

ENVIRONMENTAL RADIOACTIVITY AT THE PERUVIAN SCIENTIFIC STATION "MACHU PICCHU"

^{137}Cs , ^{226}Ra , ^7Be and ^{40}K concentrations in Antarctic samples by gamma spectrometry

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ABSTRACT

In order to continue with the Research Program in Environmental Radioactivity in the Antarctic Region initiated in 1996, the Peruvian Institute of Nuclear Energy (IPEN) participated in the 11th. Scientific Expedition to Antarctica (ANTAR XI) on 2000. The main objective of this study is to evaluate environmental components for achieving a baseline study related to artificial and natural radioactivity level. For this purpose, samples of brown macro-algae (Phaeophyta), lichen, moss, gramineous, soil, marine sediment, sea water and air were collected in the surrounding area of the Machu Picchu Scientific Station. The physical, radiochemical treatment and radiometric assays of the samples were done in the Environmental Control Department of the "RACSO" Nuclear Center. The presence of anthropogenic radionuclide ^{137}Cs , in some antarctic environmental components, confirms that this element was dispersed globally after the nuclear testing carried out in other latitudes. The environmental radiological impact in the antarctic ecosystem has been minimum due to the low levels of found radioactivity. In general, lichens seem to accumulate more ^{137}Cs than other biological components.

1. INTRODUCTION

The determination of fission product levels, in particular ^{137}Cs in environmental samples such as soil and sediment may give information about atmospheric circulation. Although, the main quantity of this radionuclide was released and deposited in the Northern Hemisphere, it was also partially transported through stratospheric circulation to the Southern Hemisphere (Kogan *et al.* 1971). With exception of the 12 atmospheric nuclear weapon test conducted by the United Kingdom in Australia (Woomera 31°S, 137°E and Maralinga 30°S, 131°E) and the 26 test

performed by France in Mururoa, Tuamotu Archipelago (21°S, 137°W), the other 383 atmospheric nuclear weapons test were carried out in the Northern Hemisphere (Carter and Moghissi, 1977).

Tropospheric radioactive fallout tends to remain in the same hemisphere where it was produced. Ascendant air currents at the equator do not allow the input of fission products from the Northern to the Southern Hemisphere. Only the radionuclides which reach the stratosphere, due to the tests at higher altitudes as well as the more powerful detonations, are able to reach the Southern Hemisphere from tests in the Northern Hemisphere. In general, stratospheric fallout shows a typical seasonal variation, with a spring maximum and autumn minimum in both hemispheres (UNSCEAR 1977).

Based on measurements performed since 1956, Piccioto and Wilgain (1963) have found fission products in air filter samples collected at different places in the Antarctic Region. The concentrations were 50 times lower than those obtained in the Northern Hemisphere.

The absence of vascular plants in the Antarctic is partially compensated by a great abundance of moss and lichen species. Lichens are a symbiotic association of algae and fungus and have been used for some years as "bio-indicators" to detect environmental pollution. Water absorption by lichens occurs in the whole stalk area and lichen can contain several times its dry weight in water. Therefore, soluble pollutants can be easily incorporated into the lichen via rain water. The surface structure of lichen also make easy the accumulation of pollutants through dry fallout.

Since lichens can live for a very long time, even more than 100 year (Quilhot, 1988), they act as a long-term integrator of environmental pollutants. As a result, the analysis of organisms older than 40-50 year may give

information about the total radioactive fallout from atmospheric nuclear testing.

The aim of this study was to determine the actual ^{137}Cs levels in environmental samples collected in the South Shetland Archipelago, and using these data, estimate the total regional ^{137}Cs inventory. In addition to ^{137}Cs , other gamma emitting radionuclides were analyzed by gamma spectrometry.

2. MATERIAL AND METHODS

Soil, lichen, moss, algae, seawater and sediment samples were collected in January and February (1996-2000) on King George Island ($62^{\circ}10'S$, $58^{\circ}30'W$), between Mackellar Inlet and Crepin Point. (Fig. 1), in the surrounding area of the Peruvian scientific station "Machu Picchu" ($62^{\circ}05'39"S$, $58^{\circ}28'16"W$).

Soil sampling was performed in an area of 100 cm^2 and from the 0-5 cm. layer at each site. The soil samples were air-dried and sieved to < 0.5 mm. About 250 g dry soil were weighed in a 12 cm. high by 7 cm. diameter polyethylene vessel.

The lichen samples were collected at the same places as the soil samples, when available, and identified as *Usnea antarctica* and the moss samples as *Polytrichum* sp. and *Drepanocladus* sp. The algae samples were collected from Inca beach and Naylamp beach. They were dried at 105°C until reaching a constant weight and ashed at 400°C for 24-48 hours. The ashes were sieved to remove soil particles (0.5 mm. sieve) and weighed in polyethylene pots. The sample mass was limited by the amount of moss or lichen present at each sampling site, and ranged from 50 to 250 g of dry weight.

The sediment samples were collected using a dredge at Admiralty Bay, more precisely at the Mackellar Inlet located in King George Island (Fig. 2). The sampling depths were between 15 and 30 m. The sediment samples were wet-sieved (0.5 mm. sieve) and dried at 105°C until reaching a constant weight. About 250 g of dry sample were placed in a 12 cm. high by 7 cm. diameter polyethylene pot. The pots were then sealed to allow ^{222}Rn and its short-lived daughters to equilibrate.

The seawater samples were collected at the Mackellar Inlet. The sampling volume were between 20 and 50 L. The seawater samples were treated by ammonium

molybdophosphate (AMP) to concentrate Caesium (Lopez, 1997). The final precipitate, about 5 g, was placed in a 2 cm. high by 3 cm. diameter polyethylene pot.

Air samples were collected at the Peruvian scientific station "Machu Picchu" using a Staplex high volume air sampler and TFA filter type "S". The sampling volume was between 500 and 1000 m^3 .

Gamma spectrometry analysis was performed between one and two months after sampling. Canberra intrinsic germanium detector of 15% relative efficiency were used. The detector had xx cm of lead and 1 mm. of cooper and plexiglass as shielding. The typical counting time for the samples and for the background was 1000 minutes (IAEA, 1989). For the determination of the ^{226}Ra and ^{228}Ra levels, ^{214}Bi (609 keV) and the ^{228}Ac (911 keV) gamma ray peaks were used, respectively (Godoy, *et al.* 1998). Quality assurance was maintained by a regular program of gamma spectrometry interlaboratory exercises with the International Atomic Energy Agency (IAEA).

The spectra were evaluated manually and the detection limits were calculated according EPA-600/7-77-088 (1977). The analytical results were calculated according Eurachem/Citac Guide (2000) with 95% of confidence ($\alpha=0,05$).

3. RESULTS AND DISCUSSION

The ^{137}Cs activity concentrations in biological, geological and hydrological samples are shown in Table 2 and Table 3. ^{134}Cs has not been detected in these samples, showing that no detectable Chernobyl fallout has reached this Antarctic region (Aoyama, *et al.* 1991).

Note that in sea water the levels of ^{137}Cs increased in 1998 with 6.76 Bq.L^{-1} going down to 0.01 Bq.L^{-1} in 1999. Since then, the values reported not to be detectable. These results probably suppose some not reported liberation of ^{137}Cs at the end of 1997 and as time passes, it has been diluted.

The measured ^{137}Cs concentrations in antarctic soils (Table 2) were high, comparable to those obtained in Brazil (Schuch *et al.*, 1992) and higher than those obtained in Peru (Gonzales, *et al.* 1994). The results obtained in this work were compatible with those from Hashimoto *et al.* (1989), Triulzi *et al.* (1991) and Godoy, *et al.* (1998).

The ^7Be activity concentrations in lichens and gramineae are shown in Table 4. This element is produced by the interaction of the cosmic rays with the atmosphere and is concentrated with more magnitude on lichens. We can observe that the biggest concentrations were given in 1996 and 1997 with $953.70 \text{ Bq.kg}^{-1}$ and $230.00 \text{ Bq.kg}^{-1}$ respectively.

Levels of radionuclides descending of the chain of disintegration of Thorium and Uranium are found to be higher in the abiotic components, specially in the geologic ones because of being the main source. However, in some cases, levels of activity in algae are found to be higher than in geologic components. This could be due to some bioconcentration process in the marine ecosystem. Presence of Thorium and Uranium descending radionuclides are not evidenced in lichens because of their capability of taking nutrients directly from the atmosphere. This is not true for gramineous and mosses, which receive nutrients directly from the soil, including radioactive elements.

It is interesting to note the difference between the ^{226}Ra , ^{228}Ra and ^{40}K concentrations in soil samples observed in King George Island and those in other islands. Since the Antarctic soil is of volcanic origin, it is possible to classify it based on the mean ^{226}Ra content (18.31 Bq.kg^{-1}) of King George Island and 3.43 Bq.kg^{-1} of the other islands (Godoy, et al. 1998). According to Iyengar (1990), the King George Island soil with the higher ^{226}Ra content should have been derived, probably, from an intermediary volcanic rock while the other island soils are of volcanic base rock origin.

The ^{40}K , ^{226}Ra and ^{228}Ra content in sediments (Table 5) reflects those observed in the King George Island soils. The observed ^{226}Ra and ^{228}Ra content in soils and sediments are generally lower than those observed by Triulzi et al. (1989) near the Italian base in the Terra Nova Bay (74°S , 164°W) and same as Godoy et al (1998) in Marlet inlet near the Mackellar inlet.

4. CONCLUSIONS

Gamma emitters data of the surrounding area of the peruvian scientific station has been obtained during the last five years, following with previous work done in this area by other researchers.

The presence of anthropogenic radionuclide ^{137}Cs , in some antarctic environmental components, confirms that this element was dispersed globally after the nuclear testing carried out in other latitudes. The environmental radiological impact in the antarctic ecosystem has been minimum due to the low levels of found radioactivity. In general, lichens seem to accumulate more ^{137}Cs than other biological components. Therefore, they are more adequate as bio-indicators than mosses and gramineous.

To estimate the atmospheric behavior, more studies on the presence of natural radionuclides, product of the cosmic activity in the region and those of terrestrial origin as the descendants of Thorium and Uranium, are required.

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