

CESIUM-137 INVENTORIES IN UNDISTURBED AREAS IN DIFFERENT REGIONS OF BRAZIL

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ABSTRACT

Cesium-137 is an anthropogenic radionuclide introduced in the environment in the early of 1960s to the end of 1970s. The Cesium-137 has very used to assess soil redistribution in the landscape because this is very tight in

the fine soil particles and its movement in the landscape is due to soil redistribution. To use Cesium-137 to assess soil redistribution is need to known the Cesium-137 inventory in an area that not has experimented soil erosion neither soil deposition. So, this work present Cesium-137 inventories in undisturbed areas in different regions of Brazil, from South to Northeast of Brazil. The inventories in these areas represent the variational deposition of Cesium-137 in the whole national territory of Brazil. The inventories of Cesium-137 varied from $200 \pm 15 \text{ Bq.m}^{-2}$ for South region to $15 \pm 2 \text{ Bq.m}^{-2}$ for Northeast region. Moreover, was verified that the Cesium-137 inventories depend on latitude and altitude of the area.

1. INTRODUCTION

Soil loss by erosion is one of agriculture's greatest problems in the world. Although farmers are using soil conservation techniques more frequently, erosion continues to be an important process in soil degradation. Erosion degrades the topsoil, rich in organic matter and plant nutrients, and improves sedimentation reducing the storage of reservoirs.

Conventional erosion determination models (that use plots and are not a good representation of a field) may need much data and require much time to determine variables, such as erodibility. These models are applicable only in regions close to experiments, as in the case of RUSLE (Revised Universal Soil Loss Equation) and WEQ (Wind Erosion Equation). The RUSLE is an empirical equation with regionally dependent parameters. Due to its structure, the RUSLE does not work well on ridge-tillage systems, contouring, and practices such as strip cropping which deposits sediment on the landscape. The WEQ is another empirical equation that may present problems. It is empirically based on the climatic erosivity of Garden City, Kansas, and its extrapolation to other regions with different climatic conditions can lead to large errors in erosion estimation. Other method, the topography survey considers comparisons between eroded and uneroded pedons of the same soil series. One of the major problems of this method to estimate erosion is establishing a benchmark or reference soil for which relative degrees of erosion can be evaluated. Moreover, benchmark or reference soils are difficult to find in regions with cultivated soil.

The most recent alternative method that has been used for soil erosion estimation is the ^{137}Cs methodology¹. Several radioisotopes were introduced in the environment by nuclear explosion, and one that has been widely study is cesium-137. Cesium-137 has a half-life of 30.2 years and its biological behavior is similar to the potassium. When cesium-137 reaches the earth's surface, it is rapidly and tightly adsorbed by fine soil particles. After adsorbed by soil, cesium-137 has a limited movement by chemical processes, and it redistribution in

landscape is due to soil movement by physical processes. Because this, cesium-137 has been widely used in superficial soil erosion assessment. Many works has been developed utilizing cesium-137 methodology in soil erosion in different countries. In Brazil, scarce works has been realized using cesium-137 methodology for soil erosion quantification.

To use cesium-137 methodology, the behavior and depth distribution of cesium-137 in soil, spatial variability and inventory value is necessary. Many authors has devoted works to determine depth distribution, inventories values and spatial variability of cesium-137. Ritchie et al (1974)² presented cesium-137 inventory of 1590 Bq m⁻² in Mississipi, USA. Martz and de Jong³ presented cesium-137 inventory of 2537 Bq m⁻² in Saskatchewan, Canada. Owens and Walling (1996)⁴ presented cesium-137 inventory of 2172 Bq m⁻² in Yendacott, UK and 252,3 Bq m⁻² in Masna, Zimbabwe.

In Brazil, Guimarães (1988)⁵ presented cesium-137 inventory of 306 Bq m⁻² in a basin of Piracicaba, SP and Bacchi et al (2000)⁶ presented cesium-137 inventory of 419 Bq m⁻² in another basin of the same region. Andrello et al (2003)⁷ presented cesium-137 inventory of 292 Bq m⁻² in Londrina, PR.

The aim of this paper was study and compares the spatial variability and inventory value of cesium-137 in undisturbed soil for different regions of Brazil.

2. METHODOLOGY

To determine the depth cesium-137 inventories for undisturbed soil, some areas were sampling at region of Londrina, PR, Porto Alegre-RS, Guarapuava-PR, Três Barras-MG, Bom Jardim – RJ, Aiuaba – CE e Barreiras-BA. IN Londrina city, four areas were sampled: area 1 was a native forest area inside of State University of Londrina; area 2 was a native forest 30 km south faraway of area 1; area 2 was a native forest at a midlle distance between area 1 and area 2; and area 4 was undisturbed pasture closed to area 3. The samples were collected in a grid where was possible, and in the minimum 3 points were collected for areas where not possible to sampling in grid. These samples were used to determine the spatial variability and the average value of cesium-137 inventory. For each site in grid, an area of 1 m² was defined and three replicates of 80 cm² were sampled. Each replicate were formed of three depth increments, 0 – 5 cm, 5 – 15 cm, 15 – 30 cm. The three replicates of each depth increment were bulked so that each site had three depth increment samples.

All samples were dried in open air for 48 hours and sieved in 2 mm mesh. Posterior, the samples were packed in Marinelli beaker of 2 liters for gamma spectrometry in HPGe detector and shield for environmental samples. The time acquisition for each samples was 24 hours and the limit detection was 0.29 Bq kg^{-1} . Cesium-137 activity of samples was determined at the 95% confidence level.

3. RESULTS

The Cesium-137 inventories was determinated using the equation (1):

$${}^{137}\text{Cs inv} = At \cdot \rho \cdot i \quad (1)$$

where At is the Cesium-137 concentration of the sample (in Bq.kg^{-1}), ρ is the bulk density of the sample (in kg.m^{-3}) and i is the sampled depth incremnet (in m). The Cesium-137 concetrantion was determinated by gamma ray spectrometry as explicited above. None of the samples presented Cesium-137 concentration below the detection minimum activity. Table 1 presents the results of Cesium-137 inventories determined in the sampled areas.

Table 1. Cesium-137 inventories for the studied regions.

Brazilian Region		Cesium-137 Inventory (Bq.m^{-2})
Barreras City – Bahia		29 ± 9
Aiuaba City – Ceara		16 ± 1
Três Barras City – Minas Gerais		183 ± 7
Bom Jardim City – Rio de Janeiro		232 ± 30
Londrina City - Paraná	Área 1	202 ± 15
	Área 2	296 ± 15
	Área 3	231 ± 19
	Área 4	211 ± 10
Guarapuava City – Paraná		420 ± 39
Porto Alegre City – Rio Grande do Sul		246 ± 15

The results presented in table 1 show how the Cesium-137 inventory change with the latitude. As the major pecentage of radioactive fallout in south hemisphere is due to atmospheric test

of nuclear weapons that reach the stratosphere in the explosion, and the reinjection of this debris in to troposphere occur in specific season in the year (early of the spring) and in middle latitudes (Glasstone, 1957)⁸, we can see that region closed to the equator has a minor fallout of Cesium-137. More over, Guarapuava city has a altitude of 1000m above sea level, and because of this present more Cesium-137 inventory. The altitude of the other studied regions is around of 100 – 500 m above sea level. The average Cesium-137 inventory for the studied areas is $206 \pm 117 \text{ Bq.m}^{-2}$, given a spatial variability of 57%. However, when it is used only the Cesium-137 inventory for a specific region, as example Londrina region, the average cesium-137 inventory is $235 \pm 42 \text{ Bq.m}^{-2}$, with a spatial variability of 18%. To applied Cesium-137 methodology for soil erosion assessment in Brasil, it is clear that is necessary to use a Cesium-137 inventory reference determinated closed to the region that is intended to apply this methodology.

The representative depth distribution of Cesium-137 in the soil profile is presented in Figure 1 for the studied areas. As can see of Figure 1, the Cesium-137 depth distribution present a exponential decay, as is observed for major of stable undisturbed soil.

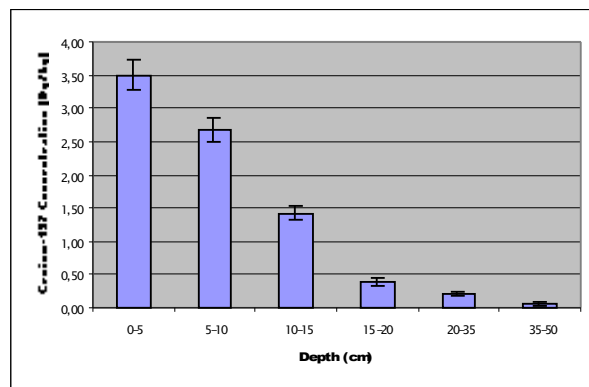


Figure 1. Representative Cesium-137 depth distribution for the studied areas.

3. CONCLUSION

Brazil is a great country with great inhomogeneity, as cultural as environmental and is necessary to study very weel each of this inhomogeneity. Cesium-137 has a valuable tool to assess the soil redistribution in several environments, and in Brazil this tool has very little application. This study has intended to contribute in show how the Cesium-137 inventories change from one extreme to another of Brazil. The Cesium-137 methodology can be applied for different environments and in Brazil this can by applied in several regions, since is

possible to found Cesium-137 in all regions of Brazil. Although, in the northeast of Brasil the Cesium-137 concentration is low, this concentration is above of minimum detectable activity using a beaker Marinelli geometry and HPGe detectors. So, is possible to use Cesium-137 methodology to study soil redistribution in this environment, as presented in Soares Neto (2005)⁹.

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