

# NATURAL RADIONUCLIDES CONTENT AND RADON EXHALATION RATE FROM BRAZILIAN PHOSPHOGYPSUM PILES



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M.B. Nisti, M.P Campos and B.P. Mazzilli  
Instituto de Pesquisas Energéticas e Nucleares

Av. Prof. Lineu Prestes, 2242 – Cidade Universitária, CEP: 05508-000, São Paulo – SP, Brasil  
mpcampos@ipen.br

## INTRODUCTION

Phosphogypsum, a waste of the fertilizer industry, can be classified as TENORM. The Brazilian production of phosphogypsum reaches 5.5 million tons per year and the major generating industries are located in Cajati and Cubatão, State of Sao Paulo and in Uberaba, State of Minas Gerais. Currently, most of the phosphogypsum produced is stored in outdoor piles, which requires environmental and radiological monitoring. In this study it were evaluated the natural radionuclides content and the radon exhalation rate from phosphogypsum piles from Ultrafértil and Fosfertil fertilizer industries.



Phosphogypsum pile - Uberaba/MG



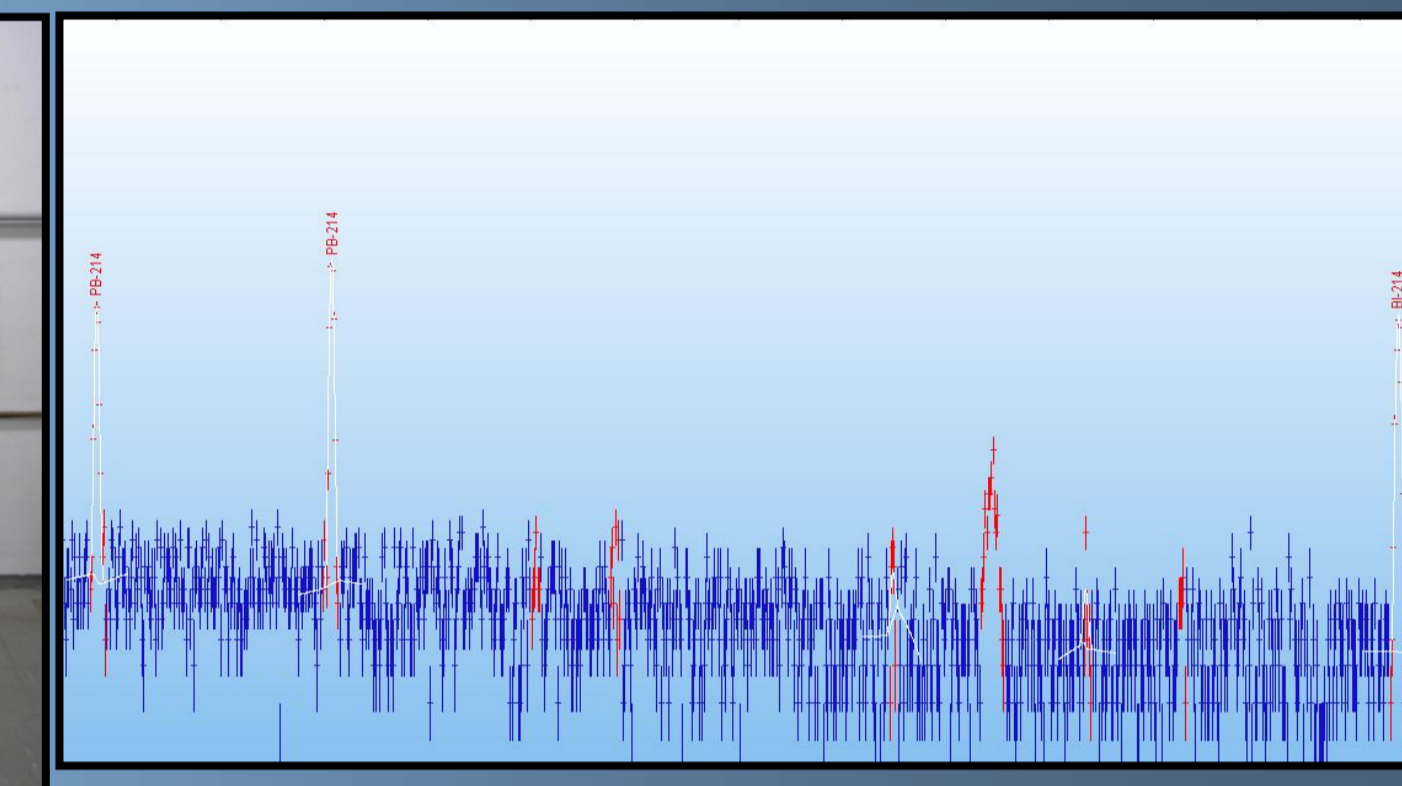
Phosphogypsum pile - Cubatão/SP

## METHODOLOGY

- ✓ Phosphogypsum was measured by gamma-ray spectrometry for their  $^{226}\text{Ra}$ ,  $^{228}\text{Ra}$ ,  $^{228}\text{Th}$ ,  $^{40}\text{K}$  and  $^{210}\text{Pb}$  activity concentration.
- ✓ Radon exhalation rate from phosphogypsum piles was determined through the activated carbon adsorption technique. The radon amount exhaled from material was determined through the concentration of  $^{214}\text{Pb}$  and  $^{214}\text{Bi}$  descendants in activated carbon, obtained by gamma-ray spectrometry.
- ✓ A polyethylene bottle of 100 ml with pure activated charcoal granules with holed lid and tulle were used as collector for radon adsorption. The collectors were placed inside a PVC pipe with a diameter of 7.2 cm, sealed with the PVC pipe cover and installed in four different points in each phosphogypsum pile, thus forming a cumulative radon.
- ✓ The activated charcoal collector and samples of phosphogypsum piles were measured by gamma-ray spectrometry with a hyper-pure germanium detector Canberra model GX2518, 25% relative efficiency, effective resolution of 1.8 keV on the 1332 keV  $^{60}\text{Co}$  with associated electronics.
- ✓ In order to check the experimental results, the radon exhalation rate from Fosfertil and Ultrafértil phosphogypsum piles were also calculated, following the UNSCEAR through the  $^{226}\text{Ra}$  concentration from phosphogypsum, the real density and total porosity of phosphogypsum.



HPGe detector



Gamma-ray spectra – activated charcoal collector

## RESULTS AND DISCUSSION

Average concentrations of  $^{226}\text{Ra}$ ,  $^{228}\text{Ra}$ ,  $^{228}\text{Th}$ ,  $^{40}\text{K}$  and  $^{210}\text{Pb}$  (Bq kg<sup>-1</sup>) from Ultrafértil phosphogypsum

Sampling Point	Concentrations (Bq·kg <sup>-1</sup> )									
	$^{226}\text{Ra}$		$^{228}\text{Ra}$		$^{228}\text{Th}$		$^{40}\text{K}$	$^{210}\text{Pb}$		
1	324	10	262	16	285	11	< 26	433	63	
2	316	7	281	3	313	13	< 31	401	27	
3	317	7	266	1	277	15	< 32	421	45	
4	308	2	267	4	293	7	< 27	397	29	

Average concentrations of  $^{226}\text{Ra}$ ,  $^{228}\text{Ra}$ ,  $^{228}\text{Th}$ ,  $^{40}\text{K}$  and  $^{210}\text{Pb}$  (Bq kg<sup>-1</sup>) from Fosfertil phosphogypsum

Sampling Point	Concentration (Bq·kg <sup>-1</sup> )									
	$^{226}\text{Ra}$		$^{228}\text{Ra}$		$^{228}\text{Th}$		$^{40}\text{K}$	$^{210}\text{Pb}$		
1	296	7	319	2	218	6	< 41	323	11	
2	274	9	305	5	180	5	< 43	300	49	
3	357	5	455	13	366	4	< 45	372	5	
4	291	12	332	4	227	16	< 49	312	16	

$^{222}\text{Rn}$  exhalation rate (Bq m<sup>-2</sup> s<sup>-1</sup>) from Ultrafértil and Fosfertil phosphogypsum piles

Sampling point	ULTRAFERTIL		FOSFERTIL	
	$^{222}\text{Rn}$ (Bq m <sup>-2</sup> s <sup>-1</sup> )	$^{222}\text{Rn}$ (Bq m <sup>-2</sup> s <sup>-1</sup> )	$^{222}\text{Rn}$ (Bq m <sup>-2</sup> s <sup>-1</sup> )	$^{222}\text{Rn}$ (Bq m <sup>-2</sup> s <sup>-1</sup> )
1A	0.102	0.004	0.073	0.003
1B	0.083	0.003	0.070	0.003
2A	0.214	0.008	0.053	0.004
2B	0.195	0.007	0.051	0.003
3A	0.268	0.010	0.098	0.006
3B	ND		0.091	0.006
4A	0.119	0.005	0.082	0.003
4B	ND		0.115	0.005
<b>mean ± SD</b>	<b>0.164</b>	<b>0.073</b>	<b>0.079</b>	<b>0.022</b>

$^{222}\text{Rn}$  exhalation rate (Bq m<sup>-2</sup> s<sup>-1</sup>) in the phosphogypsum piles of Ultrafértil and Fosfertil, using the UNSCEAR model

Point	$^{222}\text{Rn}$ (Bq m <sup>-2</sup> s <sup>-1</sup> )	
	mean	SD
ULTRAFÉRTIL 1	0.161	
ULTRAFÉRTIL 2	0.155	
ULTRAFÉRTIL 3	0.156	
ULTRAFÉRTIL 4	0.152	
<b>mean</b>	<b>0.156</b>	<b>0.004</b>
FOSFÉRTIL 1	0.092	
FOSFÉRTIL 2	0.086	
FOSFÉRTIL 3	0.111	
FOSFÉRTIL 4	0.090	
<b>mean</b>	<b>0.094</b>	<b>0.011</b>

- ✓ Results of radionuclide concentrations of  $^{226}\text{Ra}$ ,  $^{228}\text{Ra}$ ,  $^{228}\text{Th}$ ,  $^{40}\text{K}$  and  $^{210}\text{Pb}$  in the phosphogypsum piles from Ultrafértil and Fosfertil are in accordance with literature values
- ✓ The  $^{222}\text{Rn}$  exhalation rates from phosphogypsum piles of Ultrafértil and Fosfertil, using activated charcoal collectors, were consistent with the values calculated by the UNSCEAR model.
- ✓ Results obtained in this study indicate that radon exhalation rate is strongly related with porosity.