The use of lichen (*Canoparmelia texana*) as biomonitor of atmospheric deposition of natural radionuclides from U-238 and Th-232 series

[1]Lucio Leonardo, [1]Sandra Regina Damatto, [1]Barbara Paci Mazzilli, [2]Mitiko Saiki

[1]Laboratório de Radiometria Ambiental, [2]Laboratório de Análise por Ativação
Instituto de Pesquisas Energéticas e Nucleares
Av. Prof. Lineu Prestes, 2242 - São Paulo, CEP 05508 000
lucioleo@ipen.br

Lichens have been used in studies of environmental pollution monitoring of various air pollutants, especially heavy metals. This paper aims to study the possibility of using this specimen for the assessment of radionuclides deposition in the vicinity of a nuclear research institute, Instituto de Pesquisas Energéticas e Nucleares (IPEN) located in São Paulo, Brazil. This Institute has as major activity to perform research in the field of the nuclear fuel cycle, and therefore deals with considerable amounts of natural radionuclides of the U and Th series. The activity of the naturally occurring radionuclides U-238, Ra-226, Ra-226 and Pb-210 was determined in samples of lichen (*Canoparmelia texana*) and soil collected at IPEN campus. The concentrations of Ra-228, Ra-226 and Pb-210 were determined by measuring alpha and beta gross counting in a gas flow proportional detector; U and Th were determined by neutron activation analysis. The values obtained varied from 164 Bq/kg to 864 Bq/kg, 13 Bq/kg to 50 Bq/kg, and from 287 Bq/kg to 730 Bq/kg for Ra-228, Ra-226 and Pb-210 respectively. For natural U and Th the values obtained varied from 1.2 Bq/kg to 162 Bq/kg and 1.84 Bq/kg to 5.17 Bq/kg respectively. The results obtained so far suggest that the *Canoparmelia texana* can be used as radionuclide monitor in the vicinity of nuclear installations.

Keywords: lichens, radionuclides, U and Th series.
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INTRODUCTION

Biomonitoring of environmental pollution with lichens is widely used due to its good accumulation properties of chemical and radioactive pollutants.[1-4]

Among the lichen species available in Brazil, *Canoparmelia texana* is one of the most widely spread in the natural primary secondary vegetation formation as well as cities, since this species survives in polluted urban areas. *Canoparmelia texana* is a foliose lichen with large thallus and radial growth found in tree trunks.[5]

This paper aims to study the possibility of using this specimen for the assessment of radionuclides deposition in the vicinity of a nuclear installation, Instituto de Pesquisas Energéticas e Nucleares (IPEN) located in São Paulo, Brazil. This Institute has as major activity to perform research in the field of the nuclear fuel cycle, and therefore deals with considerable amounts of natural radionuclides of the U and Th series,

which are usually found in the effluents released by the facilities available. The concentrations of Ra-228, Ra-226 and Pb-210 were determined by measuring alpha and beta gross counting in a gas flow proportional detector, after radiochemical separation; U and Th were determined by neutron activation analysis.

MATERIALS AND METHODS

Sampling - The lichens samples were collected in six points inside the campus of IPEN (Figure 1), in the trees' barks at about 1,5 m from the ground level. The samples were extracted using a plastic knife and stored in paper bags. In the laboratory the lichens samples were washed with distilled water to remove dust and cleaned by a manual process. After this the samples were dried at 60 ^{o}C and pulverized in a glass mortar.

Ra-228, Ra-226 and Pb-210 determination – 500 mg from each sample, in duplicate, were dissolved in mineral acids in a microwave digestor and submitted a radiochemical procedure for the determination of Ra-226, Ra-228 and Pb-210. After the procedure, the Ra-226 and Ra-228 concentration were determined by gross alpha and beta counting of the $Ba(Ra)SO_4$ precipitate and the Pb-210 concentration through its decay product, Bi-210, by measuring the gross beta activity of the $PbCrO_4$ precipitate. Both radionuclides were determined in a low background gas flow proportional detector.

U and Th determination – lichens samples were analyzed by neutron activation analysis to determine U and Th. Approximately 150 mg of lichen (duplicate samples), and about 150 mg of reference materials and synthetic standards were accurately weighed and sealed in pre-cleaned double polyethylene bags, for irradiation. Single and multi-element synthetic standards were prepared by pipetting convenient aliquots of standard solutions small sheets of Whatman n^{o} 41 filter paper. The samples, reference materials and synthetic standards were irradiated for 16 hours, under a thermal neutron flux of 10^{12} n cm^{-2} s^{-1} in the IEA-R1m nuclear reactor at IPEN. Two series of counting were made: the first, after one week decay and the second, after 15 days. The counting time was 1.5 hours for each sample and reference material. Gamma spectrometry was performed using a coaxial Be-layer HPGe detector with 22% relative efficiency, resolution of 2.09 keV at 1.33 MeV and associated electronic devices. The spectra were acquired by multichannel analyser SpectrumMaster and for the analysis, WinnerGamma software was used.

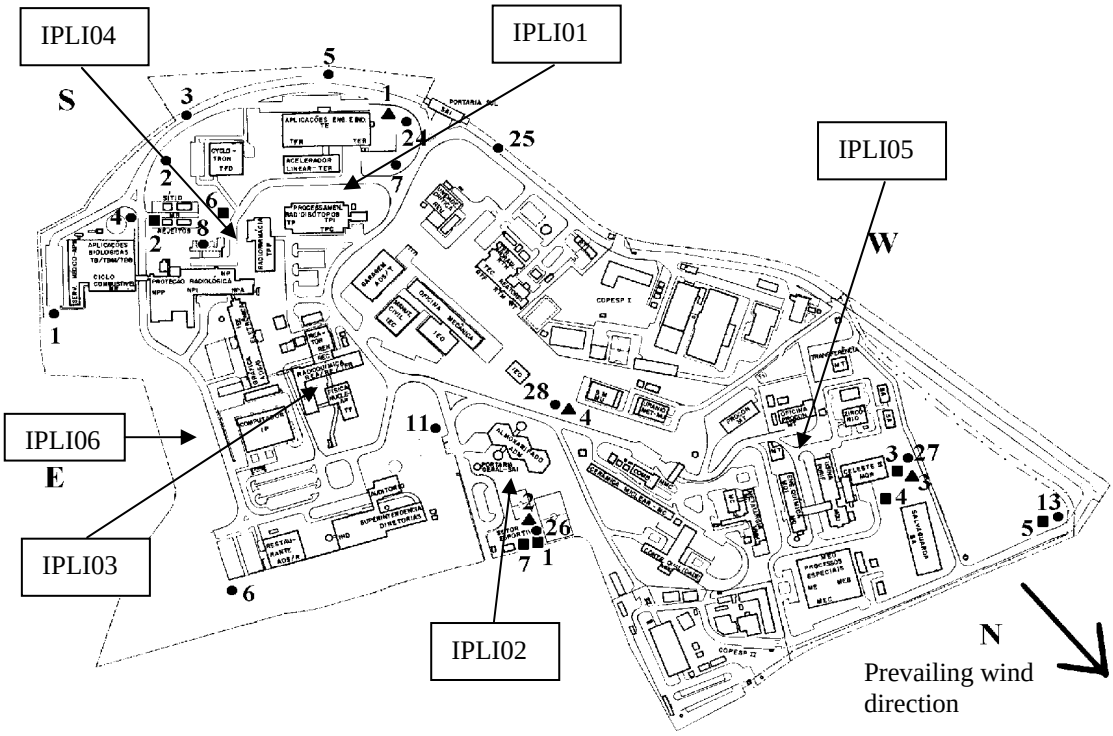

FIGURE 1. IPEN map with the localization of the sampling points.

RESULTS AND CONCLUSION

The results obtained for the activity concentration are presented in Table 1 for the lichen samples and in Table 2 for the soil samples. The Pb-210 activity concentrations are higher than the Ra-226, indicating a clear contribution from the fallout deposition. The ratio Ra-226/Ra-228 varied significantly in the lichen samples, at least in three locations a clear enrichment was observed for Ra-228, indicating a direct influence from IPEN facilities. The results obtained for the same ratio in the soil samples presented a more constant pattern, indicating that the contribution for the Ra-228 in the lichens is probably due to atmospheric deposition. The results obtained so far suggest that the *Canoparmelia texana* can be used as radionuclide monitor in the vicinity of nuclear installations.

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Table 1. Activity concentration of U, Ra-226, Ra-228, Pb-210 and Th-232, in lichens samples collected at IPEN (in Bq kg^{-1}).								
	IPLI01A	**IPLI01B**	**IPLI02A**	**IPLI03A**	**IPLI03B**	**IPLI04A**	**IPLI05A**	**IPLI06A**
U	2,19 ± 0,25	2,98 ± 0,70	2,78 ± 0,48	3,42	1,21 ± 0,43	4,79	34,2	12,5
Ra-226	30 ± 4	32 ± 1	30 ± 3	13±2	27 ± 5	38±2	50±5	20±5
Pb-210	369 ± 23	375 ± 6	449 ± 8	392±10	287 ± 15	436±16	730±65	678±30
Th-232	3,24 ± 0,42	5,17 ± 0,72	5,03 ± 0,69	na	1,84 ± 0,25	na	na	na
Ra-228	200 ± 10	183 ± 30	204 ± 45	351±12	164 ± 11	247±12	864±6	241±65
Ra-228/Ra-226	6,7	5,7	6,8	27	6,1	5,2	17,3	12,0
Th-232/U	1,5	1,7	1,8	-	1,5	-	-	-

* Not available

Table 2. Activity concentration of U, Ra-226, Ra-228, Pb-210 and Th-232 in soil samples collected at IPEN (in Bq kg^{-1}).			
	IPSL01A	**IPSL01B**	**IPSL01C**
U	na	na	33,6 ± 3,2
Ra-226	43,6 ± 3,3	32,6 ± 2,6	22 ± 1
Pb-210	na	na	na
Th-232	na	na	91,8 ± 2,4
Ra-228	71,2 ± 5,1	51,9 ± 4,0	37,4 ± 2,4
Ra-228/Ra-226	1,6	1,6	1,7
Th-232/U	-	-	2,7

* Not available

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