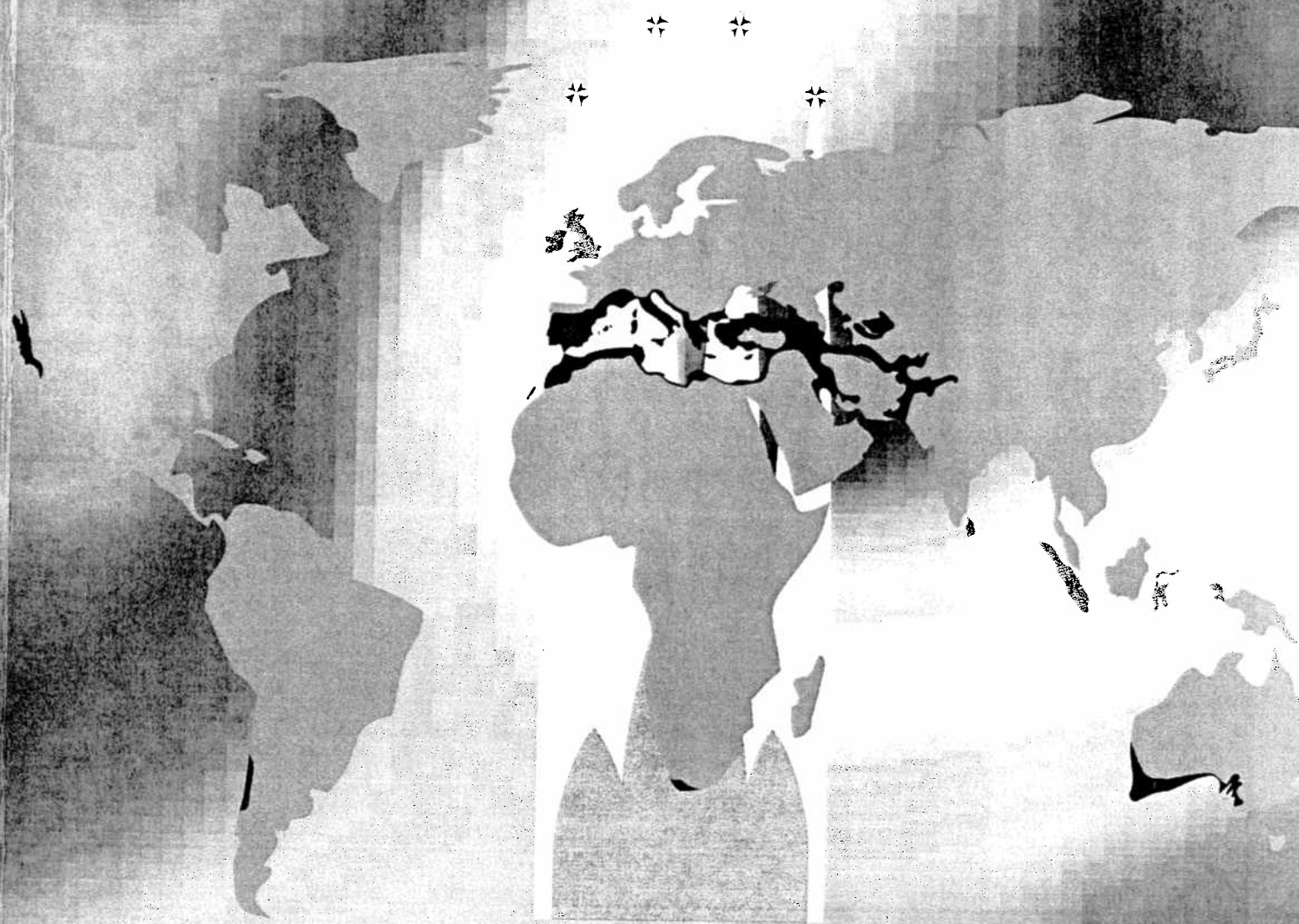


EXTENDED ABSTRACTS

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RADIONUCLIDES IN SOILS FROM CATALONIA: INVENTORY AND VERTICAL DISTRIBUTION

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INTRODUCTION

Soils in the Earth surface show a differential distribution of natural and artificial radionuclides in depth. Some of the radionuclides (⁴⁰K, ²²⁶Ra, etc.) have their source on the soil itself. The thermonuclear explosions (1945-1970) and, more recently, the accident at Chernobyl, incorporate some artificial radionuclides, such as ¹³⁷Cs, into the environment. Once on the soil surface (by wet and dry fallout) and being fixed to the silt-clay soil particles, these radionuclides undergo several processes of both downwards and horizontal transport (by soil erosion or agricultural practices).

The Chernobyl accident, May 1986, meant a significant contribution of ¹³⁷Cs on the Earth's surface of the north hemisphere. Almost all the territory of Catalonia (NE Spain) suffered an additional input of ¹³⁷Cs although not everywhere in the same manner. The values of ¹³⁷Cs activity detected were very changeable even in nearby areas. The most influenced zone of Catalonia was the Pyrenees Range, where ¹³⁷Cs concentrations reached values that ranged between 125 and 4000 Bq/m². During the last decade, the effects of fallout on soils of this region have been studied in a general way, but no detailed studies of the distribution along the area have been made up to now. The purpose of the work was to establish the total inventory as well as the vertical distribution of the radionuclides found in the soil. Likewise, a mean depth factor has been defined (*Pm*), in order to evaluate the mean penetration of the radioisotopes in the soil profiles.

MATERIALS AND METHODS

The study was carried out in two areas of Catalonia: one in a seminatural area in the pre-Pyrenees and the other one in an agricultural zone in the Vallès-Penedès depression. In each area of study, soil profiles in depth have been sampled accounting both, the position within the basin and the previous knowledge of the area. At the Vallcebre catchment area (Pre-Pyrenees) three soil profiles were done, in accordance with the known geomorphic processes and differentiated zones existing in the basin. In the same way, at the experimental farming station of Torre Marimon, two profiles were chosen, following topographic criteria, in a 10 Ha cultivated catchment.

The profiles were carried out following the methodology recommended by Walling and Quine (1993). Each profile was sampled in 3 cm intervals down to a total depth of at least 24 cm, where no significant radionuclides concentrations were found. These soil sub-samples were

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air dried in the laboratory for about 3 days. Afterwards, the sample was disaggregated and sieved to obtain particles less than 2 mm of grain size to perform gamma spectrometry analysis. All the samples were counted for times ranging between 24 and 48 hours, using a (Ge(int)) detector surrounded by a 10-cm-thick lead shield, with a detector efficiency of 20% and a resolution of 1,73 keV (at 1332 keV). The radioisotopes evaluated were ^{137}Cs , ^{210}Pb , ^{40}K , ^{234}Th , ^{232}Th and ^{214}Pb . $^{210}\text{Pb}_{\text{excess}}$ is calculated subtracting ^{210}Pb total activity from ^{214}Pb activity which is in secular equilibrium with the ^{226}Ra in the soil.

RESULTS AND DISCUSSION

The total inventory of fallout radionuclides was very different for the two basins considered. This is in agreement with the fact that they are geographically apart and also was expected from its annual precipitation. Variations of the other radionuclides activities only reflects the different kind of soils we were studying.

The results for the profiles in the pre-Pyrenees area show a direct relationship between soil drainage properties and the ^{137}Cs activity in the different soil layers. Within the agricultural zone, vertical distribution of ^{137}Cs is related to topography, reflecting soil loss at upper levels and accumulating processes downwards. However, soil redistribution caused by tilling activities is not the only explanation for the variations of ^{137}Cs concentration. At this zone, the textural properties of the soil play an important role.

Vertical distribution of deposited radionuclides in the soil profile (incorporated by fallout) is usually described as an exponential function of depth that can be written as:

$$\text{Activity}(\text{Bq} / \text{kg}) = C \cdot e^{-bz}$$

Profiles at "Cal Parisa" basin showed the typical vertical distribution of fallout radionuclides for undisturbed soils reflecting the low mobility of the radionuclides. Both ^{137}Cs and $^{210}\text{Pb}_{\text{excess}}$ were concentrated in the upper 10 cm of the soil. Fitting the previous exponential function to the vertical distribution values for the radionuclides we have found curves that fit with a correlation values higher than 0,85 for ^{137}Cs and higher than 0,93 for $^{210}\text{Pb}_{\text{excess}}$.

At Torre Marimon, no exponential function could be fit with the activity values. The agricultural practices made a redistribution of the soil.

A new parameter Pm , to reflect the penetration of the fallout radionuclides into the soil, was proposed to study vertical distribution of the radionuclides in soils. We have found resemblance between Pm values for ^{137}Cs and $^{210}\text{Pb}_{\text{excess}}$ (coming from fallout). The new parameter, Pm , was defined as:

$$Pm_{\text{profile}}(\text{cm}) = \frac{\sum_{\text{horizon}} \text{depth}(\text{cm}) \cdot \text{Activity}(\text{Bq} / \text{kg})}{\text{Profile activity}(\text{Bq} / \text{kg})}$$

This factor calculated for each profile, presented related values for the behaviour of both, ^{137}Cs and $^{210}\text{Pb}_{\text{excess}}$. In all cases, Pm values for $^{210}\text{Pb}_{\text{excess}}$ were slightly lower than those reported for ^{137}Cs .

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REFERENCES

Walling, D.E. and Quine, T., Use of ^{137}Cs as a tracer of erosion and sedimentation: Handbook for the application of the ^{137}Cs technique. *Overseas Development Administration Research Scheme R4579 p. 196*, Dep. of Geography Univ. of Exeter, 1993.

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INTRODUCTION

The Chernobyl accident, May 1986, meant a significant contribution of ¹³⁷Cs on the Earth's surface of the north hemisphere. Almost all the territory of Catalonia (NE Spain) suffered an additional input of ¹³⁷Cs although not everywhere in the same manner. The values of ¹³⁷Cs activity detected were very changeable even in nearby areas. The most influenced zone of Catalonia was the Pyrenees Range (N Catalonia), where ¹³⁷Cs concentrations reached values that ranged between 125 and 4000 Bq/m².

STUDY AREAS

The study was carried out in two areas of Catalonia: one in a semi-rural area in the pre-Pyrenees and the other one in an agricultural zone in the Vallès-Penedès depression. In each area of study, soil profiles in depth have been sampled according both, the position within the basin and the previous knowledge of the area. At the Vallès-Penedès depression (Pre-Pyrenees) three soil profiles (VC1, VC2 and VC3) were done, in accordance with the known geomorphic processes and differentiated zones existing in the basin. In the school of Torre Marimón (Vallès-Penedès depression), three profiles were selected. One reference profile (TMB), in an undisturbed site, was done for the inventory determination. The other two profiles (TMA and TMC) were chosen, following topographic criteria, in a 10 Ha cultivated catchment.

RESULTS

The total inventory of fallout radionuclides (¹³⁷Cs, ²¹⁰Pb) was very different for the two basins considered. This is in agreement with the fact that they are geographically apart and also was expected from its annual precipitation. Variations of the other radionuclides (⁴⁰K, ²²⁶Ra and ²³²Th) activities only reflects the different kind of soils we were studying.

Vertical distribution of deposited radionuclides in the soil profile (incorporated by fallout) is usually described as an exponential function of depth that can be written as:

$$Activity(Bq/kg) = C \cdot e^{-k \cdot z}$$

Profiles within the Vallès basin showed the typical vertical distribution of fallout radionuclides for undisturbed soils. Both ¹³⁷Cs and ²¹⁰Pb_{excess} (which is unimpacted by the content of ²¹⁰Pb in soils) were concentrated in the upper 10 cm of the soil. Fitting the previous exponential function to the vertical distribution values for the radionuclides we have found curves that fit with a correlation values higher than 0.85 for ¹³⁷Cs and higher than 0.93 for ²¹⁰Pb_{excess}.

At Torre Marimón, an exponential function could be fit with the activity values, except for the inventory profile. The agricultural practices used a redistribution of the soil.

A new parameter *Pm*, to reflect the penetration of the fallout radionuclides into the soil, was proposed to study vertical distribution of the radionuclides in soils. We have found resemblance between *Pm* values for ¹³⁷Cs and ²¹⁰Pb_{excess}. The new parameter, *Pm*, was defined as:

$$Pm_{profile} (cm) = \frac{\sum_{depth} depth(cm) \cdot Activity(Bq/kg)}{Activity(Bq/kg)}$$

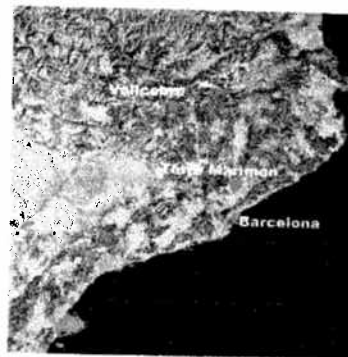
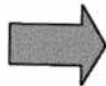
CONCLUSIONS

Profiles in the pre-Pyrenees area show a relationship between soil properties and the ¹³⁷Cs activity in the different soil layers. Within the agricultural zone, vertical distribution of ¹³⁷Cs is related to topography, reflecting soil loss at upper levels and accumulating processes downwards.

Pm factor calculated for each profile exhibits a remaining behaviour of both ¹³⁷Cs and ²¹⁰Pb_{excess} in depth. In all profiles, *Pm* values for ²¹⁰Pb_{excess} were slightly lower than those calculated for ¹³⁷Cs.

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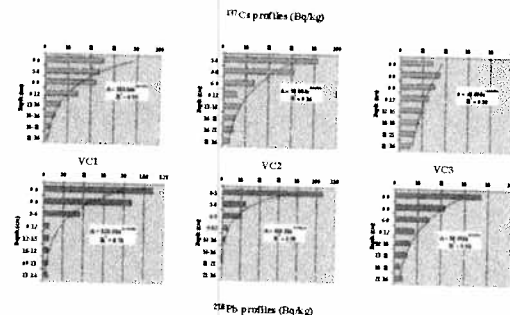
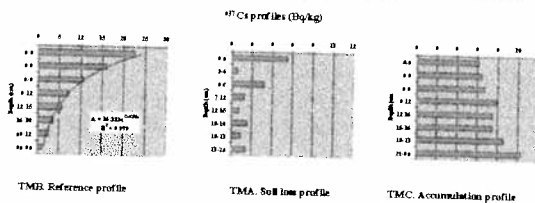
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Experimental basin of Vallcebre



Farming School "Torre Marimón"



Soil radioactivity (Bq/g) and total inventory (Bq/m²) for ¹³⁷Cs and ²¹⁰Pb_{excess}

	VC1	VC2	VC3
¹³⁷ Cs (Bq/m ²)	3630 ± 217.8	1789 ± 89.5	1072 ± 75
²¹⁰ Pb _{excess} (Bq/m ²)	4055 ± 608.3	1149 ± 114.9	567 ± 57
⁴⁰ K (Bq/kg)	368.3 ± 64.9	54.8 ± 8.1	308.9 ± 15
²²⁶ Ra (Bq/kg)	25.3 ± 0.1	33.2 ± 3.2	28.1 ± 1.3
²³² Th (Bq/kg)	38.1 ± 7.9	7.2 ± 0.2	39.6 ± 1.7

Soil radioactivity (Bq/g) and total inventory (Bq/m²) for ¹³⁷Cs and ²¹⁰Pb_{excess}

	TMB	TMA	TMC
¹³⁷ Cs (Bq/m ²)	2340 ± 23.4	437 ± 30.6	2637 ± 263.7
²¹⁰ Pb _{excess} (Bq/m ²)	5004	46.2	
⁴⁰ K (Bq/kg)	673 ± 18.1	524 ± 10.2	715 ± 20
²²⁶ Ra (Bq/kg)	24.7 ± 1.1	17.4 ± 1.2	19.8 ± 0.8
²³² Th (Bq/kg)	43.1 ± 1.6	41.8 ± 3.3	36.5 ± 1.8

Mean Penetration Depth (cm) for ¹³⁷Cs and ²¹⁰Pb_{excess}

