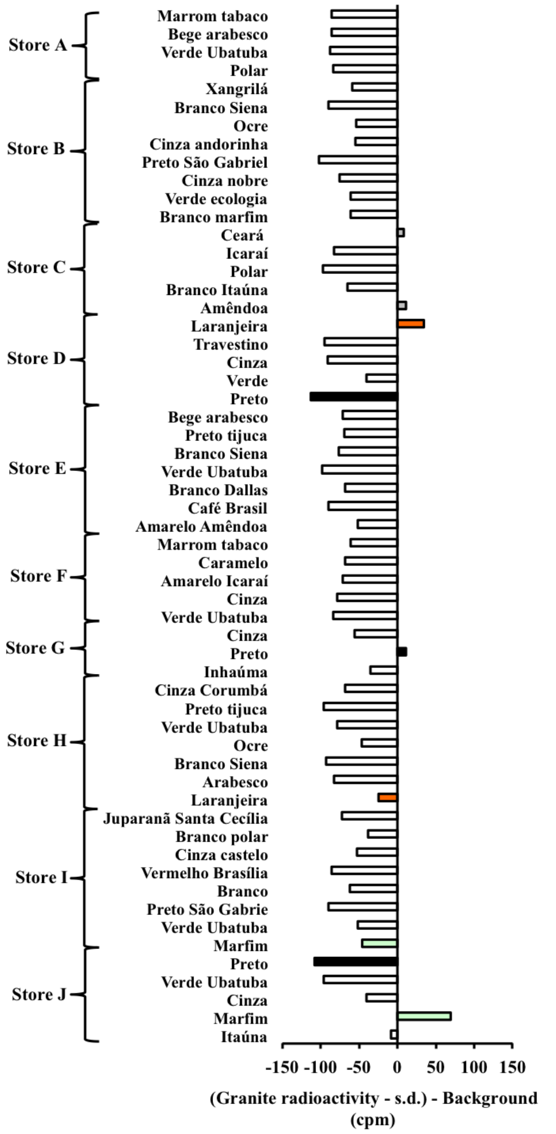

Figure 1. Levels of radioactivity in each 57 samples obtained at 10 granite stores (A-J).

We were not able to find studies in the literature that had measured radioactivity in granite samples of the same types we used in this work. This impeded comparisons between radioactivity levels of samples from different sources and regions. However, figure 1 compares the radiation levels of the samples of granite Marfim, Preto, and Laranjeira, obtained in different granite stores (Marfim: stores I and J; Preto: stores D, G and J; Laranjeira: stores D and H). This comparison shows that the high levels of radioactivity found were characteristic of the samples.

Due to limitations of the detector we were not able to distinguish the type of radiation involved in the detected radioactivity. However, the limitations of the detector used in this study do not turns invalid the results obtained. Therefore, the need of new studies with this focus becomes clear.

5. CONCLUSIONS

We concluded that, although most granite samples presented radioactivity levels below that due the Background, the finding of some samples presenting radioactivity levels above that due the Background indicates that a better control of granite market is needed in the Amazon region.

6. REFERENCES

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7. APPENDIX

Table 1. Types of granite obtained per store and the respective measured radioactivity for each sample.

Store	Granite	Total radiation* (cpm)	Granite radiation** (cpm)	Radioactivity > Background***(cpm)
	Polar	81.4	5 ± 12.56	-83.96
A	Verde Ubatuba	77.9	1.5 ± 12.42	-87.32
	Bege arabesco	79.4	3 ± 12.48	-85.88
	Marrom tabaco	79.4	3 ± 12.48	-85.88
	Branco marfim	105	28.6 ± 13.47	-61.27
	Verde ecologia	105	28.6 ± 13.47	-61.27
	Cinza nobre	90	13.6 ± 12.90	-75.70
B	Preto S. Gabriel	62.8	-13.6 ± 11.80	-101.80
	Cinza andorinha	112	35.6 ± 13.73	-54.53
	Ocre	113	36.6 ± 13.76	-53.56
	Branco Siena	75	-1.4 ± 12.30	-90.10
	Xangrilá	108	31.6 ± 13.58	-58.38
	Amêndoa	**180**	**103.6 ± 16.01**	**11.19**
	Branco Itaúna	101	24.6 ± 13.32	-65.12
C	Polar	68.3	-8.1 ± 12.03	-96.53
	Icaraí	82.5	6.1 ± 12.61	-82.91
	Ceará	**177**	**100.6 ± 15.92**	**8.28**
	Preto	51.3	-25.1 ± 11.30	-112.80
	Verde	127	50.6 ± 14.26	-40.06
D	Cinza	74.5	-1.9 ± 12.28	-90.58
	Travestino	70	-6.4 ± 12.10	-94.90
	Laranjeira	**204**	**127.6 ± 16.75**	**34.45**
	Amarelo amêndoa	115	38.6 ± 13.83	-51.63
	Café Brasil	75.1	-1.3 ± 12.31	-90.01
	Branco Dallas	98	21.6 ± 13.21	-68.01
E	Verde Ubatuba	66.5	-9.9 ± 11.95	-98.25
	Branco Siena	89.7	13.3 ± 12.89	-75.99
	Preto tijuca	96.7	20.3 ± 13.16	-69.26
	Bege arabesco	95	18.6 ± 13.09	-70.89
	Verde Ubatuba	82	5.6 ± 12.59	-83.39
	Cinza	87.1	10.7 ± 12.79	-78.49
F	Amarelo Icaraí	94.4	18 ± 13.07	-71.47
	Caramelo	97.9	21.5 ± 13.20	-68.10
	Marrom tabaco	105	28.6 ± 13.47	-61.27
	Inhaúma	132	55.6 ± 14.44	-35.24
G	**Preto**	**180**	**103.6 ± 16.01**	**11.19**
	Cinza	111	34.6 ± 13.69	-55.49
	Laranjeira	143	66.6 ± 14.81	-24.61
	Arabesco	82.6	6.2 ± 12.61	-82.81
	Branco Siena	72.5	-3.9 ± 12.20	-92.50
H	Ocre	120	43.6 ± 14.01	-46.81
	Verde Ubatuba	86.7	10.3 ± 12.77	-78.87
	Preto tijuca	69.1	-7.3 ± 12.06	-95.76
	Cinza Corumbá	97.5	21.1 ± 13.19	-68.49
	Marfim	121	44.6 ± 14.05	-45.85
	Verde Ubatuba	115	38.6 ± 13.83	-51.63
	Preto S. Gabriel	75	-1.4 ± 12.30	-90.10
I	Branco	104	27.6 ± 13.43	-62.23
	Vermelho Brasília	80	3.6 ± 12.51	-85.31
	Cinza castelo	114	37.6 ± 13.80	-52.60
	Branco polar	129	52.6 ± 14.33	-38.13
	Juparanã S.Cecília	93.7	17.3 ± 13.04	-72.14
	Itaúna	160	83.6 ± 15.38	-8.18
	Marfim	**240**	**163.6 ± 17.79**	**69.41**
J	Cinza	127	50.6 ± 14.26	-40.06
	Verde Ubatuba	69	-7.4 ± 12.06	-95.86
	Preto	56.4	-20 ± 11.52	-107.92

*(granite radiation + Background); **(total radiation – Background) ± s.d.; ***((Granite radiation - s.d.) – Background); s.d., standard deviation; cpm, counts per minute. Background radioactivity: 76.4 cpm.