EVALUATION OF SMALL SCALE LABORATORY AND POT EXPERIMENTS TO DETERMINE REALISTIC TRANSFER FACTORS FOR THE RADIONUCLIDES ^{90}Sr, ^{137}Cs, ^{60}Co and ^{54}Mn

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Much of the information on uptake of radionuclides from soils for determination of transfer factors have been obtained from laboratory experiments with prepared soils or soils contaminated by nuclear weapon tests. These results may not be valid for estimation of transfer factors in the field. On the other hand, it is nearly impossible to conduct field experiments to determine the transfer of radionuclides for every site and condition. We have started lysimeter experiments in a controlled experimental field to study the root uptake of ^{90}Sr, ^{137}Cs, ^{60}Co, and ^{54}Mn under outdoor conditions. (Figure 1).

Since this type of experiments are time-consuming and expensive, and can only be conducted at locations which permit the use of radionuclides under outdoor conditions, we have also set up experiments parallel to those in the outdoor lysimeter using the Kick-Brauckmann experimental pots (3) under greenhouse and using the Neubauer cups under growth chamber conditions. The results obtained from the three types of experiments are compared.

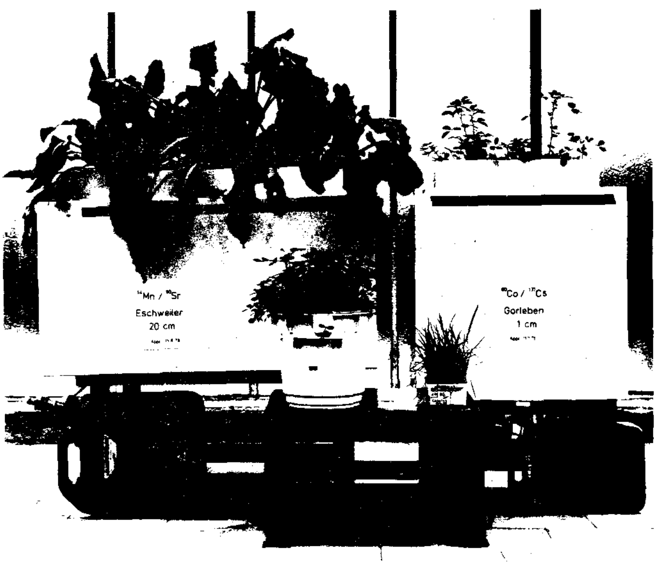

Figure 1. Test units used: 1 m^2 lysimeter filled with topsoil (Ap-horizon), 0,25 m^2 lysimeter with undisturbed soil profile, Kick-Brauckmann pot (8 kg topsoil), and Neubauer cup (400 g of topsoil).

MATERIALS AND METHODS

Two soils were used: a podzolic soil (spodosol) and a degraded loess soil (alfisol). Their properties and details about the lysimeter experiment were presented by Steffens et al. (4). For the pot and cup experiments the soils were sieved (< 5 mm and < 2 mm, respectively), fertilized (120 mg N, 120 mg P_2O_5, 200 mg K_2O/kg soil), treated with 10 μCi $^{90}Sr(NO_3)_2$ or $^{54}MnCl_2$ or 5 μCi $^{137}CsCl$ or $^{60}CoCl_2$/kg soil, and thoroughly mixed. The pots in 4 replicates containing 8 kg soil each were watered to 65 % of the water holding capacity of the soil and placed in greenhouse under natural light conditions. The cups in 4 replicates and containing 400 g soil each were placed in the growth chamber maintained at 12-hour day/night photoperiod at 23 °/16 °C and 65/85 % relative humidity. The soils in the lysimeters were equilibrated for 8 months and in the pots and cups for 2 weeks before the initiation of the experiments. Plants were grown to ripeness in the lysimeters and pots, but were harvested from the cups 4 weeks after sowing or planting. The plants were dried at 105 °C. ^{90}Sr was measured according to Cerenkov via the decay product ^{90}Y, ^{137}Cs, ^{60}Co, and ^{54}Mn on a surface Ge(Li) detector. Additional details are listed by Führ (1). The transfer factors are expressed as the quotient

$$TF_{SP} = \frac{\text{dpm/g plant fresh weight}}{\text{dpm/g dry soil (application)}}$$

The transfer factors from the pot and cup experiments were expressed in relative values based on those from the lysimeter experiments equal to 1.

RESULTS

The results (Table 1) demonstrate that the transfer factors for ^{90}Sr, ^{137}Cs, ^{60}Co, and ^{54}Mn obtained under the specific conditions of the small scale Neubauer cup experiment differed greatly from those obtained from the outdoor lysimeter experiment. These differences may be mainly due to the short equilibration period, daily water addition (repeated desorption), plant density, short vegetation period, and higher transpiration rates in the cup experiment.

In the pot experiment the transfer factors for ^{90}Sr, ^{137}Cs, and ^{54}Mn showed less deviation especially in crops grown on podzolic soil. On the average they are 1.5 to 2 times higher than the lysimeter values, with a tendency to higher deviation in the root crops. In the case of ^{60}Co, transfer factors were found to be similar in potatoe leaves and tuber on podzolic soil, 2 to 3 times higher in sugar beets on loess soil, but up to 23 times higher in barley and salad. Yields and to a smaller extent some of the nutrient contents were generally higher in plants grown in pots than those from field trials (2), probably due to higher ferti-

Table 1: Relative transfer factors of pot and cup experiments compared with transfer factors from outdoor lysimeter experiments.

Plants		Transfer factors[1]	Relative transfer factors[2] pot	cup
Sr-90: podzolic soil				
Barley	straw	2,08	1,6	0,5
	grain	0,17	1,5	-
Potatoes	leaf	0,79	1,3	-
	tuber	0,014	3,7	-
Salad		0,46	2,1	1,7
Sr-90: loess soil				
Barley	straw	1,91	1,2	0,25
	grain	0,09	1,8	-
Sugar beets	leaf	0,21	2,9	3,5
	beet	0,29	2,2	-
Salad		0,34	1,4	3,5
Cs-137: podzolic soil				
Barley	straw	0,081	2,0	5,9
	grain	0,039	1,4	-
Potatoes	leaf	0,057	1,9	-
	tuber	0,046	2,1	-
Salad		0,018	2,2	16,1
Cs-137: loess soil				
Barley	leaf	0,0051	-	5,9
	grain	0,0023	-	-
Sugar beet	leaf	0,0087	5,2	7,9
	beet	0,0037	1,7	-
Salad		0,0036	0,8	0,8
Co-60: podzolic soil				
Barley	straw	0,018	17,8	6,8
	grain	0,013	23,1	-
Potatoes	leaf	0,32	1,0	-
	tuber	0,082	0,9	-
Salad		0,0074	15,0	13,5
Co-60: loess soil				
Barley	straw	0,0088	7,2	0,5
	grain	0,0059	8,1	-
Sugar beet	leaf	0,012	3,1	3,0
	beet	0,0099	2,1	-
Salad		0,0037	6,2	1,7

1) Obtained from lysimeter experiments

2) Based on lysimeter data equal to 1

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Plants		Transfer factors[1]	Relative transfer factors[2] pot	cup
Mn-54: podzolic soil				
Barley	straw	3,40	2,1	0,2
	grain	1,00	1,5	-
Potatoes	leaf	2,00	1,5	-
	tuber	0,14	1,0	-
Salad		0,48	4,2	2,1
Mn-54: loess soil				
Barley	straw	1,30	1,5	0,1
	grain	0,31	1,0	-
Sugar beet	leaf	0,15	8,7	1,9
	beet	0,08	3,9	-
Salad		0,28	2,4	0,8

[1] Obtained from lysimeter experiments

[2] Based on lysimeter data equal to 1

lizer application rates, less competition for light and water, higher root mass per soil unit, and hence higher interception. Therefore transfer factors obtained in pot experiments can only be applicable to a limited extent to field conditions. Factors dominant in influencing the transfer factors in pot experiments may include soil volume, root density and root/shoot ratio, water supply, and fertilizer application rate.

In order to make use of the advantages of pot experiments outlined earlier, these experiments will be continued for two more vegetation periods to reduce the magnitude of variation in transfer factors for some plants on a given soil. The following plants will also be included: wheat, alfalfa, grass, bush beans, carrots, and radish.

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