MEASURED DEPOSITION VELOCITIES AND RAINOUT COEFFICIENTS AFTER THE CHERNOBYL ACCIDENT COMPARED WITH THEORETICAL MODELS AND EXPERIMENTAL DATA

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INTRODUCTION

The determination of different radioecological parameters for the calculation of the transport of radionuclides in the environment was, besides radiation protection measurements, an important aim of the post Chernobyl measurements in Aachen. As the growth had just begun, the only vegetations which allowed extensive deposition measurements during the first days were grass and stinging nettles.

DRY DEPOSITION OF PARTICLEBOUND NUCLIDES AND RADIOIODINE ON GRASS

Fig. 1 shows the time integrated activity concentration in the air at Aachen for Cs 137 and I 131; the concentrations of other important nuclides are published in /1/. About 35% of the total amount of iodine was bound to particles. The elemental fraction of the gazeous iodine was derived from /2/, /3/. Besides iodine, all nuclides detected in Aachen were particlebound. The activity size-distributions of the particlebound nuclides were measured with an impactor. The graphs (also given in Fig. 1) are the result of these measurements. They are corrected for the separation curves and the wall losses of the instrument. The deposition of airborne radionuclides on a green near the institute was measured hourly. Until the first rainfall (6.30 p.m., 3rd of May) the deposited activity of particlebound nuclides (e.g. Cs 137, fitted curve on the left hand side of Fig. 2) increased continuously. The dry deposition on extremely short or

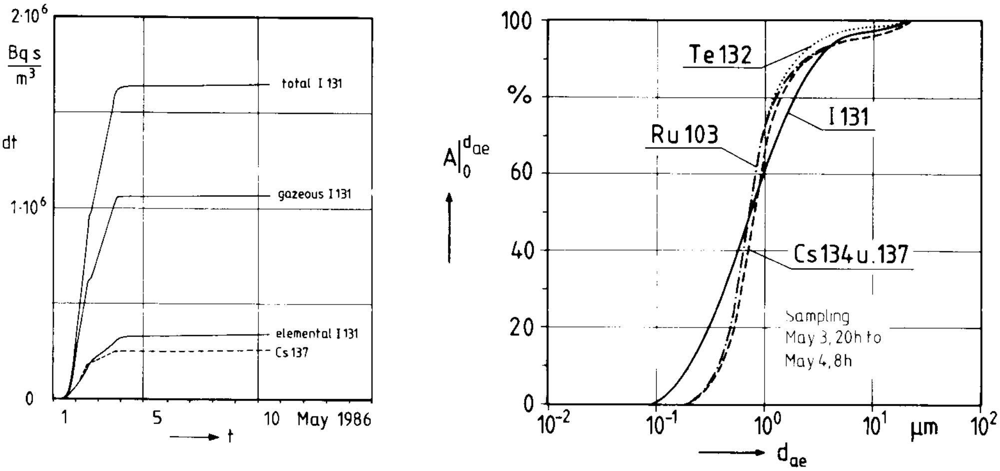

Fig.1: Time-integrated activity concentration of Cs 137 and I 131 and activity size distribution for some particlebound radionuclides in the air at Aachen /1/.

long grass yields to strong variations in the deposition per unit ground area (points in brackets in Fig.2). The strong variation of the deposition of Cs 137 per unit ground area after the rain is mainly caused by the inhomogeneous distribution of the particles on the grass and the small sampling areas. The variation of the specific activity is much smaller /1/. In contrary to the dry deposition of particlebound nuclides, the concentration of I 131 on grass showed two peaks before the rainfall (right hand side of Fig. 2). This peaks can be explained with desorption of that part of the gazeous iodine, which was not taken up into the plants' tissue. The desorption after sunrise could have been caused by the evaporation of the intense overnight dewfall. The extreme decrease of the iodine concentration in the air in the afternoon of May 2 (after the passage of the maximum concentration) could have influenced the desorption too. In addition to the deposition measurements on grass, a very early deposition on stinging nettles is shown in Fig.2, too.

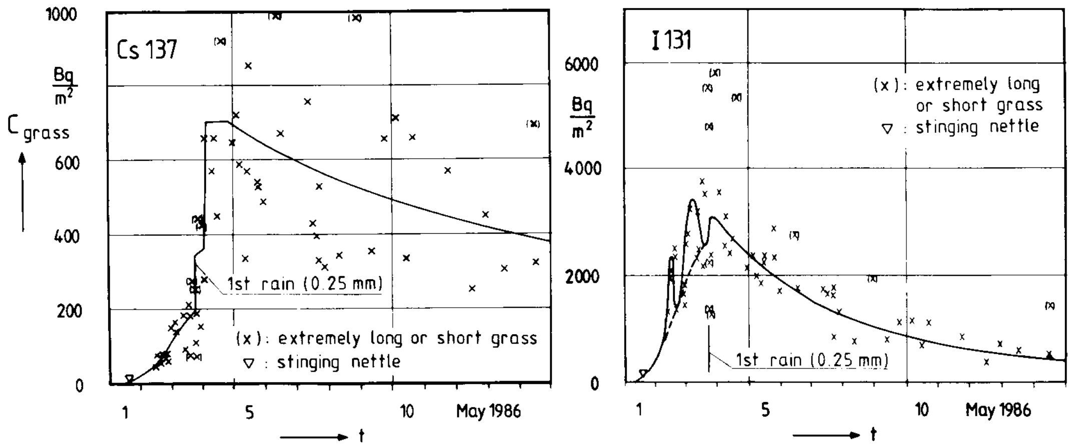

Fig. 2: Measured depositions per unit ground area for Cs 137 and I 131 on grass at Aachen, specific activity see /1/.

The measurements allow the calculation of the deposition velocity by dividing the deposited activity per unit ground area (from Fig. 2) by the time integrated activity concentration in the air (from Fig. 1). The result of this calculation -for the single measurements as well as for the fitted curves- is shown in Fig. 3. In the case of Cs 137, the deposition velocities range from 0.025 to 0.11 cm/s, including the deposition on extremely long and short grass. The mean is approximately 0.07 cm/s. As the separation of deposited particlebound iodine from gazeous species was not possible, the measurements only allow the derivation of a deposition velocity for the total amount of iodine. Ignoring the peaks in Fig. 2, the deposition velocity is around 0.15 cm/s (crosses and dashed curve in Fig. 3). If the peaks of the iodine deposition are included, the deposition velocities range from 0.13 to 0.28 cm/s. In order to predict the dry deposition, models have been developed during the recent years /4/. These models take account of the activity size distribution of particlebound radionuclides, the wind speed and the kind of vegetation. On the right hand side of Fig. 3, the deposition velocity for grass resulting from the model is shown for three different wind speeds. Additionally, the means and ranges of published experimental data /4/ are shown. With the aid of the measured activity size-distributions (Fig. 1) and the wind speeds during the period of dry deposition, deposition velocities can be calculated. As the monitored wind speed ranged from 2 to 4 m/s, the calculated deposition velocity for Cs 137 lies between 0.03 and 0.07 cm/s for grass of 10 cm height. This corresponds very well with the

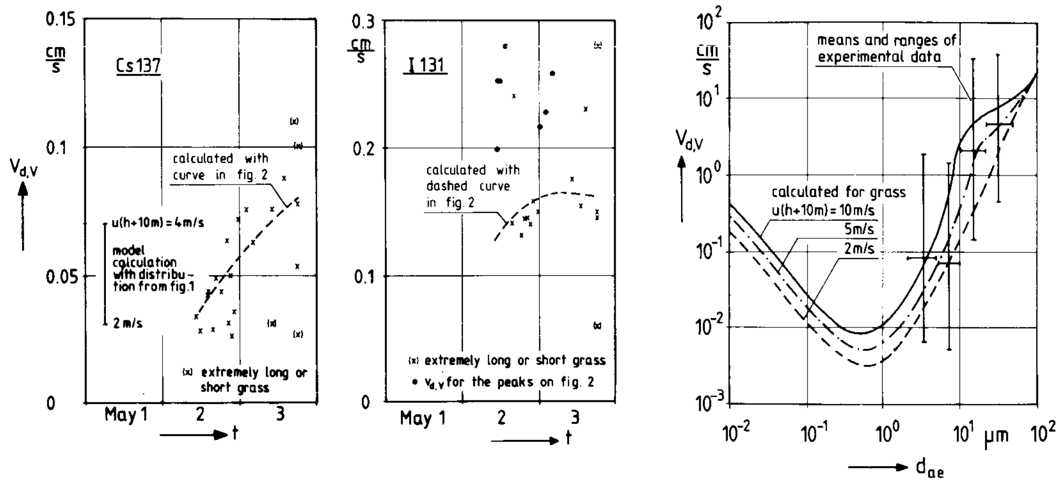

Fig. 3: Deposition Velocities for Cs 137 and I 131 on grass as results of the measurements and model calculations /4/.

deposition velocities derived from the post-Chernobyl measurements. Model calculations with the activity size-distribution of particlebound I 131 from Fig. 1 yield to nearly the same deposition velocity for particlebound I 131 as for Cs 137. With a relationship between particlebound, elemental and organical iodine of 35:20:45 /2/, /3/, thus the deposition velocity for elemental iodine can be estimated. It turns out to be approximately 0.7 cm/s (without the peeks of grass contamination). Considering all measured grass contaminations, the deposition velocity for elemental iodine ranges from 0.5 to 1.2 cm/s. The specific activity of I 131 on leaves was nearly the same and the specific activity of the particlebound radionuclides nearly two times higher than the respective specific activity on grass on May 2.

WET DEPOSITION OF PARTICLEBOUND NUCLIDES AND RADIOIODINE

During the first rainfalls, the activity concentration in the rainwater was measured as a function of the rainfall intensity. As there was no information about the distribution of the radionuclides with height, a rainout coefficient can only be estimated. The washout was small compared with the rainout. Assuming a homogenous distribution from ground level to the top of the clouds and taking account of the extension of the cloud layer (from 1400 to 12000 m; reported from meteorologists for the first rainfall on 3rd of May in Aachen) leads to the x-values plotted in Fig. 4. These x-values correspond to the rainout coefficient if the height depending activity concentration is constant. They are within the usually expected range. Mean washout coefficients $\overline{\Lambda}(I)$ can be calculated with the aid of the measured activity size-distributions and the modelled $\Lambda(d,I)$ shown in Fig. 4. For the first rain, these mean washout coefficients have nearly the same proportionality to the rainfall intensity as the estimated x-values for rainout. From this fact, it can be concluded that the rainout was dominated by incloud scavenging processes while nucleation was not of importance. For the second rainfall, the proportionality shifted to a smaller exponent (a=0.56). This can either be the result of a change in particle size distribution or a greater importance of nucleation.

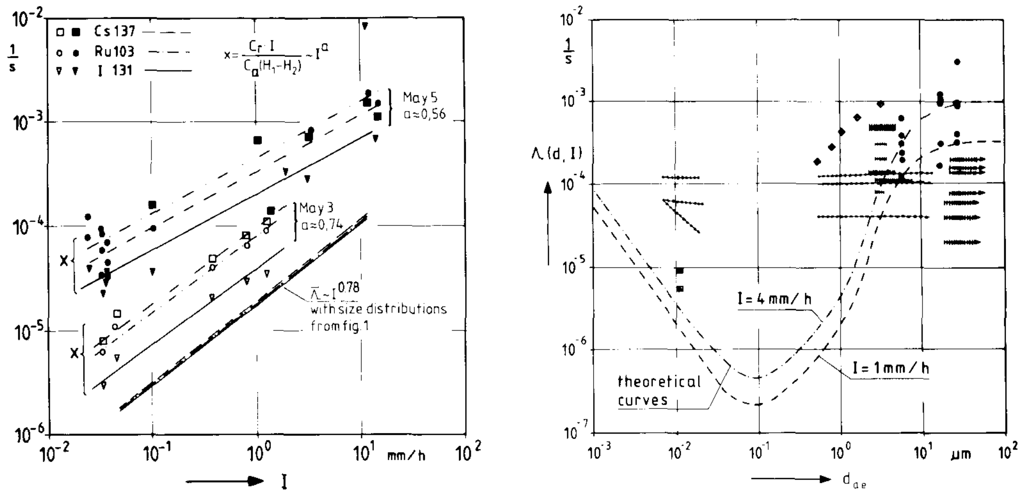

Fig. 4: Concentration of Cs 137 and I 131 in rainwater at Aachen, compared with results of model calculations and published experimental data /4/.

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