CONTAMINATION OF AIR AND THE RESULTING CONTAMINATION OF GRASS

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Abstract—Since the summer of 1963 a lawn was mown every second week during the growing season. The β-activity of the consecutive grass samples collected was considered to have been produced by fallout throughout the two week period of regrowth of the grass. It was compared with the activity of the air due to fission products during the same period. In this way an overall deposition velocity was obtained, covering both dry deposition and deposition by rain. This deposition velocity shows considerable scatter and increases during the period of observation. The increase is larger than can be explained by the influence of soil contamination.

In addition, the activity found on the grass samples was compared with the activity found on other fallout collectors. Here, too, the ratios increased with time, whereas the ratios between physical samplers stayed constant.

GRASS SAMPLING

Deposition of fallout on grass has been observed by different authors. However, the present authors are not aware of any longer series of consecutive samples taken to study the variation over a longer period of the deposition on to grass of fallout present in the lower atmosphere.

Since the summer of 1963, therefore, a lawn (96 m^2) at the Eidg. Institut für Reaktorforschung was mown every two weeks during the growing season. The same mowing machine was always used in order to mow the grass at the same height above ground. The mown grass was collected as completely as possible by a brushing machine.

The samples were analysed for gross β-activity which was expressed in units of pCi per m^2 of ground harvested. It may be assumed that a grass sample obtained this way is contaminated exclusively by fallout from the atmosphere during the two week period, together with a contribution from older fallout isotopes entering into the plants by the growth process and stemming from root uptake or uptake into parts of the grass below the height of mowing. This assumption may be not quite correct, as grass grows not only by producing new leaves but also by stem growth; accordingly, some direct contamination of the grass sample may be due to fallout in periods preceeding a period in question. However, this possible contribution of fallout was neglected.

It is well known that deposition of fallout on samplers or on vegetation can be described by a deposition velocity, which is usually given in units of cm per sec, or as a ratio to the wind velocity. This indicates that deposition is considered as an instantaneous process rather than as the result of processes acting over a considerable length of time. For a sampling programme such as the one outlined above it would be impractical, however, to take samples at short intervals. One week is the shortest feasible interval for sampling over the whole season in which grass grows and samples of reasonable size can be obtained. In our climate, this minimum period of one week is not short enough to permit with a reasonable probability any useful discrimination between periods of exclusively dry deposition and periods of mixed dry

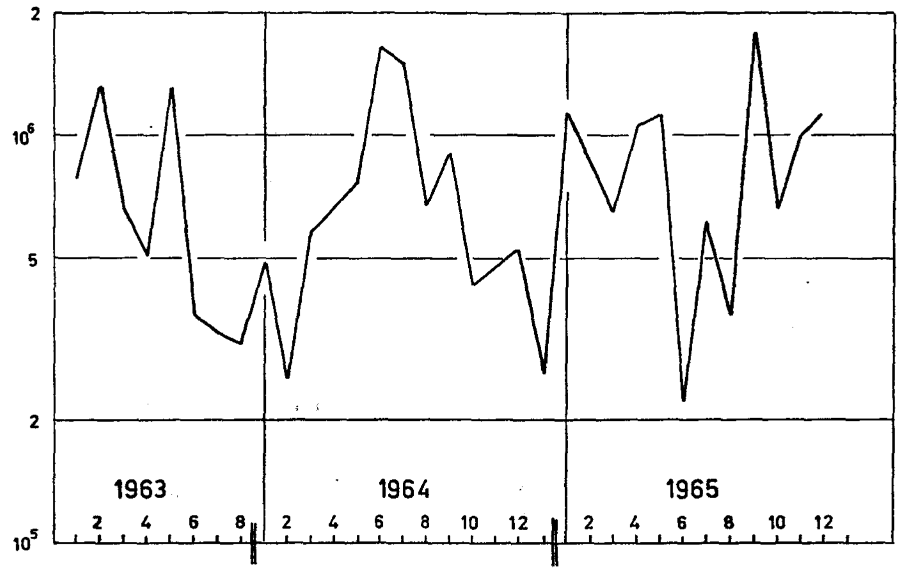

FIG. 1. Ratio of concentrations of radioactivity in rain and in air, both in pCi/cm³.

and wet deposition.* A period of two weeks was therefore considered acceptable, especially in view of decreasing fallout concentrations after the weapons test ban of 1962. The comparison of fallout on grass to fallout in air or rain can, therefore, only produce an averaged deposition velocity $\bar{v}_g$, where:

$$\bar{v}_g = \frac{\mathrm{Act_{grass}}}{\int_o^T \bar{v}_g \, \mathrm{Act_{air}} dt} = \frac{\mathrm{Act_{grass}}}{T \cdot \overline{\mathrm{Act_{air}}}} \qquad (1)$$

in which formula it is assumed that

$\mathrm{Act_{rain}}$ is proportional to $\mathrm{Act_{air}}$.

Accordingly, data on $\bar{v}_g$ are quoted in m/day only, in order to eliminate confusion with short period observations.

PHYSICAL SAMPLERS

The following samples were collected by physical samplers over the same period as the grass samples.

(*A*) Air samples taken by moving filter bands, ashed at the end of the period and counted after decay of natural activity.

(*R*) Rain samples, collected in a large rain sampler rinsed every day to remove dry fallout as far as possible.

(*T*) Samples of fallout deposited on to an open water surface (Totalisator: plastic tray kept filled with water, rain water collected by the tray flowing via over-flow to a plastic bottle).

(*V*) Samples of fallout deposited on to a flat and level plate of plexiglass covered by vaseline and placed on a short pole. By a long series of special observations we have shown that fallout trapped by the vaseline is not lost by subsequent weathering (at least for periods of up to three months), and that dry fallout is trapped as well as by a tray full of water.

RESULTS OF PHYSICAL SAMPLERS

The data of the three physical samplers (*R*), (*T*) and (*V*) agree reasonably well. The ratio of the average activity in rain (*R*) to the average activity in air (*A*) yields a mean of $7 \cdot 72 \pm 0 \cdot 74) \times 10^5$, if concentrations in pCi/cm³ are compared; the data presented in Fig. 1 shows the

* In the following data only the periods 6 and 7 for 1964 and period 13 for 1965 were generally dry, rainfall being less than 10 l./m² in 14 days.

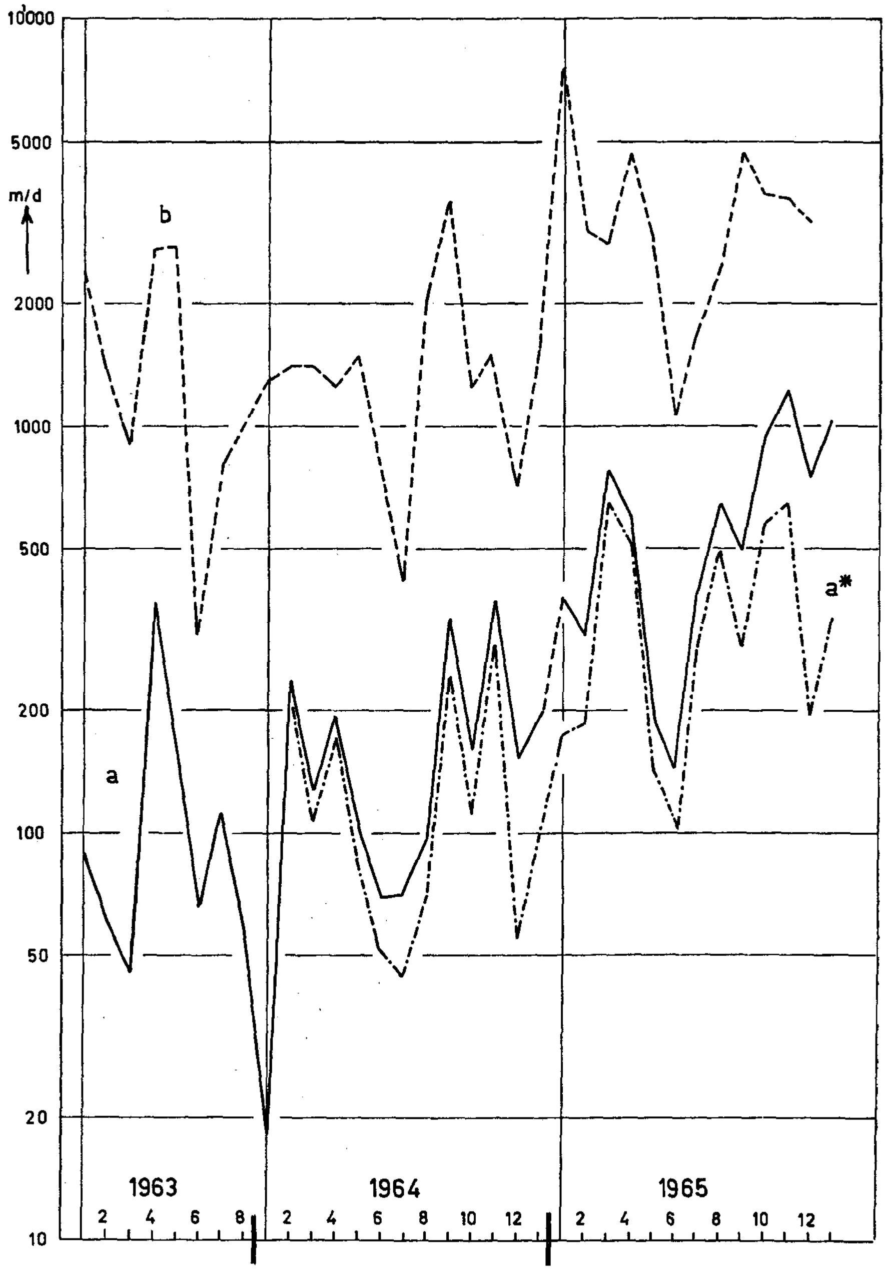

FIG. 2. (a) Ratio of average concentration of radioactivity on grass, in pCi/m² day, and in air, in pCi/m³. (a*) Values of curve a, minus ground contribution to the total radioactivity on grass. (b) Ratio of concentration of radioactivity deposited by rain, in pCi/m² day, and average concentration in air, in pCi/m³.

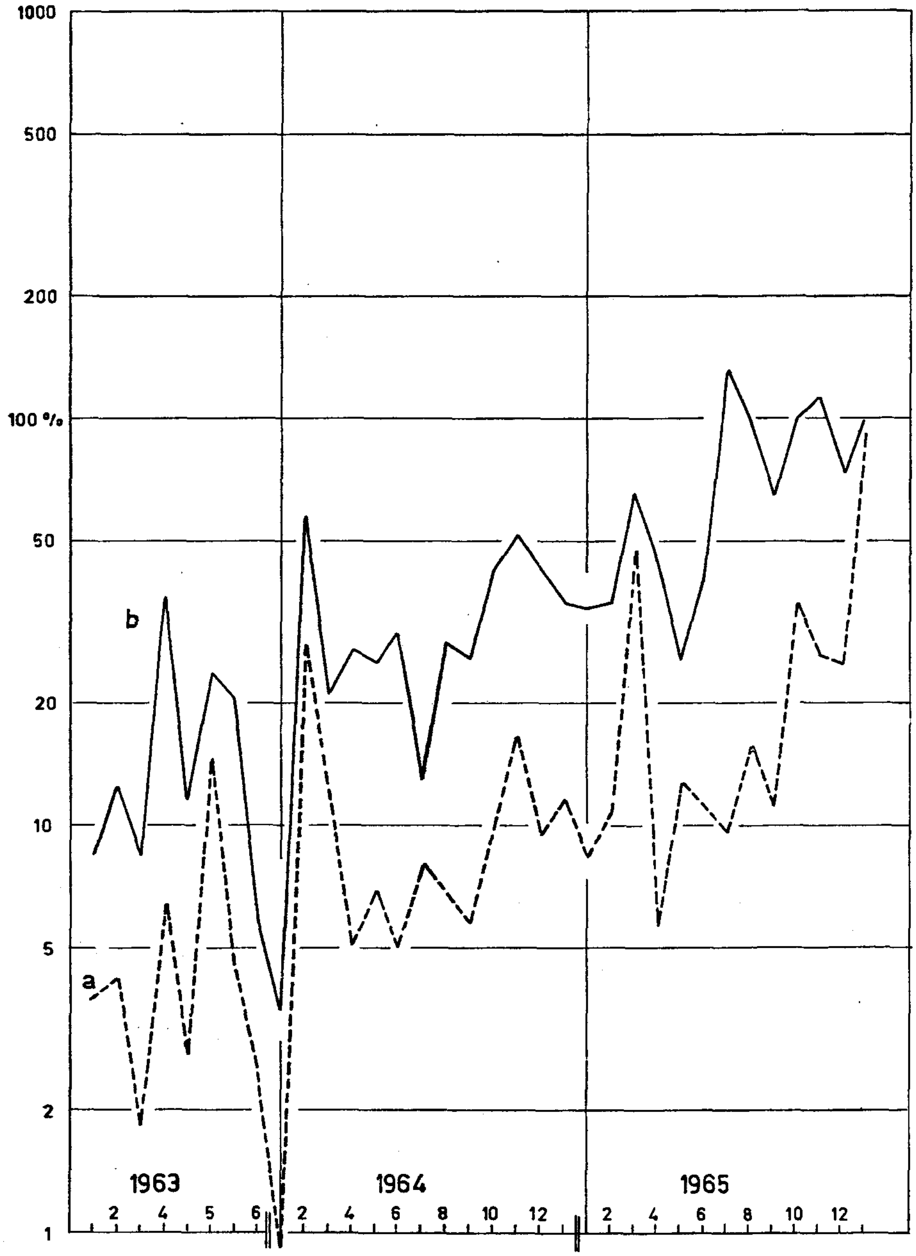

FIG. 3. (a) Ratio of concentration of radioactivity on grass and in totalisator, both in pCi/m².
(b) Ratio of concentration of radioactivity on grass and on vaseline-sampler, both in pCi/m².

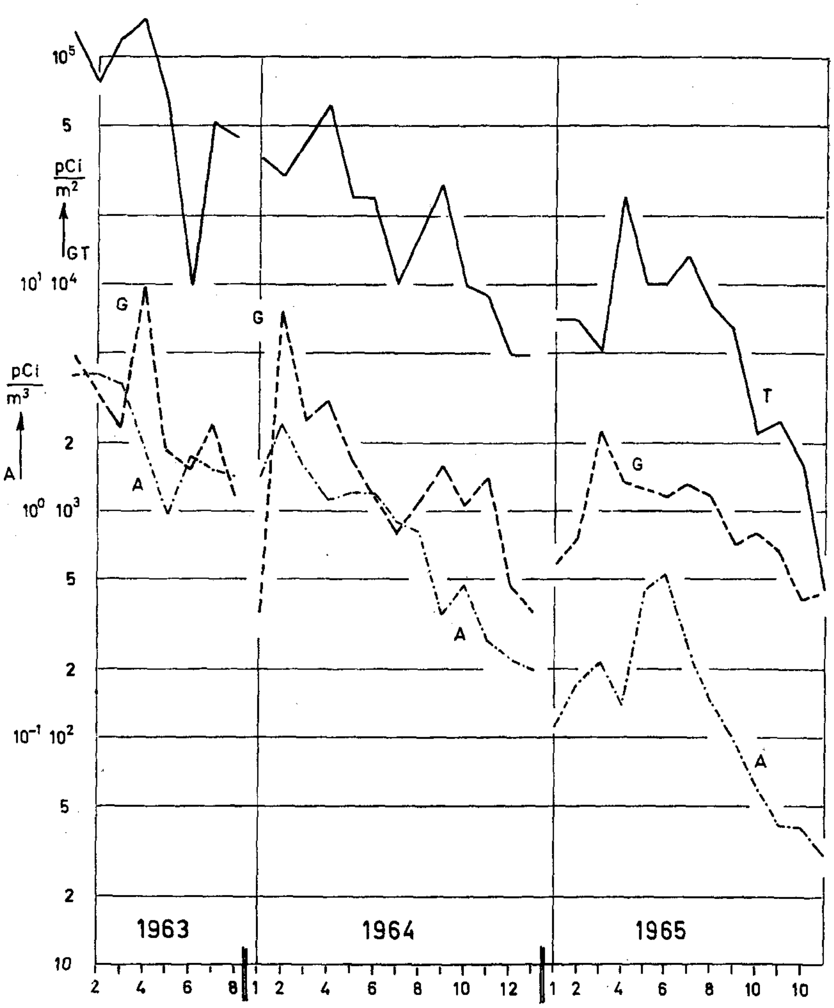

FIG. 4. (T) Gross β-radioactivity in totalisator, in pCi/m². (G) Gross β-radioactivity, minus ^{40}K on grass, in pCi/m². (A) Gross β-radioactivity in air, in pCi/m³.

ratio to be fairly constant in spite of possible changes of particle size with age of fallout.

Figure 2 (curve b) shows the ratio of (R) in pCi/m² and per day to average (A) in pCi/ m³. This ratio of (R) to (A) is expressed as a velocity of (wet) deposition, but this is not strictly correct as rain is not falling constantly. The data (curve b) shows somewhat more scatter than the ratio of the concentrations per unit volume and the values for 1965 are markedly increased, presumably due to the higher rainfall during that summer.

The deposition velocities calculated from (T) or (V) and (A) according to formulae like (1) show fairly constant values in spite of a reduction of activities by a factor of about 100 over the three summers of observation. The averages are 2980 $\pm$ 420 m/day for (T) and 740 $\pm$ 60 m/day for (V).

We have determined the coefficients in the regression formula $(V) = r.\ (R) + \bar{v}_g\ (A)$ for our continuous series of two weekly periods from 1959 through 1965 to be $r = 27 \pm 2{\cdot}3\%$ (r = efficiency of collection of wet fallout by vaseline) and $\bar{v}_g = 237 \pm 32$ m/day (corresponding to 0·27 cm/sec) as deposition velocity of dry fallout on to vaseline.

RESULTS OF GRASS SAMPLES

The deposition velocity on grass, as calculated according to formula (1) and without any correction for ground contamination, is given in Fig. 2 by curve a. It is seen that again there is considerable scatter and that the velocity increases with time. This increase is also seen in the efficiencies of deposition on grass as compared to deposition on the physical samplers (Fig. 3). Both curves show an increase with time which is similar to the increase in curve a, Fig. 2.

THE EFFECT OF GROUND CONTAMINATION

At the end of 1964 this trend in the data on grass activity had not been fully recognized, being rather veiled by the scatter. A correction for the effect of ground contamination seemed, therefore, to be unimportant. This was further supported by the result of comparisons between two series of grass samples grown during 1964 in parallel over three week periods, in part open and in part permanently covered by plastic hoods. The 1 m^2 areas under the plastic hoods were watered using tap water with a negligible activity content. Some air circulation through the hoods had to be tolerated in order not to over-heat the plants but contamination from this way was shown to be negligible (vaseline-sampler under one of the hoods). Hence, the contamination found in the covered samples was considered to be derived from the existing contamination of the soil only. For the purpose of comparison between both series of grass samples, a correction for the somewhat different yields in dry-weight/m^2 had to be made. The ground contribution to the total activity found in the open grass samples, averaged over the summer for six different fallout isotopes (γ-emitters), was 27% (ranging between 22 and 32% for the different isotopes). The average for all the isotopes increased somewhat during the summer, due to the decreasing air activity. ^{40}K could be used as a control for the above mentioned correction, yielding a ground contribution of practically unity, as would be expected for this isotope.

Soil activity was determined by gamma spectroscopy and ^{90}Sr analysis. The contamination of soil was practically the same in 1965 as it was in 1964, whereas the fallout intensities decreased further, as shown in Fig. 4. If, accordingly, a constant value of the ground contribution deduced from the 1964 data on open and covered samples is deducted from the grass activities in 1964 and 1965, the corrected curve a* in Fig. 2 results. However, this correction does not remove the trend which shows in the uncorrected curve a.

DISCUSSION AND CONCLUSIONS

The trend which remains in curve a* may be due in part to the somewhat increased rainfall during 1965, as shown by curve b in Fig. 2 and mentioned above, but a representation of the deposition velocity on to grass as a function of the amount of rainfall showed no clear correlation.

Further explanation of the rest of this trend is difficult. It may be due to a general change in particle size of fallout which will influence the deposition effects that are basically due to the movement of particles in boundary layers around the sampler.

In conclusion it may be stated (using mainly the data for 1963 and 1964) that deposition of fallout on to short grass is of the order of 150 m/day if averaged over periods of two weeks with mixed dry and wet deposition. There is considerable scatter and single periods may differ from an average by as much as a factor of 5. The efficiency of grass as a sampler is 10% or less if compared to an open water surface. It is 20 to 30% if compared to a level surface covered with vaseline.