

SURVEY OF THE ^{137}Cs CONTAMINATION IN BELGIUM AFTER THE CHERNOBYL ACCIDENT BY *IN-SITU* GAMMA SPECTROMETRY

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ABSTRACT

The residual radiocesium concentration, more than 10 years after the Chernobyl accident, is measured at different sites on the Belgian territory by means of in-situ γ -spectrometry. A possible link between the rainfall at the beginning of May 1986 and the actual cesium concentration is investigated. The radiological impact of this contamination, even in the most affected regions in the Ardennes, is very small (appr. 6 μSv per year).

INTRODUCTION

On Friday, May 2, 1986 a cloud containing radioactive particles from the Chernobyl accident reached Belgium during the morning. At noon, an activity in the air of 58 Bq/m^3 was measured in Gent. Together with short living isotopes (^{131}I , ^{132}Te , etc.) a concentration of 5 Bq/m^3 of the long living ^{137}Cs was registered (half-live 30 y). One day after, on Saturday, May 3, the air activity was already reduced to a few percent of this peak value. In fig. 1 a typical γ -spectrum of the air activity on May, 2 at noon is displayed.

The aim of this research is to evaluate residual radiocesium in different parts of Belgium by means of in-situ γ -spectrometry.

EXPERIMENTAL PROCEDURE

The *in-situ* γ -spectrometry technique using efficient high resolution Ge-detectors allows a fast, accurate and sensitive determination of radionuclides in the soil. This method is described by Beck et al. (1) and more recently by Miller et al. (2, 3). The ICRU report nb. 53 (4) (December 1994) gives a complete review on the subject.

In this work, the measurements were performed with two different measuring chains, one of the University Gent (RUG) and the other of the SCK-CEN Mol. The RUG detector is a 34 % p-type (energy resolution 1.75 keV) with a 7.5 litre MAC-dewar. The SCK chain uses an n-type HPGe coaxial detector (resolution 1.83 keV and efficiency 10%) mounted in a small multi-attitude cryostat.

Figure 2 gives a typical spectrum of a measurement with the RUG-detector in a high activity region; one can easily see the 662 keV ^{137}Cs line together with the 1461 keV ^{40}K line and the typical lines of the natural U and Th series. A measuring time between 30 and 60 minutes allows accuracy better than 15% at the actual remaining ^{137}Cs concentrations from Chernobyl in Belgium (typical values from .4 to 6 kBq/m² or in older units .01 to .16 Ci/km²). Even a quick 10 minutes test measurement can give a good indication on the concentration.

Both spectrometers were calibrated completely independent and intercompared during two in-situ measurements. All results are in good agreement within the total experimental error of about 15%.

Laboratory analysis at the SCK-CEN of soil samples confirms the in-situ data. Details about the calibrations and the intercomparison are given in internal reports (5, 6).

After some preliminary measurements in Gent, Mol and the Ardennes, a systematic survey of the Belgian territory (30507 km²) by in-situ gamma spectrometry has been carried out. About 60 measurements, equally distributed across the country were executed. For all measurements, pastures that we know as undisturbed during the last 12 years were selected.

A drawback of the method is its dependence on the assumption made on the depth distribution of fallout in the soil. In the calculations of the ^{137}Cs concentration we use an exponential depth profile with relaxation parameter $\alpha = 20 \text{ m}^{-1}$ (equivalent with a relaxation length of 5 cm). This value was derived at the SCK-CEN from the comparison of the in-situ measured ^{137}Cs surface activity, S_A , with the mean activity \bar{S} of soil samples (depth $D = 10$ cm) taken at the same location:

$$\bar{S} = \frac{(1 - e^{-D \cdot \alpha})}{\rho \cdot D} \cdot S_A$$

In fact, the appropriate relaxation parameter is found by varying the α -value in the calculation of the surface activity, until the right hand side of the expression matches the left-hand side. A typical value was deduced from measurements at 23 locations.

Our actual choice of $\alpha = 20 \text{ m}^{-1}$ complies with the data for aged fallout (table 3.5 in (4)).

RESULTS AND INTERPRETATION

The map (figure 3) summarises the results of our survey for ^{137}Cs . This contour map was created from our database with the Kriging gridding method using SURFER for Windows (7). The numbers on the axes are the Lambert co-ordinates, a local system widely used in Belgium; the country is situated between 49.5 and 51.5 N and 2.5 and 5.5 E. Figure 4 shows a post map displaying the various measuring points.

The occurrence of regions with higher concentration (a peak value of 6.6 kBq/m^2 was obtained near Tintigny) coincides roughly with the zones of higher deposition as mentioned by Govaerts et al. (8). Based on the rainfall data from 270 observation points obtained from the Royal Meteorological Institute (KMI - Ukkel) we also have drawn contour maps of the rainfall in the critical days of May 1986. Only on May 3, a considerable rainfall occurred in the eastern part of Belgium (fig. 5). By comparing the maps of fig. 3 and fig. 5, also some overall correlation can be found between that rainfall and the residual ^{137}Cs concentration, but the maximum values do not coincide. This can be explained by the fact that the rainfall data are integrated over the whole day of May 3. During this day there was a considerable variation in air activity and time difference between the maxima in rainfall and the air activity remains unknown.

Some discrepancies between neighbouring points can be explained by the variations in the use of the grassland. Although our careful selection of the measuring sites, it can not be completely excluded that some pastures have been ploughed or modified in some way, disturbing the natural distribution of the cesium.

CONCLUSIONS

In-situ gamma spectrometry has proven to be a very powerful tool in the determination of low-level soil contamination with radioactive material. In the case of the Chernobyl related cesium deposition, the situation in Belgium is very similar to this in our neighbouring countries. Even in the rare regions with relative high concentrations (6 kBq/m^2), the additional contribution of the Chernobyl cesium to the radiation dose is extremely low. Using a conservative conversion factor of $1 \text{ } \mu\text{Sv/year}$ per kBq/m^2 , based on the data in the proceedings of the Minsk conference (9), the maximal annual extra dose of $6 \text{ } \mu\text{Sv}$ is negligible in comparison with the normal annual dose of 3.5 mSv .

This paper is an updated version of our publication in Health Physics (10) with new additional measuring points.

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REFERENCES

1. Beck, H., De Campo J. and Gogolak C. , USDOE Report HASL-258 (1972)
2. Helfer, I. and Miller, K. , Health Physics, 55 No 1, 15-29 (1988)
3. Miller, K. And Shebell P. , EML - USDOE , EML-557 (1993)
4. ICRU report 53, ICRU, Bethesda, Maryland, USA (1994)
5. Van Waeyenberge B., thesis Univ. Gent, (1995)
6. Pommé S. , internal report SCK-CEN, BLG-695 (1995)
7. SURFER for Windows, User Guide, Golden Software Inc., Golden, Colorado, USA
8. Govaerts P., Fieuw G., Deworm J.P. and Zeevaert Th., report SKV-86-1013 SCK-CEN, Mol
9. Balonov, L.; Jacob, P.; Likhtarev, I.; Minenko, V. Pathways, Levels and Trends of population Exposure after the Chernobyl Accident. In: The radiological consequences of the Chernobyl accident, Proceedings of the first international conference (Minsk, Belarus 1996), EUR 16544 EN, ISBN 92-827-5248-8; 238-249; 1996
10. J.Uyttenhove, S. Pommé, B. Van Wayenberge, F. Hardeman, J. Buysse, J-P. Culot, Health Physics, vol. 73, Nb. 4 (1997) 644-646

Figure 2: typical *in situ* gamma spectrum measured in Tintigny (Ardennes)
The calculated ^{137}Cs concentration is about 6600 Bq/m^2

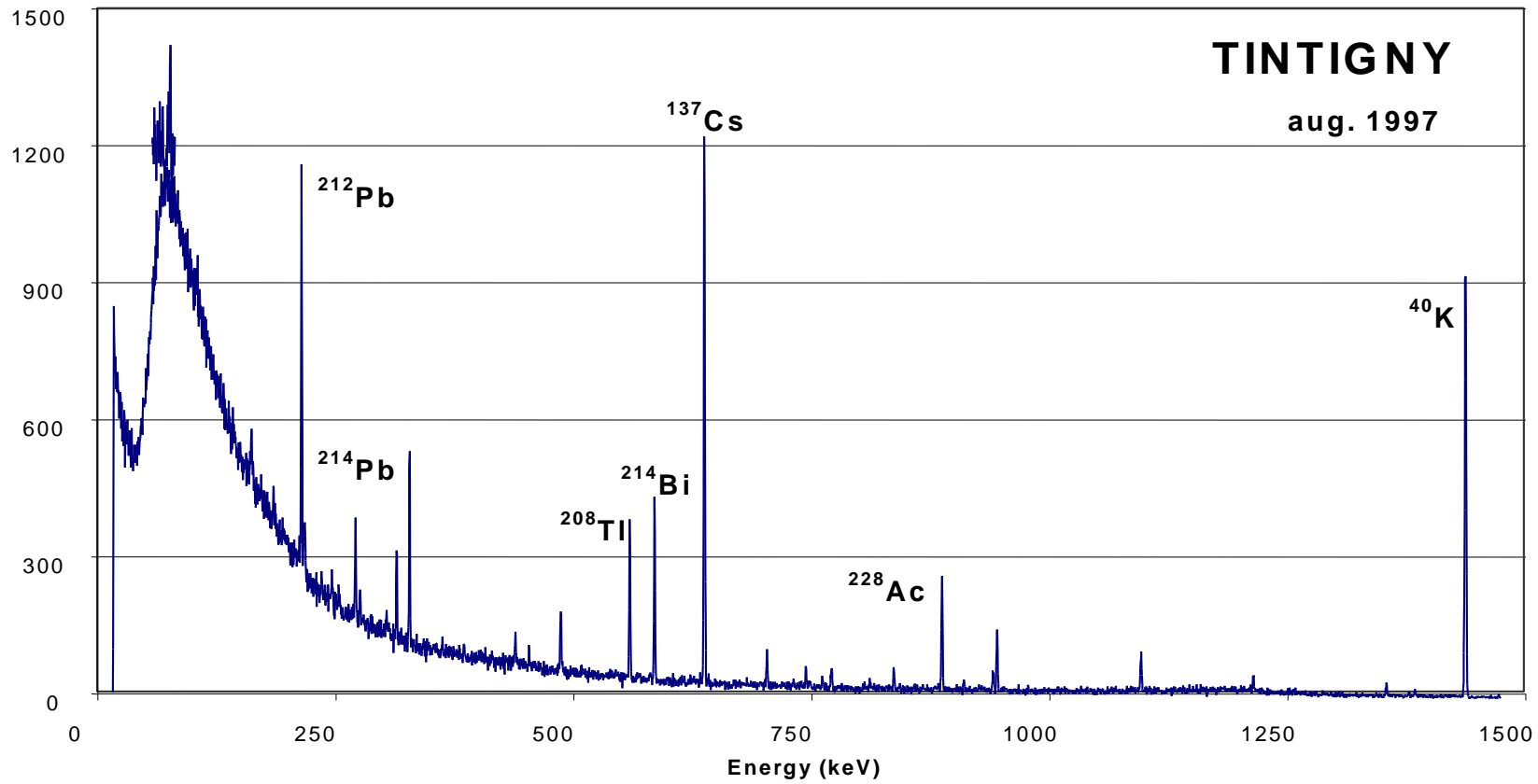


Fig. 3: Contour map with ^{137}Cs concentration in Bq/m^2 ($1/\alpha = 5 \text{ cm}$)

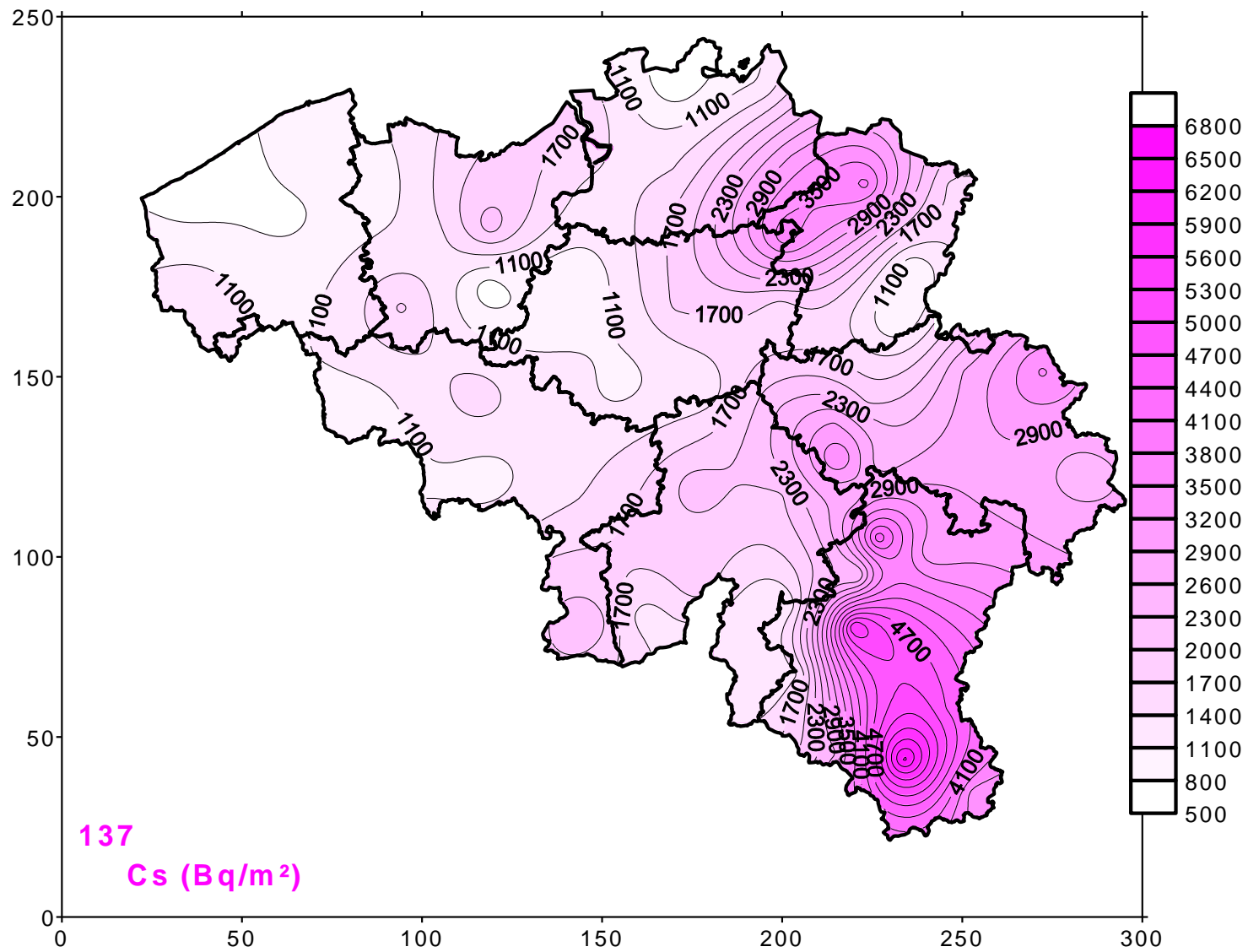


Fig. 4: Post map

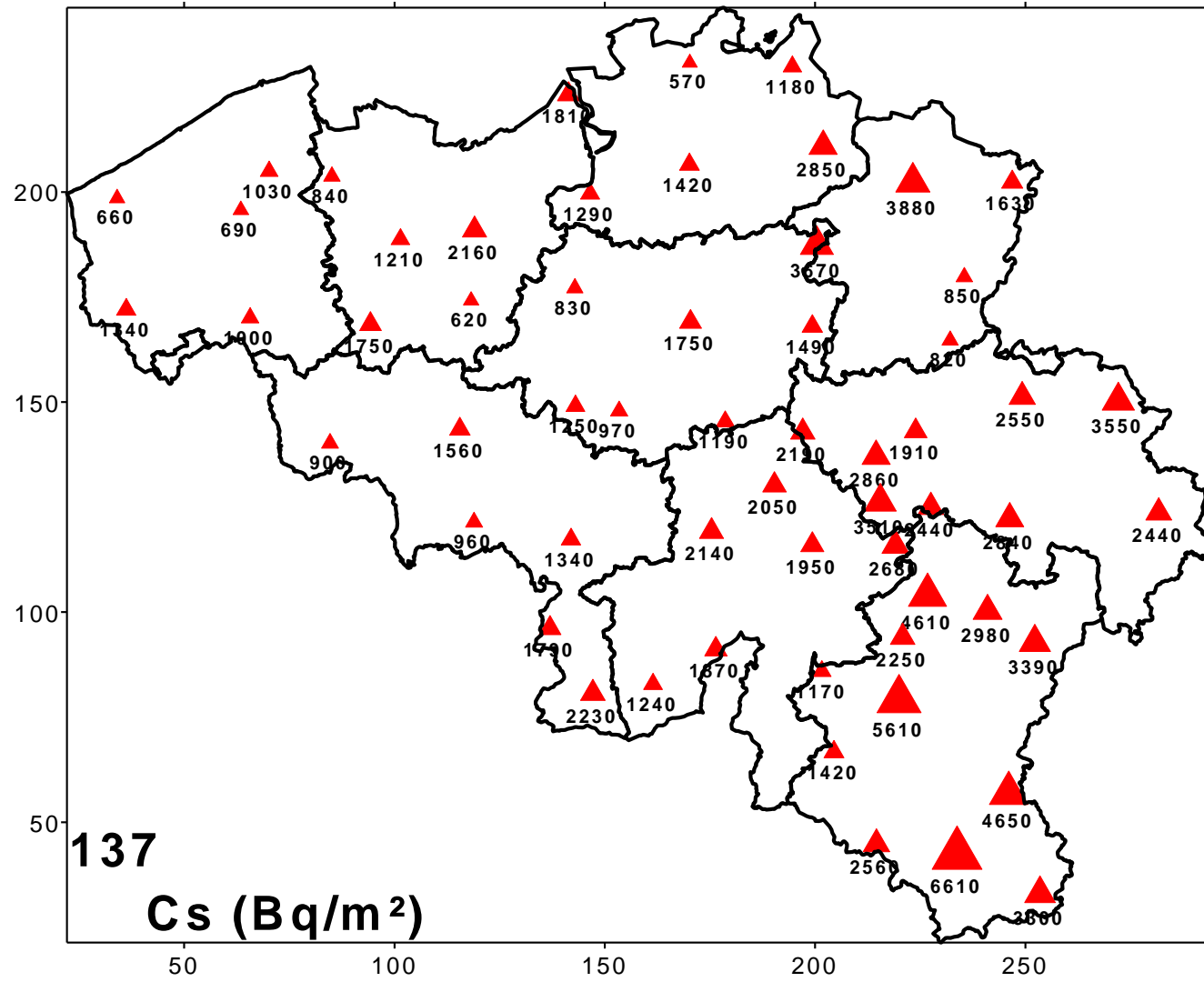


Fig. 5: Contour map with rainfall data for Belgium (in 0.1mm) on May 3, 1986

