Long-term dynamics of Cs in dairy products in Austrian Alpine regions

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Abstract. Among the Western European Countries Austria was one of the most heavily effected by the radioactive fallout from the Chernobyl accident. Initial ground deposition levels of ^{137}Cs between < 10 and 150 kBq/m² resulted in considerably contaminated agricultural products. On average these contamination levels dropped fast after the first winter following the accident, when contaminated feeding produced in the summer after the radionuclide deposition accident had to be used for feeding the livestock. However, in seminatural environments in the alpine regions, which are only inhabited and used for agricultural production during the summer time, higher soil-to-plant-transfer resulted in a long-term contamination of the local produced foodstuff. For ^{137}Cs the effective half-life in these regions ranges between 3 and 8 years. These effects are most pronounced in areas with silicate bedrock material and they seem to be closely associated with slow migration of the radiocaesium into deeper soil layers. A considerable fraction of the nuclide inventory is cycling within the organic layer on top of the soil.

1. INTRODUCTION

Outside the territories of the former USSR, Austria was one of the highest contaminated regions in (Western) Europe. Surface deposition of the radioactive fallout has been caused mainly by wet deposition, dry deposition was ineffective in producing high contamination levels. The combination of these two deposition processes resulted in a in a very patchy contamination pattern with ^{137}Cs levels between < 10 an 150 kBq/m² [1,2], depending on the time and intensity of precipitation. The fallout can be described as a multifractal pattern [3]. Though to the overall random distribution of the radioactive fallout the northern parts of the Alps, which are oriented towards the prevailing westerly winds have been most affected by the radioactive fallout. Despite of the large distance to Chernobyl and the small size of the territory, 2.7% of the Cs contamination has been deposited in Austria [4]. The surface deposition caused considerable contamination of the vegetation and subsequently of the livestock and dairy products. In the phase following the radionuclide deposition, the "initial phase" that coincided with the beginning growth period for the vegetation, the contamination decreased quickly by washoff from plants, dilution by growth of plants, removal of the first green cut that was contaminated on the surface and growing of new, not on the surface of the leaves contaminated grass. The main contamination pathway changed from surface deposition to root uptake, which is much less effective in general. In the winter 1986/87 a significant peak in the contamination of milk and dairy products occurred due to the feeding of hay that was harvested after being contaminated by the fallout. Because directly by surface deposition contaminated foodstuff has been used up for feeding after the winter 1986/87, since that time the time trends in activity concentration in milk and dairy products are controlled by root uptake processes on the soil/plant level. Root uptake in general results in smaller contamination than direct contamination on the leaves, but the ecological half-lives for reduction are longer than those observed in the initial period after the fallout. Typical values for the long-term reduction of ^{137}Cs in the ecosystem seem to be in the range of 2 years effective half-life [5]. This is very important for the production of milk in regions where this is the main source of income of the agriculture. 1999 in Austria 3.3 Million tons [6] of milk are produced per year, the main part of it is coming from small scale farms in mountainous regions. 62% of the milk is produced in mountainous areas, which are defined according the EC as areas above 700m or areas with slopes above 15%. Appr. 2,3 % of the milk production originate from alpine pastures at elevated altitudes which can only be used during the summer for dairy and cattle production. At that time part of the livestock moves to upland regions above appr. 1400m to use the short vegetation period for seasonal production. The grass and vegetation in the upland regions, the alpine pastures, in general is more

contaminated than vegetation from intensively managed lowland pastures. It has been documented in a number of studies that these higher levels of contamination are due to increased soil-to-vegetation transfer of radiocaesium [7,8,9] and only to a small extent due to increas9ed deposition levels.

2. METHODS

The data presented are collected from one large dairy in the Tauern Region (Maishofen, Province of Salzburg, 7153 km²) and upland regions (alpine pastures, alps) in the catchment of that dairy. For the dairies milk is usually collected on the farms by tank lorries with tank volumes of a few thousand liters. In the initial phase milk samples have been collected rather systematically from the main dairies and the different milk collection routes. The majority of the milk-data can be traced back to samples taken from large containers that have been filled by milk collected from a larger area, one valley for example. Due to this sampling procedure the data are average values over larger areas and can thus not be related to specific sites. Since 1988 sampling was extended to a number of specific alpine pastures, which had been identified to have high Cs contamination of milk. In the following years some of these alpine pastures have been sampled on a regular basis during the summer, in some years even in regular intervals between 1 and 4 weeks. For a few alpine pastures in the Tauern region, the Central part of the Austrian Alps, complete data sets since 1988 have been collected. The milk samples of the initial phase have been collected more or less randomly and thus represent a good overview over the whole catchment region of the dairy. After the winter 1986/1987 sampling was done more focusing on collection routes known to have a significant contribution of milk from alpine pastures, which was assumed to have higher Cs-contamination levels. The data are therefore strongly biased and demonstrate the increase during the summer seasons.

3. RESULTS AND DISCUSSION

The data presented in this paper are from one major dairy (Maishofen, Province of Salzburg) and for a number of different alpine pastures are considered to be exemplarily for the central part of the Austrian Alps, the Tauern Region. In the initial phase following the radioactive washout, the contamination of the

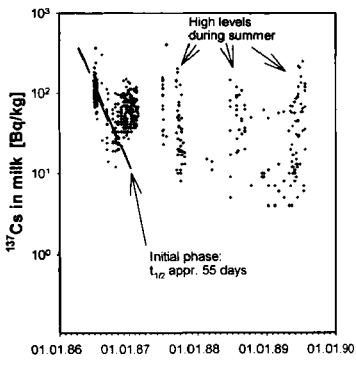

Fig.1: Time dependency of ^{137}Cs in milk from production sites in alpine regions and valleys of the Province of Salzburg

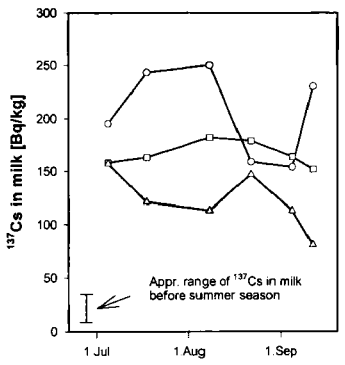

Fig.2: Variation of ^{137}Cs in milk from three different alpine pastures during the summer season

milk (Fig.1) very fast reached high levels close to 400 Bq/kg, but the majority of the data was less than 200 Bq/kg. Large scattering can be observed, for which a number of influencing factors could be identified: For example, the ^{137}Cs-deposition was not homogeneous, some farmers used old hay or other uncontaminated foodstuff according to the recommendations of the government to avoid contamination. In the period after the fallout until late autumn, as long as grass was still available and hay had not to be fed to the cattle, the average contamination decreased with a half-life of 55 days (dashed line in Fig. 1). Though the correlation coefficient is low due to the large scattering of the data, the fitted half-life is in acceptable agreement with appr. 34 days, derived from data for skim and milk powder in Austria [10]. Between October and November after the initial phase the contamination levels started to increase coinciding with the beginning of feeding contaminated hay. The maximum levels could be observed around January when the contamination had reached saturation and would not increase further according to the short biological half life of Cs in milk, which is quoted in the literature to be between 7 and 20 days [11,12]. With the end of hay feeding in spring the average Cs levels decreased according to uptake of less contaminated green cut forage. Since that time the contamination levels in the major production areas are decreasing with effective half-lives of about 2 years. This is also the case for dairies in mountainous regions but not for the alpine pastures. Because their mass contribution to the gross milk production is small, this influence is minor and more or less only exhibited during the summer season. Usually the contribution is not more than a few percent but it depends on the specific region. In Fig. 1 the high levels in milk during the summer can be clearly identified, the large variation of the data is mostly an effect of different contribution of milk from alpine pastures to milk from the production sites in the valleys and lowland regions and from differences in the contamination of the catchment regions. The Cs-concentration in milk for any specific site or area is a fluctuating value; due to the short biological half-life for milk (1,5 – 20 days) differences in the concentration of the fodder will be exhibited only with small attenuation. This can be seen in Fig. 2, where the time dependent Cs-concentration for 3 different alpine pastures are charted. Saturation was reached within a few days after the cows had moved to the alpine pastures, which happens usually around the end of June. During the summer period the Cs in milk might undergo fluctuations by a factor of 2 or more, depending on the sites where they are grazing, as the

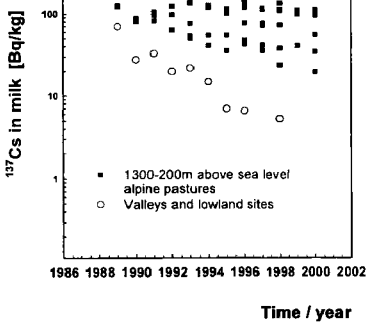

Fig.3: Decrease of ^{137}Cs in milk from different alpine production regions

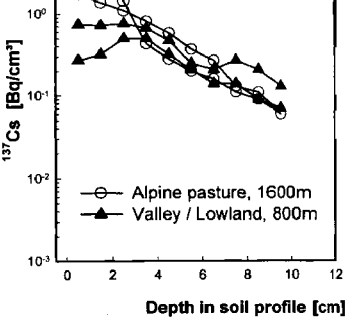

Fig.4: Typical profiles of the specific ^{137}Cs concentration in soils from alpine pastures and from a lowland site in a valley.

contamination of the vegetation is rather inhomogeneous and varying during the season [8,13,14]. An overview of milk-data collected from various alpine pastures is presented in Fig. 3. Alpine pastures in that respect are considered as pastures above appr. 1300m sea level, which are not suitable for intensive agricultural production and which are only used for grazing cattle. The data are mean values for one summer season each and based on different numbers of samples between only 1 and 8 samples. The alpine pastures show differences in contamination by almost one order of magnitude. During the period of survey the differences widen due the different ecological half-lives for the specific sites. The data for the different sites were fitted assuming a simple model with exponential decay controlled by the ecological or effective half-life. Results obtained from the fitting are varying between 3 and 8 years; though the differences are not significant for all alpine pastures the variation in the ecological half-lives is significant as such. For comparison average data from valleys and lowland sites in the Province of Salzburg are plotted on Fig.3 to demonstrate the differences in the ecological half-life, that corresponds with the two different production styles: intensively managed in valleys and lowlands and extensively and seasonal managed on the alpine pastures. On alpine pastures the soil-to-plant transfer is much higher than on lowland pastures; this is well known from literature and has been documented by many studies [7,8,9] trying to find processes that control the transfer factors. On a phenomenological basis the differences in the soil-to-plant transfer can be put into relation with the depth profiles of ^{137}Cs in the soil. On alpine pastures the proportion of Cs in the upper soil layer, where the root activity is dominant, is much higher than in the soil of low-land pastures and intensively managed farmland. According to their elevated height above sea level alpine pastures are exposed to more extreme climatic factors like lower average annual temperature, short vegetation period and long snow cover. These factors together with the fixation and cycling of radiocaesium in the biomass are supposed to have a dominant influence on the long ecological half-life. Because the people who are managing the alpine production sites during the summer season consume at least part of their locally produced food, their 50 year dose following the nuclear fallout might be significantly higher than for the average population.

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