THE TRANSFER OF SR-90, CS-137, CO-60 AND MN-54 FROM SOILS TO PLANTS -RESULTS FORM LYSIMETER EXPERIMENTS.

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Predicting irradiation of man from food intake using computer simulation models (1) the magnitude of transfer of radionuclides from soil to plant known as transfer factor is of importance. This transfer factor is influenced by a number of environmental parameters such as climate, plant species, soil properties, concentration of the stable and radioactive isotope in the soil etc. (2). Therefore,results from laboratory studies or from experiments using radioactively contaminated soils of non-agricultural origin may not be validly applicable from one region to another.

In our investigations outdoor lysimeters containing 2 typical German soils were used to evaluate the transfer of Sr-90, Cs-137, Co-60 and Mn-54 from the soil to a variety of crop plants.

MATERIALS AND METHODS

Soils: A parabrown earth form the Eschweiler region and a podzol (sandy soil) from the Gorleben area being very different in their properties (Tab. 1).

Table 1: Chemical and physical properties of the soils.

Origin	Eschweiler	Gorleben
Soil type	Parabrown earth	Podzol
Horizon	Ap	Ap
pH ($CaCl_2$)	5,9	4,7
Org. C %	1,4	1,1
Total N %	0,1	0,1
Clay %	12,0	2,6
Silt %	28,4	2,9
Fine sand %	58,3	34,3
Coarse sand %	1,4	60,2
T-value	11,2	6,2
S-value	12,8	2,4
Ca (meq/100g)	11,8	2,0
K (meq/100g)	0,8	0,2

Lysimeter:
1) 0,25 m^2 surface undisturbed soil profile
2) 1 m^2 surface, uniformly mixed surface soil(3)

Treatment: Carrier-free Cs-137 Co-60, Mn-54 in chloride and Sr-90 in nitrate form mixed with
a) 0 - 1 cm soil layer to simulate an accidental contamination, 77 and 80 uCi/kg dry soil
b) 0 - 20 cm soil layer to simulate a 50-years contamination, 5,8 and 6,0 uCi/kg dry soil.

Plants: Grass and alfalfa pasture, sugar beets, winter wheat and summer barley grown in a rotation with

bush beans, carrots, radish, lettuce and clover as intermediate crops. The fertilization corresponded to the amounts usual in practice.

Analysis: Radioactivity measuring was done in a well type Ge(Li)-detector and in a liquid scintillation spectrometer (Sr-90).

RESULTS AND DISCUSSION

The transfer factors for Sr-90 determined in pasture grass, grass hay, and alfalfa grown on the podzol soil contaminated in the 0 - 1 cm layer were similar or up to 3 times higher than those for the parabrown earth soil, but the transfer factors for Cs-137 were 3 - 73 times higher on podzol soil (Table 2). At least in pasture grass, the transfer of both radionuclides was lower than that published previously (3) due to longer time of equilibration of Sr and Cs in the soil. The tendency of the transfer factors in the consecutive cuts was contrary to the expected decrease of transfer.

Table 2: Transfer factors (TFSP) of Sr-90 and Cs-137 for plants grown on parabrown earth and podzol soils after contamination of the 0 - 1 cm soil layer.

Plants	Dry matter %	TFSP x 10^{-1} Sr-90 Parabr. earth	TFSP x 10^{-1} Sr-90 Podzol	Dry matter %	TFSP x 10^{-1} Cs-137 Parabr. earth	TFSP x 10^{-1} Cs-137 Podzol
Grass 1. cut	11,3	4,3	4,0	12,8	0,05	0,60
2. cut	12,0	2,6	2,9	11,0	0,06	0,53
3. cut	26,8	7,0	7,7	21,3	0,08	0,51
4. cut	16,2	4,6	10,7	29,8	0,12	0,99
Grass hay 1. cut	21,0	3,7	5,7	16,5	0,01	0,73
2. cut	24,3	7,5	12,5	24,4	0,03	0,75
Alfalfa 1. cut	26,2	4,1	13,0	20,4	0,02	0,54
2. cut	29,7	30,0	41,0	26,0	0,10	0,31

Soil sampling 0 - 10 cm deep, time intervals between the cuts: grass 28 days, grass hay and alfalfa 56 days.

Similary, for winter wheat, summer barley, radish and lettuce grown on soil contaminated in the 0 - 20 cm layer (Table 3 and 4), the transfer factors for Sr-90 were only up to 2 times higher, but for Cs-137 5-59 times, for Co-60 2-27 times, and for Mn-54 1,5-17 times higher for the podzol soil than for the parabrown earth soil. The differences between the 2 soils might be due essentially to the lower sorption capacity and base saturation in the podzol soil.

In all plants and on both soils the transfer factors for Sr-90 and Mn-54 were higher by an order of 1-3 than those for Co-60 and Cs-137 (Table 2-5).

Table 3: Transfer factors (TFSP) of Sr-90 and Mn-54 for plants grown on parabrown earth and podzol soils after contamination of th 0 - 20 cm soil layer.

Plants		Parabrown earth			Podzol		
		D.M. %	TFSP Sr-90	TFSP Mn-54	D.M. %	TFSP Sr-90	TFSP Mn-54
Winter	straw	95,0	1,35	0,53	96,0	2,77	9,16
wheat	grain	91,0	0,05	0,35	90,0	0,14	3,41
Summer	straw	92,0	1,91	1,33	92,0	2,09	3,40
barley	grain	95,0	0,09	0,31	95,0	0,17	1,00
Radish	leaf	8,5	1,20	0,20	8,5	1,77	0,46
	beet	5,8	0,13	0,02	5,7	0,10	0,03
Lettuce		8,6	0,34	0,28	8,6	0,46	0,48

Table 4: Transfer factors (TFSP) of Cs-137 and Co-60 for plants grown on parabrown earth and podzol soils after contamination of the 0 - 20 cm soil layer.

Plants		Parabrown earth			Podzol		
		D.M. %	TFSP x 10^{-2} Cs-137	Co-60	D.M. %	TFSP x 10^{-2} Cs-137	Co-60
Winter	straw	95,0	0,46	1,00	96,0	11,1	26,1
wheat	grain	91,0	0,10	0,74	90,0	5,9	19,8
Summer	straw	92,0	0,51	0,88	92,0	8,1	1,8
barley	grain	95,0	0,23	0,59	95,0	3,9	1,8
Radish	leaf	7,3	0,37	0,56	9,0	2,6	1,4
	beet	5,3	0,04	0,25	5,3	o,4	0,5
Lettuce		7,7	0,36	0,37	5,7	1,8	0,7

Table 5: Transfer factors (TFSP) of Sr-90, Mn-54, Cs-137, and Co-60 for plants grown on parabrown earth and podzol soils after contamination of the 0 - 20 cm soil layer.

Plants		D.M. %	TFSP x 10^{-1} Sr-90	Mn-54	D.M. %	TFSP x 10^{-1} Cs-137	Co-60
Sugar	leaf	13,7	2,06	1,49	16,1	0,09	0,12
beet	beet	26,8	2,62	0,79	26,8	0,04	0,10
Potatoes	leaf	9,2	7,85	19,66	10,7	0,57	3,23
tuber	peel	21,4	0,67	1,32	22,0	0,64	1,05
	flesh	21,2	0,14	1,37	21,7	0,47	0,82

Sugar beets on parabrown earth, potatoes on podzol soil

Because of the higher dry matter content in grain crops, higher transfer factors for all nuclides were found in dicotyledons than in monocotyledons, Lower transfers were found in generative and storage plant parts (grains and tubers) than in straw and leaves except for sugar beets and Sr-90 (Table 3-5).

Comparing with the calculated transfer factors for these radionuclides suggested in the provisional Radioecology Regulatory Guide (1), the transfer factors for plants grown on parabrown earth soil were similar. For plants grown on podzol soil, however, they exceeded the suggested values for Sr-90, Co-60, Mn-54, and Cs-137 by factors up to 20, 30, 65, and 82, respectively.

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