2015 International Nuclear Atlantic Conference - INAC 2015
São Paulo, SP, Brazil, October 4-9, 2015
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR - ABEN
ISBN: **978-85-99141-06-9**

NATURAL RADIONUCLIDES IN THE BRAZILIAN COAST REGION: 1. ESTUARINE COMPLEX CANANÉIA-IGUAPE, SÃO PAULO STATE

E. J. De França[1], Fabiano S. Ferreira[1], Paulo C. Silva Neto[1], Emerson, E. G. de Farias[1], Rubens C. L. Figueira, Andreza P. Ribeiro

Centro Regional de Ciências Nucleares do Nordeste (CRCN-NE)
Avenida Professor Luiz Freire 200
50740-540, Recife, PE
ejfranca@cnen.gov.br; biologofabiano10@gmail.com; ptpoli@yahoo.com.br; emersonemiliano@yahoo.com.br

Universidade de São Paulo
Praça do Oceanográfico, s/n, São Paulo
figueiraru@yahoo.com.br; andrezpr@usp.br

ABSTRACT

Mangrove forests are of utmost important ecosystems for biogeochemical transport processes in a global scale because of the preferential transport via sediments and organic matter from continents to oceans. Such ecosystems are the richest biodiversity areas, in which bioaccumulation of chemical substances can be expected for some species, in this case, there is a lack of knowledge of natural radionuclides accumulation in mangrove vegetation. This work encompasses the first results obtained for the Estuarine Complex Cananéia-Iguape, a peculiar coast area of the São Paulo State, Brazil. In 2011, leaf samples of *Rhyzophora mangle* and *Laguncularia racemosa* trees with perimeter at the breast height higher than 15 cm were collected in the conservation unit Parque Estadual Ilha do Cardoso. Sample preparation consisted of leaf washing, oven-drying, milling in porcelain mortar at the particle size lower than 0.5 mm. Portions of 10 g were transferred to polyethylene vials of appropriate geometry for the analysis by high resolution gamma-ray spectrometry. Reference materials were analyzed together to evaluate the quality of the analytical procedure. K-40 was preferentially allocated in leaves. Some accumulation in leaves was noticed for Pb-210 and Ac-228 depending on the species, indicating differences of radionuclide distribution in the mangrove vegetation.

Keywords: mangroves, environmental studies, gamma-ray spectrometry.

1. INTRODUCTION

Mangrove forests are very important ecosystems in tropical coastlines around the world. Its location is restricted to the range of tides, the coast, contours bays and estuaries, functioning as an interface between marine and terrestrial environments. Brazil has one of the largest coastal regions, with a great diversity of ecosystems such as mangroves, coral reefs, cliffs, coastal lagoons, salt marshes and dunes [1].

However, little is known about the accumulation of chemicals substances for native plants [2], especially those from regions with strong marine influence and seasonal fluctuations such as the mangrove vegetation. The use of radionuclides to study these environments can answer important scientific questions, which can be useful for coastal management and development of conservation strategies.

In recent years, radionuclides were applied in environmental tracers studies, not only for the purpose of radioprotection, but also as complex markers of processes. Those radionuclides are classified into four groups according to their sources: (1) nuclide produced by cosmic rays (as ^{7}Be and ^{14}C); (2) artificially produced nuclides (such as ^{137}Cs and ^{90}Sr); (3) primary

isotopes (such as ^{232}Th, ^{238}U and ^{40}K); and (4) products of natural decay (such as ^{226}Ra and ^{228}Ra). The three naturally occurring radioactive decay chains include ^{238}U, ^{235}U and ^{232}Th, which decay through a series of radioactive elements until the stable isotopes of Pb [3].

In this work, some radionuclides was estimated in the vegetation of mangroves located at the Estuarine Complex Cananéia-Iguape, São Paulo state, Brazil.

2. EXPERIMENTAL

2.1. Areas of study

The region of Cananéia-Iguape is a estuarine-lagunar complex, 75 km long, located at the southern coast of São Paulo State, Brazil, formed by four islands (Cardoso, Cananéia, Comprida and Iguape) separated by rivers with Atlantic Ocean by means of an estuarine complex. The Parque Estadual Ilha do Cardoso - PEIC part of a continuous fragment of the Atlantic Forest, considered of great importance to ecological conservation. It is observed an area of around 200 km^2 of well-developed mangroves. Mean temperatures observed in this area variate from 19,8 ºC to 27,8 °C, with annual mean of 23,8 ºC. A sandy sediment domain is observed in the majority of this complex [4, 5].

2.2. Sample preparation

Leaf samples of *Rhyzophora mangle* and *Laguncularia racemosa* trees with perimeter at the breast height higher than 15 cm were collected in the PEIC. Sample preparation consisted of leaf washing, oven-drying at 60 ºC and milling up to particles size lower than 0.5 mm. Portions of 10 g were transferred to polyethylene vials with 5 cm of diameter and appropriate geometry for the analysis by gamma-ray spectrometry. Vials were sealed with silicone and kept under controlled conditions uduring 30 days to achieve secular equilibrium.

2.3. Gamma-ray spectrometry analysis

Radionuclides present in the samples were analyzed by high resolution gamma-ray spectrometry performed in a high-purity germanium detector (HPGe), model 4018 from Canberra®, with resolution of 1.9 keV at the 1.33 MeV ^{60}Co photopeak. Measures carried out during 1.000.000 seconds for samplers and analytical blank.

2.4. Analysis of the results

The measurements of gamma rays from radionuclides done at HPGe detector were evaluated using the software Genie 2000 provided by Canberra®, according to the Equation 1:

$$A = \frac{C - BG}{t \cdot m \cdot \varepsilon_\gamma} \tag{1}$$

In which:

A = concentration activity measured in the sample

C = counting of radionuclides gamma-rays

BG = counting of radionuclides gamma-rays at the analytical blank

t = duration of measurement (s)

m = mass of sample (kg)

ε_γ = efficiency of the detector in the region of the were counted photopeak

Analytical uncertainties for each one of the components of the Equation 2. The combined analytical uncertainties were expanded at the 95% confidence level, Equation 2.

$$U_A = A \cdot \sqrt{(\frac{uC}{C})^2 + (\frac{uBG}{BG})^2 + (\frac{um}{m})^2 + (\frac{u\varepsilon_\lambda}{\varepsilon_\lambda})^2} \quad (2)$$

The reference material IAEA 156, *Radionuclides in clover*, produced by the International Atomic Energy Agency, was analyzed together with the samples aiming to evaluation the quality of the analytical procedure, using the En number, defined in equation 3:

$$E_n = \frac{A_{\exp} - A_{ref}}{\sqrt{U_{\exp}^2 + U_{ref}^2}} \quad (3)$$

In which,

A_{exp} = concentration activity obtained in the reference material (Bq kg^{-1})

A_{ref} = concentration activity certified for the reference material (Bq kg^{-1})

U_{exp} = analytical expanded uncertainty associated to A_{exp} (Bq kg^{-1})

U_{ref} = analytical expanded uncertainty associated to A_{ref} (Bq kg^{-1})

Values obtained for En number in the range -1 and 1 were considered as an indicative of good quality of analytical procedure at the 95% confidence level (ISO, 2005).

The values obtained for radionuclides activities in different samples were evaluated using ANOVA, performed at the software Statistica (v. 10).

3. RESULTS AND DISCUSSION

The results of the activity of natural radionuclide concentration ^{40}K determined in leaves of the species Rhizophora mangle and Laguncularia rancemosa collected at the PEIC are *shown* in Table 1.

Table 1: Levels of radionuclides (in Bq kg^{-1}) in leaves of the Cananéia-Iguape Estuarine Complex (SP, Brazil).

Specie		**^{40}K**
Rhizophora mangle	Mean (Bq kg^{-1})	232
	SD (Bq kg^{-1})	42
	CV (%)	18
	Uncertainty (%)	5.3
	n	8
Laguncularia racemosa	Mean (Bq kg^{-1})	268
	SD (Bq kg^{-1})	85
	CV (%)	32
	Uncertainty (%)	4.9
	n	5

SD - standard deviation; CV - coefficient of variation; n - number of individuals

Concentrations of ^{40}K activity measured in *Rhizophora mangle* and *Laguncularia racemosa* were not meaningly different ($p \geq 0.05$).

Paiva et al. [7] studied the species of mangle *Laguncularia racemosa* and *Avicennia schaueriana* in mangroves of Pernambuco state Brazil. They used approximately 170 g (dry weight) of each sample, analyzed in modified Marinelli, containers type for comparison. Results are shown in Table 2.

Table 2: Levels of radionuclides (in Bq kg^{-1}) in leaves of the Formoso River and Chico Science mangroves (PE, Brazil).

Specie		**^{40}K (**Chico Science**)**	**^{40}K (**Formoso River**)**
Rhizophora mangle	Mean (Bq kg^{-1})	226	230
	SD (Bq kg^{-1})	40	19
	CV (%)	20	8.4
	N	4	6
Laguncularia racemosa	Mean (Bq kg^{-1})	205	236
	SD (Bq kg^{-1})	50	9
	CV (%)	24	3.7
	N	4	2

SD - standard deviation; CV - coefficient of variation; n - number of individuals

Paiva et al, used in his work samples with different geometries and masses, even with this difference was not observed in species mangle and Laguncularia racemosa significant differences in concentrations of 40K in the leaves of these species, these data were testified

with 95% confidence . However, other natural radionuclides could not be quantified in a geometry 5 mm and 10 g. In this work, unlike Paiva et al. [7] the mass of the sample was 4 times greater, and the technical protocol followed also effective only for determining the 40K.

4. CONCLUSIONS

High resolution gamma-ray spectrometry was able to quantify ^{40}K naturally present in leaves of mangrove species in the Parque Estadual Ilha do Cardoso. When compared with the result Paiva (2015), no significant differences between species of *Rhizophora mangle* and *Laguncularia racemosa* analyzed in Mangrove Rio Formoso and Mangrove Chico Science.

ACKNOWLEDGMENTS

The authors acknowledge the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP process nº 2012/08634-6) for the finantial support to this work.

REFERENCES

1. G. Hempel, K. Sherman (Ed.), *Large marine ecosystems of the World*, Elsevier, Amsterdam, Netherlands (2003).

2. E. J. França, E. A. De Nadai Fernandes, M. A. Bacchi, R. R. Rodrigues, P. Bode, M. Saiki "Native plant bioaccumulation strategies for biomonitoring the Atlantic Forest", *International Journal of Environment and Health*, **4**, pp. 181-200 (2010).

3. B. Bourbon, G. M. Henderson, C. C. Lundstrom, S. P. Turner (Ed.). *Uranium series geochemistry*, Geochemical Society and Mineralogical Society of America, Washington, United States of America (2003).

4. R.L. Barcellos, P. B.Camargo, A. Galvão, R. R. Weber, "Sedimentary organic matter in cores of the Cananéia-Iguape Lagoonal-Estuarine system, São Paulo State, Brazil", *Journal of Coastal Research*, **56**, pp. 1335-1339 (2009).

5. D. F. Godoy, A. Andriolo, G. F. Filla, "The influence of environmental variables on estuarine dolphins (sotalia guianensis spatial distribution and habitat used in the Estuarine Lagunar Complex of Cananéia, Southeastern Brazil", *Ocean & Coastal Management*, **106**, pp. 68-76 (2015).

6. ISO - International Organization for Standardization, *(ISO13528) Statistical methods for use in proficiency testing by interlaboratory comparisons*, ISO, Genebra, Switzerland (2005).

7. J. D. S. Paiva, E. E. Sousa, E. E. G. Farias, A. M. J. Carmo, E. J. França "Natural radionuclides in mangrove soils from the State of Pernambuco, Brazil", *Journal of Radioanalytical and Nuclear Chemistry* (2015), accepted for publication.