Ministry of Industry, Energy and Mines

Laboratories of National Direction of Energy and Nuclear Technology

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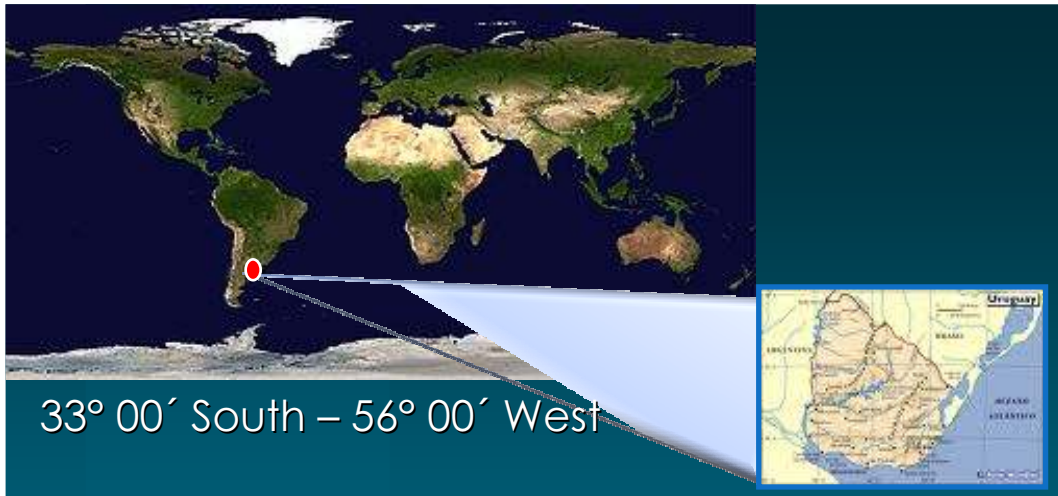


Uruguay is a country located in the southeastern part of South America. It is inhabited by **3.5 million** people of whom 1.4 million live in the capital - Montevideo.

Environmental Radioactivity Monitoring Plan in Uruguay

Technical Meeting on In-situ Methods for Characterization of Contaminated Sites

5 – 9 July 2010 IAEA Vienna, Austria

Summary

1. COUNTRY CHARACTERISTICS

2. ENVIRONMENTAL RADIOACTIVITY MONITORING PLAN

3. EXPERIMENTAL

4. RESULTS

5. DISCUSSION

URUGUAY Country Characteristics

- Area - 176,214Km^2 (68,037 sq mi) continental land 142,199 km^2 of jurisdictional water
- Uruguay's economy relies heavily on trade, particularly in **livestock production and agricultural exports**.
- Today, agriculture contributes roughly 15% to the country's GDP (Gross Domestic Product) and is still the main foreign exchange earner.

- Up to now, Uruguay doesn't have nuclear power plant facilities and it does not have nuclear research reactors. In 2006, the President of Uruguay appointed a commission to study the possibility to install a nuclear facility related to energy production. The Commission followed the guidelines and recommendations of the IAEA. *In the other hand*
- The government has taken the concept of Uruguay "Natural Country".
- ALARA principle "as low as reasonably achievable" is applied.

Environmental Radioactivity Monitoring Plan

- The study of natural radioactivity and radioactive contamination of territories is an important and necessary condition for the correct understanding and investigation of how, the exposure to sources of radiation could affect the environment and the population.
- The main external source of irradiation to the human body are the Gamma radiation emitted from naturally occurring radioisotopes, such as ^{40}K and the radionuclides from the ^{232}Th, ^{235}U and ^{238}U series and their decay products. The behaviour and distribution of these decay series radionuclides in the environment are based on their biogeochemistry and half-life, and the nature of their surroundings (^{238}U 99.28% : ^{235}U 0.72%).

URU/9/008 "Environmental Radioactivity Monitoring Plan in Uruguay"

- Since more than fifteen years, different kind of samples were analyzed by Gamma Spectrometry without a formal program.
- In 2001 the authorities of the Ministry of Industry, Energy and Mines - National Direction of Energy and Nuclear Technology considered the importance of determining the radioactivity levels of the Uruguayan territory, whether natural levels, anthropogenic / fallout levels and to establish a radiation background of the country.
- With the support of the IAEA – in the frame of URU/9/008 project "Environmental Radioactivity Monitoring Plan in Uruguay", a program was established and it began to operate in March 2003.

Experimental

- Secular Equilibrium: Because of the conditions reached (30 days) between ^{232}Th and ^{238}U and their decay products, the ^{232}Th activity concentration was determined from the average concentrations of ^{212}Pb (238.63keV), ^{228}Ac (911.07keV).
- The activity concentration of ^{238}U (^{226}Ra) was determined from the average concentrations of the ^{214}Pb (351.92keV) and ^{214}Bi (609.31keV; 1120keV; 1764keV) decay products. ^{40}K was measured directly at its line – 1460.75keV and ^{137}Cs was determined at its line – 661.66keV.

Experimental

- Laboratories Facilities -to measure/analyse environmental samples
- Selection of the samples to be collected: soil, sediments, meat, milk, grains, water, and air particulate matter.
- Selection of the radionuclides:
  - Naturals ^{40}K; ^{238}U and ^{232}Th series (^{226}Ra; ^{228}Ra)
  - Anthropogenic: ^{137}Cs
- Sampling frequency and geographical distribution

Sampling Sites - Frequency

- The samples of soils were taken (1m^2 with 5cm depth) once a year in different departments of the country since 2004
- In order to obtain representative samples of rice, milk products and meat from all the departments of the country, it was developed a program with the Ministry of Livestock, Agriculture and Fisheries.
- A Monitoring Station – Berthold (air particulate matter) is located in Colonia, 80km from nuclear facilities of the neighbouring country; it works 24hs a day, since March 2004.

Sample preparation

- The soil samples were dried at (60 ± 5) °C to constant weight.
- The samples were sieved trough 2mm sieve and the fractions < 2mm were homogenized and used for the direct determination of gamma emitting radionuclides.
- Marinelli geometry was used.
- Food products samples were dried at (55 ± 5) °C for 24hs and then measured directly in a 1kg Marinelli for 64800seg .

Analysis and Measurement

- The samples were measured in a Gamma Spectrometry System, consisting in a Ge detector; model Canberra GC3020, vertical dipstick, coaxial.
- The detector is mounted in a lead shielding Canberra – 747E (10cm Pb; 1mmCu; 1mm Cd). The software Genie 2000 was used to evaluate the spectra and for calculations of the activity concentrations.
- Resolution of Germanium Detector

E (keV)	FWHM
1332	1.85 keV
122	0.842 keV
661.66	1.263 keV

- Detection Limits (DL) are calculated using L.A. Currie formula

Standards as control samples

IAEA – 375 and IAEA – SOIL 6 were used as control samples for soils

IAEA – 321 as control sample for milk products.

The activity concentration of ^{137}Cs measured and recommended value were in good agreement.

The uncertainties were calculated using the following formula :

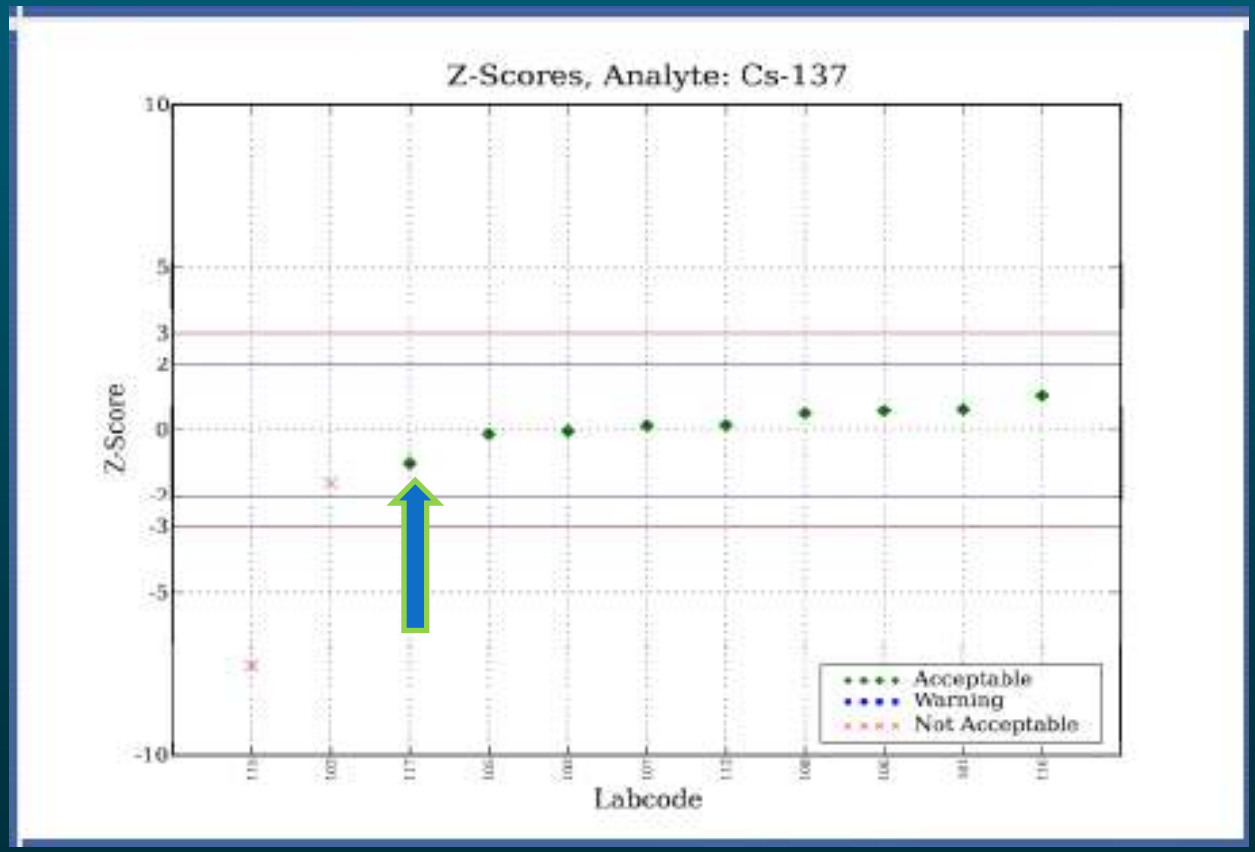
$$\frac{u_c(A)}{A} = \sqrt{\left(\frac{u(m)}{m}\right)^2 + \left(\frac{u(N)}{N}\right)^2 + \left(\frac{u(\gamma)}{\gamma}\right)^2 + \left(\frac{u(\varepsilon)}{\varepsilon}\right)^2 + \left(\frac{u(K)}{K}\right)^2}$$

Where $K = K_1 . K_2 . K_3 . K_4 . K_5$

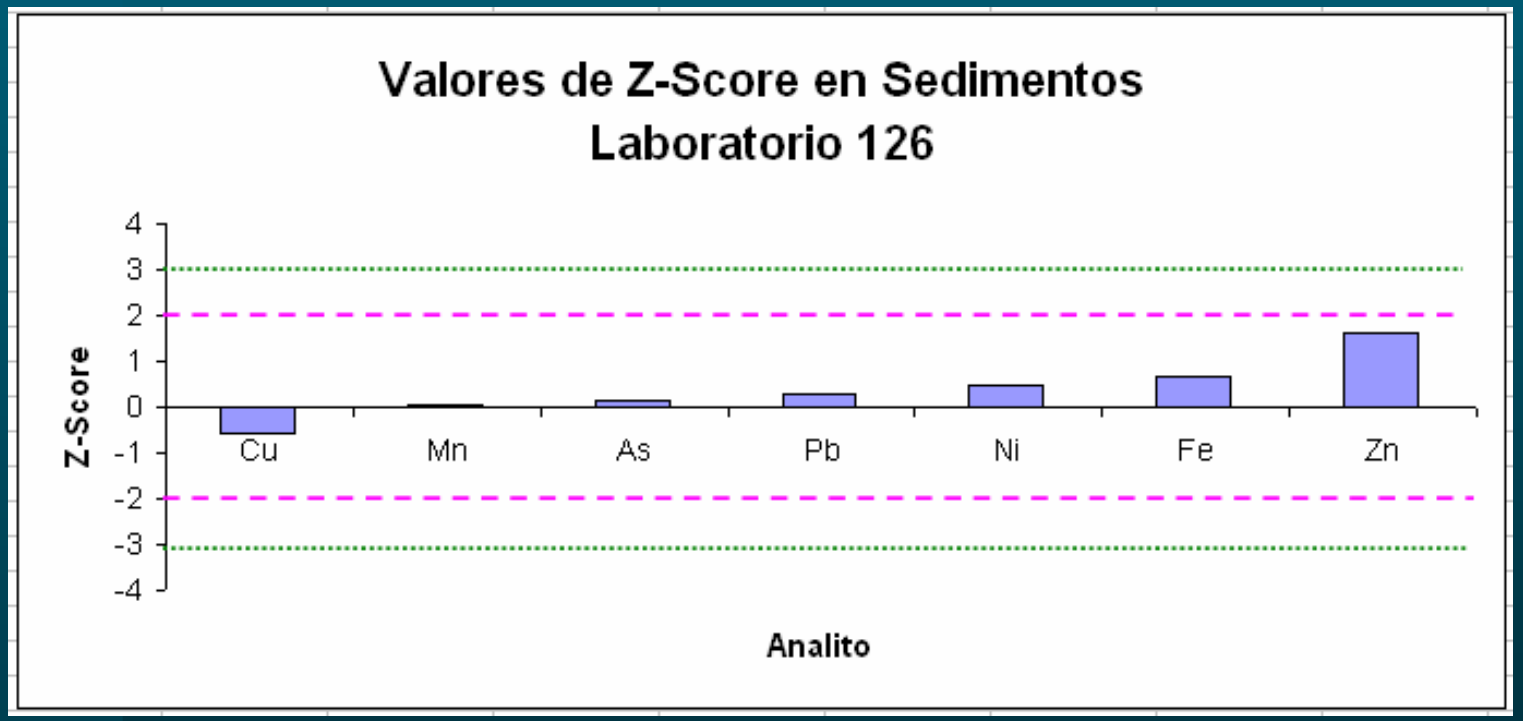
Uncertainty in K:

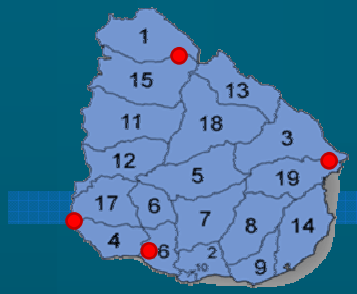
$$\frac{u(K)}{K} = \sqrt{\left(\frac{u(K_1)}{K_1}\right)^2 + \left(\frac{u(K_2)}{K_2}\right)^2 + \left(\frac{u(K_3)}{K_3}\right)^2 + \left(\frac{u(K_4)}{K_4}\right)^2 + \left(\frac{u(K_5)}{K_5}\right)^2}$$

Gamma Spectrometry 2009



X - Ray Fluorescence - 2009

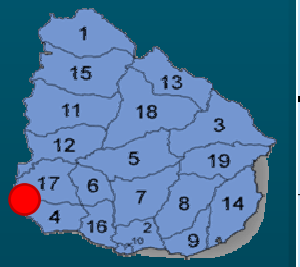




RADIONUCLIDES IN URUGUAYAN SOILS - 2009

Coordinates	Departments	^{40}K (Bq/Kg)	^{226}Ra (Bq/Kg)	^{232}Th (Bq/Kg)	^{137}Cs (Bq/Kg)
32º 26´S 54º 19`W	Cerro Largo	1054.1 ± 100.0	19.3 ± 1.5	75.4 ± 7.0	2.1 ± 0.5
34º 10´S 57º 41`W	Colonia	340.5 ± 30.5	14.1 ± 1.0	19.1 ± 1.5	2.2 ± 0.5
31º 18´S 57º 02`W	Salto	89.5 ± 5.0	7.2 ± 0.5	10.5 ± 1.0	<DL
34º 20´S 56º 43`W	San José	439.5 ± 40.0	23.2 ± 2.0	50.5 ± 5.0	3.2 ± 0.5

RADIONUCLIDES IN COLONIA SOILS 2004 - 2009

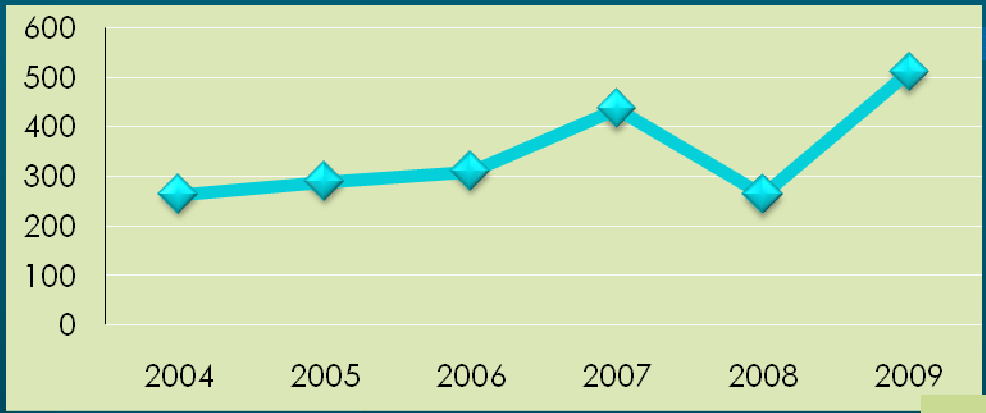


Year	^{40}K (Bq/Kg)	^{226}Ra (Bq/Kg)	^{232}Th (Bq/Kg)	^{137}Cs (Bq/Kg)
2004	491.6 ± 45.0	19.2 ± 1.5	8.6 ± 0.5	2.3 ± 0.5
2005	560.0 ± 50.5	21.6 ± 2.0	35.8 ± 30.5	1.8 ± 0.2
2006	495.0 ± 45.0	20.5 ± 2.0	35.0 ± 30.0	1.2 ± 0.2
2007	255.0 ± 20.5	7.7 ± 0.5	9.4 ± 0.5	1.7 ± 0.2
2009	340.5 ± 30.0	14.1 ± 1.0	19.1 ± 1.5	2.2 ± 0.5

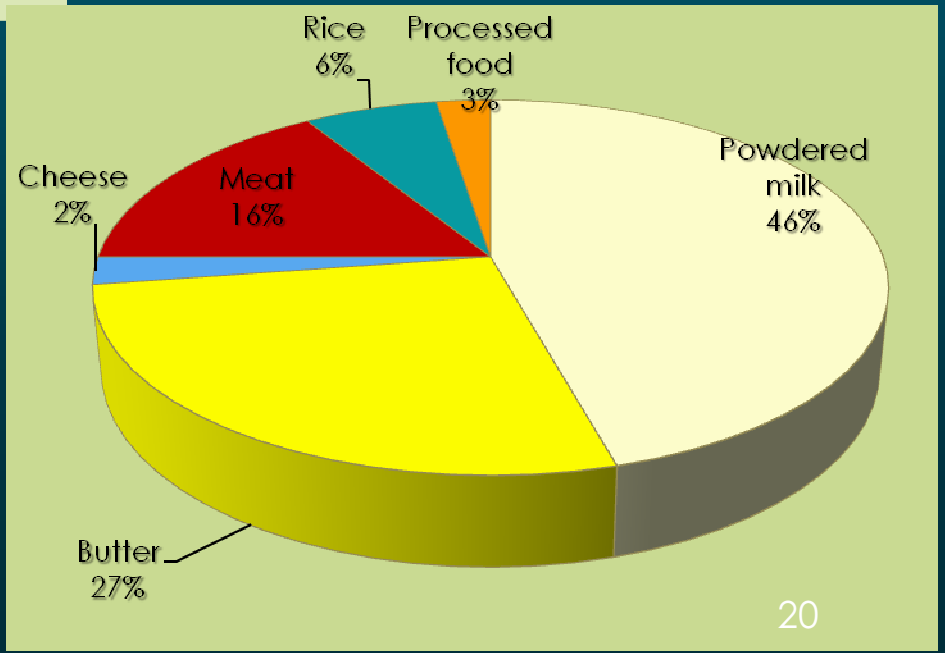
The Uruguayan soils analyzed during 2004 to 2009, show the following ranges:

- ^{226}Ra in Bq/Kg: 7.2 ± 0.5 – 23.2 ± 2.0
- ^{40}K in Bq/Kg: 89.5 ± 5.0 – 1054.1 ± 100.0
- ^{232}Th in Bq/Kg: 5.5 ± 0.5 – 75.4 ± 5.0
- ^{137}Cs in Bq/Kg : < DL – 3.4 ± 0.2

Number of food products analyzed per year



Percentage distributions of food products analyzed during 2009



RADIONUCLIDES IN URUGUAYAN FOOD PRODUCTS – 2009

FOOD	^{40}K (Bq/Kg)	^{226}Ra (Bq/Kg)	^{232}Th (Bq/Kg)	^{137}Cs (Bq/Kg)
Milk	465.0±40.0	1.5±0.5	1.1±0.5	<LD
Butter	48.4±45.5	1.5±0.5	0.7±0.1	<LD
Cheese	72.0±5.0	1.4±0.5	0.6±0.1	<LD
Meat	133.0±10.5	0.8±0.1	0.7±0.1	<LD
Rice	60.9±5.5	0.9±0.1	0.7±0.1	<LD

The Uruguayan powdered milks analyzed during 2009, show the following ranges

^{226}Ra in Bq/Kg: < DL – 6.9 ± 0.5

^{40}K in Bq/Kg: 240.0 ± 20.0 – 645.3 ± 60.5

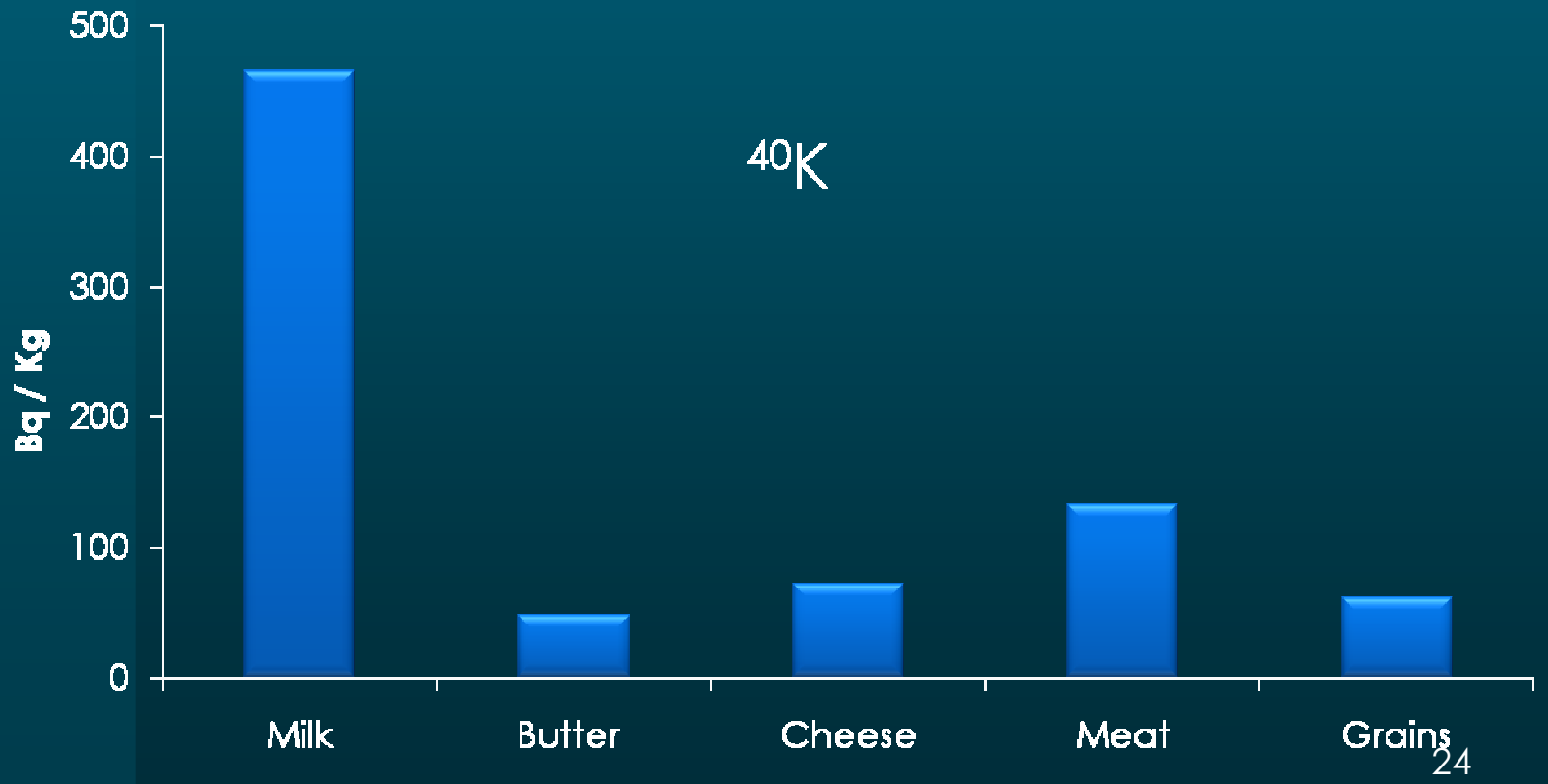
^{232}Th in Bq/Kg: < DL – 2.9 ± 0.2

^{137}Cs in Bq/Kg: < DL

RADIONUCLIDES IN URUGUAYAN MEAT - 2009

	Departments	^{40}K (Bq/Kg)	^{226}Ra (Bq/Kg)	^{232}Th (Bq/Kg)	^{137}Cs (Bq/Kg)
32º 26´S 54º 19` W	Cerro Largo	142.6 ± 10.5	0.8 ± 0.1	0.5 ± 0.1	<DL
34º 10´S 57º 41` W	Colonia	134.9 ± 10.0	1.0 ± 0.1	0.6 ± 0.1	<DL
33º 33´S 26º 53` W	Flores	143.3 ± 10.5	0.6 ± 0.1	<DL*	<DL
33º 47`S 55º 49` W	Florida	152.8 ± 15.0	0.9 ± 0.1	0.7 ± 0.1	<DL
33º 55`S 54º 57` W	Lavalleja	162.0 ± 15.5	0.6 ± 0.1	<DL	<DL
32º 03`S 57º 19` W	Paysandú	142.5 ± 10.5	0.7 ± 0.1	<DL	<DL
31º 28`S 55º 15` W	Rivera	140.3 ± 10.0	0.8 ± 0.1	<DL	<DL
32º 47`S 57º 26` W	Río Negro	126.2 ± 10.0	0.7 ± 0.1	<DL	<DL
31º 18`S 57º 02` W	Salto	147.3 ± 10.5	1.5 ± 0.2	0.5 ± 0.1	<DL
33º 31`S 57º 45` W	Soriano	133.9 ± 10.0	0.7 ± 0.1	<DL	<DL
33º 03´S 54º 13´W	Treinta y Tres	162.4 ± 15.0	1.2 ± 0.2	0.7 ± 0.1	<DL

^{40}K in Food products analysed during 2009



Conclusions

- The obtained results for food products show that the values were not higher than the values of the natural background. It confirms that the concept taken by the government like a "Natural Country" it's real from the radioactive point of view.
- ALARA principle establish that exposure should be "as low as reasonably achievable", Uruguay is working in the regulatory framework to base national regulations on the results of its Environmental Radioactivity Monitoring Plan.
- The obtained results in soils show that the activity concentrations of ^{137}Cs were low and could be attributed to the atmospheric fallout.

Uruguay is working in same way with the Energy Dispersive X ray Fluorescence in the analysis of soils (superficial and in depth) and PM10 – PM2.5 in urban areas.

Site characterization due to the contamination by mobile sources, in the surroundings of a refinery and in Central that use fuel oil.

Enrichment Factor, Multicomponent analysis, Factor analysis are used.


Muchas
gracias!