RADIOISOTOPIC CHARACTERIZATION OF A CUBAN PELOID BY GAMMA SPECTROMETRY

R. Domínguez-Rodríguez[1*], M. Suárez-Muñoz[2], P. González-Hernández[2], A. M. Abreu-Díaz[1], C. Melián-Rodríguez[2], K. Isaac-Olivé[1†], A. Guillén-Arruebarrena[3], R. Fagundo-Castillo[2].

1- Instituto Superior de Tecnología y Ciencias Aplicadas, 2-Centro Nacional de Medicina Natural y Tradicional, 3-Centro de Estudios Ambientales de Cienfuegos.
† Presently at the Instituto de Física, Universidad Nacional Autónoma de México.
*e-mail: rdominguez@instec.cu

ABSTRACT

Peloids or thermal muds are complex colloidal systems with known therapeutic properties. In Cuba, peloids have been used for more than two centuries in an empiric way. The chemical characterization of these matrixes will help to obtain scientific bases to understand the behavior of bioactive and toxic elements in different human pathologies, as well as, spreading their use in medical treatments. The use of nuclear analytical techniques is suitable to characterize mainly the inorganic (including radioactive isotopes) phase of peloids. The objective of this work was to determine the natural and artificial radionuclides (gamma emitters) in the San Diego de los Baños peloid (Pinar del Rio, Cuba) by means of gamma spectrometry. The spectra show that the most significant radionuclides are ^{40}K, ^{137}Cs, and those from ^{238}U and ^{232}Th decay series. The activity concentrations of these radionuclides are in good agreement with those from regions of normal radioactive background. These results are consistent with references for similar sediments; nevertheless, ^{137}Cs has been reported for the first time in Cuban peloids.

Keywords: Peloid, sediment, spa, gamma spectrometry.

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INTRODUCTION

Peloids or thermal muds are sediments that constitute complex colloidal systems formed by two (organic and inorganic) phases with known therapeutic properties [1, 2]. Thermal muds are hydrothermal or hydrothermalized pastes produced by primary or secondary mixing of clay materials with salty thermo-mineral waters, accompanied by organic materials produced by the biological-metabolic activity of micro-organisms growing during the so-called "maturation" process [3].

In Cuba, peloids have been used for more than two centuries in an empiric way, in the topical treatment of different human pathologies. The chemical characterization and quality control of these sediments are needed to evaluate their therapeutic properties. This characterization helps to correlate the components in the peloid to their biological action, as well as, spreading their medical use. In addition, the radioisotopic characterization facilitates the assessment of the radiological doses to patients and occupational workers.

The use of nuclear analytical techniques is suitable to perform the radioisotopic characterization of sediments. The objective of this work was to determine the natural and artificial radionuclides (gamma emitters) in San Diego de los Baños peloid (Pinar del Río, Cuba) by means of gamma-spectrometry.

SAN DIEGO DE LOS BAÑOS

San Diego de los Baños is a Thermal Center located in Pinar del Río, Cuba (Figure 1). The mud used at this Thermal Center, is an estuarine sediment, originated in the southern coast of Pinar del Río province. Sediment samples from San Diego River's mouth (22º19'49" N, 83º16'28" W), depth interval of 0-20 cm, were matured for 30 days with thermal waters (calcic sulfated, sulfhidric and radonic waters) to fulfill the requirements for therapeutic muds [1]. These peloids are used in therapeutic treatment of ostiomioarticular, immune and dermatologic diseases.

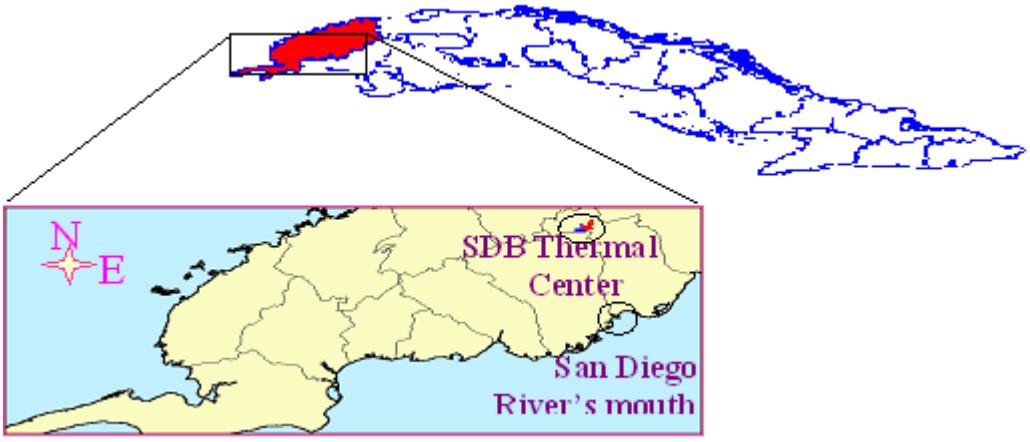

Figure 1. San Diego de los Baños Thermal Center.

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EXPERIMENTAL

Samples preparation: The peloid was collected from the maduration pool in San Diego de los Baños Thermal Center. Afterwards, it was centrifuged, dried at room temperature to constant weight, homogenized, and sifted at 125 μm.

For gamma analysis, pretreated samples (50g) were packed in a cylindrical container (60 mm diameter and 20 mm height), sealed and stored for 28 days in order to attain secular equilibrium between the long-lived radioisotopes ^{238}U, ^{232}Th, ^{226}Ra and their respective progeny.

Gamma spectrometry
Measurements were performed in a DSG Detector Systems GmbH gamma spectrometer, equipped with a HPGe Coaxial Detector (Type: NGC 3019) 30% relative efficiency and 1.9 keV resolution for the 1332 keV photopeak of ^{60}Co, coupled to a multi-channel analyzer. The detector has a beryllium entrance window (6 cm) that enables detection of gamma rays below 100 keV with excellent efficiency. In order to reduce laboratory background, the detector is shielded with iron 21 cm, cadmium 2 mm and very old lead 4,5 cm thick, and internally lined with 1 mm thick electrolytic Cu.

The certified material for soil IAEA-375 (soil from Chernobyl region (1990)) [4] was used for measurement calibration, combined with a point source of ^{226}Ra. The sample counting time was 48 hours. The spectra were analyzed with Winner 6.0 software.

^{40}K, ^{210}Pb and ^{137}Cs activities were obtained from their corresponding gamma rays at 1460.83 keV, 46.54 keV and 661.66 keV, respectively. ^{226}Ra determination was based on measurement of its decay chain descendant ^{214}Pb (351.93 keV) and the assumption of secular equilibrium. The activity concentrations of ^{238}U and ^{232}Th were determined by means of ^{234}Th (63.29 keV) and ^{228}Ac (991.07 keV) peaks, respectively. The errors on the activity concentrations arise from the statistical uncertainty in the peak areas. The background activity was properly subtracted.

RESULTS AND DISCUSSION

Gamma spectrometry
To our knowledge, it seems to be no information about radioactivity levels in San Diego sediments so far and no data have appeared in the literature concerning radionuclide concentrations in the specific region under study; therefore, no comparison in time is possible.

Gamma spectra of the peloid samples show the peaks corresponding to natural radionuclides from the ^{238}U (^{234}Th, ^{226}Ra, ^{214}Pb, ^{214}Bi, ^{210}Pb), ^{232}Th (^{228}Ac, ^{212}Bi, ^{208}Tl) and ^{235}U decay series, besides ^{40}K. The anthropogenic radioisotope, ^{137}Cs, was also found in this matrix. Figure 2 illustrates an example of these spectra.

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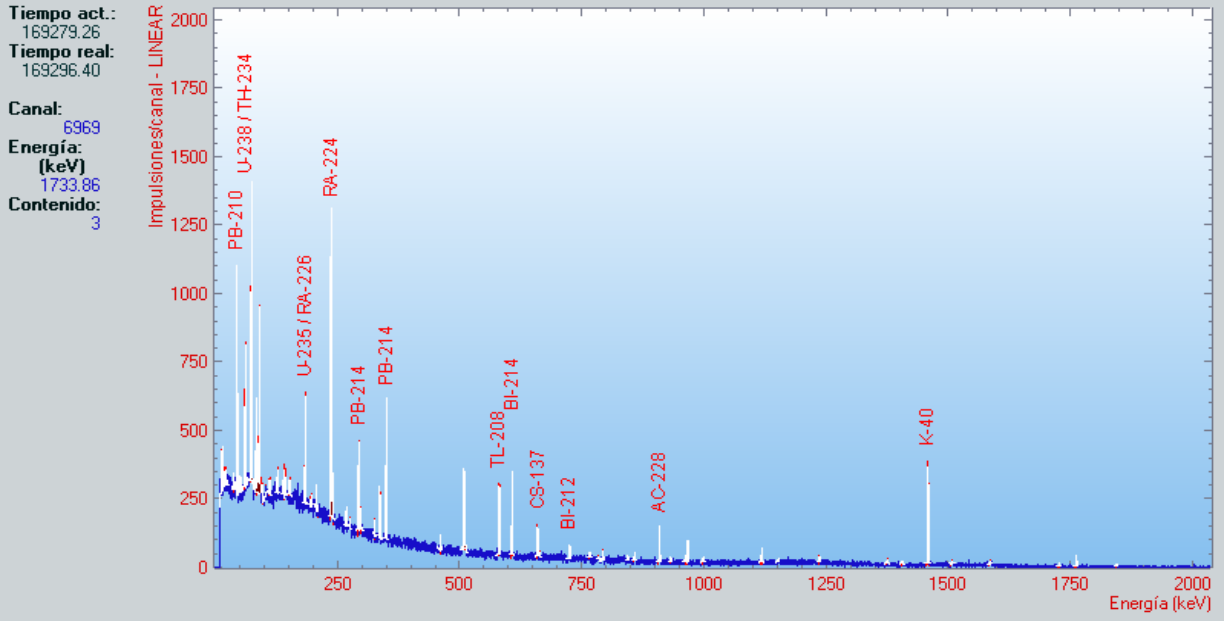

Figure 2. Gamma Spectrum of San Diego de los Baños Peloid.

Table 1 summarizes the dry weight activity concentrations of the radionuclides ^{40}K, ^{238}U, ^{226}Ra, ^{210}Pb, ^{232}Th and ^{137}Cs in the peloid as well as the world averages for comparison.

Table 1. Radionuclides activity concentrations in the peloid and world averages.

Radionuclide	Activity concentration (dry weight) [Bq/kg]	U [Bq/kg]	World average and range (surface sediments) [Bq/kg]
^{40}K	237	13	400 (140 - 850) [5]
^{238}U	31	6	35 (16 – 110) [5]
^{226}Ra	29	1	35 (17 – 60) [5]
^{210}Pb	61	6	40 - 100 [9]
^{232}Th	21	2	30 (11 – 64) [5]
^{137}Cs	5.0	0.4	6 (1 – 17) (nowadays in northern hemisphere) [10, 11]

The activity concentrations of natural radionuclides measured in this work are in good agreement with those from regions of normal radiactive background, reported by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) in its performed gamma-ray surveys in soils and sediments [5]. However, ^{226}Ra and ^{210}Pb contents in San Diego muds are slightly lower than those reported in a radioisotopic characterization of peloids from Elguea Thermal Center, located in the central region of Cuba [6].

The natural radionuclide ^{210}Pb ($T_{1/2}$ = 22.6 y) has a double origin in the sediments. It is principally produced by ^{226}Ra decay (via ^{222}Rn) in the mineral components of sediment particles and additionally by atmospheric ^{222}Rn decay. The atmospheric fraction of the ^{210}Pb activity - the so-called excess activity or unsupported fraction - is due to the fact that ^{222}Rn partially escapes to

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the atmosphere once is generated by ^{226}Ra disintegration. As a consequence, ^{210}Pb is also produced in air and deposited into sediments isolated from its progenies. Therefore, sediments will contain an excess of ^{210}Pb with respect to that produced in the own sediment by ^{226}Ra, which generally decreases with depth according to the half live of ^{210}Pb, depending on the sediment deposition rate. In the peloid, ^{210}Pb radioactivity reaches about the double of the ^{226}Ra values. This excess is typical for surface sediments, like the one under study.

By the other hand, ^{137}Cs does not exist naturally in soils and sediments; it is a product of fallout radioactivity. ^{137}Cs has been deposited in marine sediments from all over the world, mainly in the northern hemisphere, as a result of the atmospheric nuclear weapon tests conducted by several countries in the past century, as well as the nuclear power plant accident at Chernobyl on April 1986. A large number of studies have shown that ^{137}Cs is preferentially bound on clay and organic particles and is rapidly and strongly absorbed in cation exchange sites [7, 8, 9].

The content of ^{137}Cs in San Diego's peloid (5 Bq/kg dry weight) is in the range for normal background in northern hemisphere (1 – 17) [10, 4, 11, 5]; although, it has not been reported in previous characterization of Cuban peloids [6]. The appreciable content of phylosilicates (39 %) [8], main component of clay particles (<2 μm), in the peloid of San Diego de los Baños contributes to the absorption of ^{137}Cs in the surface sediments, where it is virtually non-exchangeable [12, 13, 14, 8, 15].

CONCLUSIONS

According to the radioisotopic characterization by gamma spectrometry, the most significant radionuclides are those of terrestrial origin: ^{238}U and ^{232}Th series, besides ^{40}K. There was also found the anthropogenic radionuclide ^{137}Cs. The activity concentrations of these radionuclides are in good agreement with those from regions of normal radioactive background. These results are consistent with those reported in the literature for similar sediments; nevertheless, ^{137}Cs has been reported for the first time in Cuban peloids. This study will contribute to the assessment of radiological doses to patients and occupational workers in San Diego de los Baños Thermal Center.

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