Uptake of radionuclides by spring wheat and barley from cultivated soils supplemented by contaminated sewage sludge

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Puhakainen, M. & Yläranta, T. 1992. **Uptake of radionuclides by spring wheat and barley from cultivated soils supplemented by contaminated sewage sludge.** Agric. Sci. Finl. 1: 27-36. (Finnish Centre for Radiation and Nuclear Safety, Box 268, SF-00101 Helsinki, Finland and Agric. Res. Centre of Finland, Inst. Environ. Res. SF-31600 Jokioinen, Finland.)

After the accident at the Chernobyl nuclear power station in April 1986, large amounts of fallout radionuclides originating from Chernobyl were measured in sewage sludge in Finland. Field experiments were performed to evaluate the amount of activity of fallout nuclides transferred from soil to spring wheat and barley grown in fields supplemented by contaminated sewage sludge and further to calculate the soil-grain transfer factors.

The experiments were conducted in southern Finland on clay, clay loam and sandy loam soil. The digested sludge was spread on fields, at a ratio of 22 tons of dry matter per hectare. The sludge formed in 1986 was spread in spring 1987 on ploughed fields before the preparation of the seedbed, or in autumn 1987 prior to ploughing. The different plots were fertilized with NPK fertilizer so that the amount of available nutrients was about equal in all treatments.

Application of sludge increased the concentration of ^{137}Cs in grain 2-12 times as compared with crops grown in plots without sewage sludge addition.

The transfer factor of ^{137}Cs from soil to plant defined as Bq ha^{-1} in plant (grain and straw) per Bq ha^{-1} in soil (and sludge) varied in the first experimental years (1987 and 1988) from 20 x 10^{-6} to 150 x 10^{-6} and in the second experimental years (1988 and 1989) from 6 x 10^{-6} to 50 x 10^{-6} for sludge treated soil and from 10 x 10^{-6} to 60 x 10^{-6} and from 8 x 10^{-6} to 50 x 10^{-6} for soil without sludge addition, respectively.

Key words: ^{137}Cs, ^{134}Cs, sewage sludge, spring wheat, barley

Introduction

After the accident at the Chernobyl nuclear power station in April 1986, large amounts of fallout radionuclides originating from Chernobyl were measured in sewage sludge in Finland (Puhakainen et al. 1987). The highest measured ^{137}Cs activity was 12 000 Bq kg^{-1} dry matter (compared to ^{137}Cs activities in sludge varying from 0-20 Bq kg^{-1} dry matter before the accident) (Puhakainen 1986). Yearly 1 100 000 m^3 dewatered sewage sludge is produced in Finland. Of this, 75 % is utilized; 50 % in agriculture and 25 % for landscaping.

The maximum amount of sludge recommended for agricultural use was at that time 20 metric tons of dry matter per hectare. If the maximum amount of sludge accumulated in 1986 would have been spread on the fields, the increase of radioactivity would at most have been 24 000 Bq m^{-2}.

In 1987, field experiments were started to evaluate the amount of activity of fallout nuclides transferred from soil to spring wheat and barley grown in fields supplemented by sewage sludge. Knowledge of the interaction between sludge, soil and plants is required when recommendations regarding the utilization of sludge for agricultural purposes are given in the future. The experiments were conducted at the Agricultural Research Centre of Finland at Jokioinen in southern Finland in 1987-1989 on a clay, a clay loam and a sandy loam soil.

Material and methods

The sludge used in the experiments

In the experiment dewatered digested sludge from the Kyläsaari wastewater treatment plant in Helsinki was used. Kyläsaari is the largest treatment plant in Finland, with over 100 m^3 of digested dewatered sludge being produced daily (Lundström 1987).

After the accident the activity concentrations of the sludge in Kyläsaari were at most above 5000 Bq kg^{-1} dry weight. About half of this activity was due to the precipitate coming from a water treatment plant. The flocculation with aluminium sulphate at surface water treatment plants during water purification was found to concentrate radionuclides originating from fallout relatively efficiently. This precipitate was pumped into the sewer system. A small amount of the precipitate rich in radionuclides doubled the concentration of ^{137}Cs in the sewage sludge (Puhakainen et al. 1987).

The sludge formed in spring 1986 was used for the field experiments. The ^{137}Cs activity concentration in the sludge used was 5300 Bq kg^{-1} dry matter in experiment 1 and 4700 Bq kg^{-1} dry matter in experiment 2, and the ratio $^{134}Cs/^{137}Cs$ was 0.6 (ref. day 1. May, 1986). The dry matter content in the dewatered sludge was 22 % and pH(H_2O) 6.9. The chemical composition of the sewage sludge is given in Table 1.

Extraction of radionuclides from the sewage sludge and precipitate with aluminium sulphate was done with acid ammonium acetate solution (pH 4.65). The extraction time was 1 h and the sludge to solution ratio 1:10 ($^v/_v$) (Vuorinen and Mäkitie 1955). The activity of liquids and residuals were measured by Ge(Li) gamma-spectrometry. The extractability of radiocesium from the sewage sludge was 3-5 % and from the precipitate with Al-sulphate about 3 %. The precipitate was also frozen and defrozen before extraction. The freezing did not change the extractability of radiocesium (Toivanen 1987).

Table 1. The chemical composition of sewage sludge on a dry weight basis made by Soil Analysis Service Ltd. Analysed according to Finnish requirements (Ympäristöministeriö 1991).

Element %		Method of analysis	Element mg kg^{-1}		Method of analysis
Total N	2.4	SFS 5505 1)	B	43	SFS 3044, 3047
Extr. N	0.26	SFS 5505	Cu	380	"
P	3.7	SFS 3044, 3047	Mn	390	"
K	0.1	"	Zn	1100	"
Ca	2.0	"	Mo	1.5	"
Mg	0.3	"	Co	19	"
S	0.9	2)	Cr	94	"
Fe	14	SFS 3044, 3047	Cd	3.7	"
Al	2.1		Ni	91	"
pH (H_2O)	6.9	SFS 3021	Hg	0.26	ISO 5666/1 3)
Dry matter	22 %	SFS 3008	Pb	120	SFS 3044, 3047

1) = SFS standard, available from Suomen Standardisoimisliitto SFS, Box 205, 00121 Helsinki, Finland
2) = Hesse, P.R. 1971. A textbook of soil chemical analysis. John Murray (Publishers) Ltd. 520 p.
3) = International Standard (ISO, International Organization for Standardization)

Field experiments

The field experiments were conducted during two growing seasons on a clay, a clay loam and a sandy loam soil. The crops were spring wheat (cv. Ruso) and barley (cv. Kustaa). The size of the experimental plots was 2.5 m x 15 m, replicated four times.

The sludge formed in spring 1986 was spread in spring 1987 on ploughed fields before the preparation of the seedbed (experiment 1) or in autumn 1987 prior to ploughing (experiment 2). The amount of sludge used was 100 m^3 per hectare. This amount contained 22 metric tons of dry matter per hectare.

The plots where no sludge was added were fertilized at a rate of 600 kg per hectare with a NPK fertilizer containing 16 % N, 7 % P and 13.3 % K. To the plots to which sewage sludge was added also 200 kg per hectare of a NPK fertilizer containing 20 % N, 4.4 % P, 8.3 % K was added. Hence, the amounts of plant available nutrients were about equal in all treatments. The residual effect of sewage sludge applications was studied in 1988 and 1989, respectively. Samples were taken from soil, sludge, grain and straw.

Soil samples were taken before addition of sludge and cored to depths of 0-20 cm and 20-40 cm. The samples were dried at 35°C, and ground, avoiding disintegration of primary particles, through a 2-mm sieve and analyzed for volume weight, pH($CaCl_2$) (Tares and Sippola 1978), content of organic carbon (Sippola 1982) and gammaradionuclides (Table 2). The pH was measured in 0.01 M $CaCl_2$ suspension at the soil to solution ratio of 1:2.5 (Tares and Sippola 1978). The measurements of radioactivity concentrations were carried out at the Finnish Centre for Radiation and Nuclear Safety. The samples were packed in Marinelly beakers (volume 0.6 l) and measured by low background Ge(Li) gamma-spectrometry.

Grains and straws collected in 1987 were measured by direct gamma measurement in Marinelly geometry. In 1988, the activity concentrations were so low that some of the samples

Table 2. The mean concentration and ranges of ^{134}Cs, ^{137}Cs, (Bq kg^{-1} dry matter) and the value of pH and volume weight and content of clay and soil organic carbon in dry soil before the sludge was added. ref. day 1.10.1987. The results are the mean on 16 different plots.

	volume weight g cm^{-3}	clay[a], %	Organic C %	pH ($CaCl_2$)	^{134}Cs, mean	Bq kg^{-1} range	^{137}Cs, mean	Bq kg^{-1} range
Experiment 1								
clay soil								
0–20 cm	1.0	61	3.7	5.5	5.0	(3.1–7.3)	20	(15–27)
20–40 cm	1.0	73	2.0	5.6	7.2	(0–13)	26	(10–40)
sandy loam soil								
0–20 cm	1.2	13	2.6	6.3	6.8	(4.5–12)	24	(17–38)
20–40 cm	1.3	20	0.5	6.1	2.9	(0–5.2)	11	(1.2–18)
Experiment 2								
clay soil								
0–20 cm	1.0	49	2.8	5.5	6.3	(2.2–11)	22	(12–34)
20–40 cm	1.1	61	1.3	5.7	2.2	(0–4.1)	8.4	(3.6–16)
clay loam soil								
0–20 cm	1.1	36	2.7	6.2	5.9	(2.6–11)	21	(11–35)
20–40 cm	1.1	45	1.5	6.3	<2		3.8	(1.7–8.2)

[a]particle size <0.002 mm

had to be concentrated by dry ashing at 450 °C. In 1989, all samples were ashed, and pressed into tablets before measurement in cylindrical geometry (volume 30 cm^3).

Because the activities in grain and straw were close to the detection limits, the error of the measurement of ^{137}Cs can be as big as 20-30 %.

Results and discussion

In 1987, ^{40}K, ^{134}Cs, ^{137}Cs and small amounts of ^{106}Ru and ^{125}Sb were detected in soil samples before the addition of sludge. The concentrations of ^{134}Cs and ^{137}Cs in the soil are presented in Table 2.

The largest amounts of radionuclides were detected at a depth of 20-40 cm in the clay soil in experiment 1 established in spring 1987. In spring 1986, the deposition had fallen on the surface of the field and in the autumn, when the field was ploughed, the active surface layer was turned down to about 20 cm. During the sampling the cores were cut at 20 cm and 40 cm. Therefore, the total amount of activity down to 40 cm was used for the calculation of transfer factors.

The mean ^{137}Cs concentration in the soils (down to 40 cm) before the sludge treatment was 23 and 15 Bq kg^{-1} dry weight in clay and 18 and 12 Bq kg^{-1} dry weight in sandy loam and clay loam soil in experiments 1 and 2, respectively.

The amount of ^{137}Cs per square meter (down to 40 cm) was calculated using the concentration of ^{137}Cs Bq kg^{-1} dry weight and the volume weight (bulk density) of dry soil samples. In Finland the ratio of ^{134}Cs to ^{137}Cs in the Chernobyl fallout on 1 May, 1986 was 0.6 (Arvela et al. 1987). Using this ratio, the concentration of ^{134}Cs and taking into account the radioactive decay the proportion of "old" fallout ^{137}Cs originating from nuclear weapons tests was estimated to be about 2000 Bq m^{-2} in the experimental soil. The Chernobyl accident added 4000-7000 Bq m^{-2} of ^{137}Cs to this soil. The addition of sludge still increased the amount of ^{137}Cs by 10 000-12 000 Bq m^{-2} to a total of 16 000-21 000 Bq m^{-2}.

The average dry matter yields of grain and straw are given in Tables 3 and 4. The addition of sludge didn't cause any statistically significant differences between the grain yields. The straw yields were in 1987 significantly higher in those plots where sludge was added than in the plots without sludge addition.

In 1988, the grain yields and especially the straw yields were remarkably lower than normal. This

Table 3. The average dry matter yields of grain and straw in experiment 1 and differences between the treatments.

Cereal/Soil	Year	Grain kg ha^{-1} no sludge	Grain kg ha^{-1} sludge	Grain Difference[1]	Straw kg ha^{-1} no sludge	Straw kg ha^{-1} sludge	Straw Difference[1]
Spring wheat							
clay	-87	2260	2190	NS	3280	4120	XX
	-88	2110	2130	NS	1090	1100	NS
sandy loam	-87	2370	1990	NS	3850	4750	X
	-88	2270	2300	NS	1950	2040	NS
Barley							
clay	-87	2980	3270	NS	2090	3110	XX
	-88	2580	2150	X	670	580	NS
sandy loam	-87	3960	3660	NS	2920	3790	XX
	-88	3600	3520	NS	1960	1910	NS

[1] Statistically significant differences in yields
at the 0.05 level of significance are indicated by X
at the 0.01 level of significance are indicated by XX
NS = not significant

was caused by the weather conditions during the growing season. The beginning of the summer was warmer and drier than normal. In July, there were many thundery rains and the precipitation was higher than normal (Ilmatieteen laitos 1988).

Of the nuclides originating from the Chernobyl fallout, only ^{134}Cs and ^{137}Cs were detected in the experimental plants. The concentrations of ^{134}Cs were so low that this isotope was detected mainly in 1987 and only in spring wheat and barley grown in the sludge treated plots. The mean concentrations of ^{137}Cs and the range of concentrations in spring wheat and barley samples are given in Tables 5 and 6. In the sludge treated plots the mean concentrations of ^{137}Cs in grain varied from 1 to 3 Bq kg^{-1} dry weight in the first growing season and from 0.2 to 0.8 Bq kg^{-1} in the second growing season. In the treatments without sludge addition the mean concentrations were 0.2-0.3 Bq kg^{-1} in 1987, 0.1-0.4 Bq kg^{-1} in 1988 and 0.07-0.08 Bq kg^{-1} in 1989.

The average concentration of ^{137}Cs in wheat in Finland was 0.05 Bq kg^{-1} dry weight in 1985 (STUK 1987) and after the Chernobyl accident in 1986 it was 2.6 Bq kg^{-1} (Rantavaara and Haukka 1987). In 1987 the average concentration of ^{137}Cs in wheat was 0.4 Bq kg^{-1} and in barley 0.6 Bq kg^{-1} (Rantavaara 1991).

The mean concentrations of ^{137}Cs in the grain of spring wheat and barley were about equal, or a little bit higher in spring wheat after sludge addition in the first experimental year. The mean concentrations of ^{137}Cs in straw were higher in barley than in spring wheat. Application of sludge increased the concentration of ^{137}Cs in grain 2-12 times and in straw 1-6 times as compared with crops grown in the control plots. The variations in different plots were high. The large variations in the activity concentrations were obviously due to the uneven distribution of radionuclides in the soil, to the heterogeneity of the sludge and the uneven spread of the sludge on the fields.

In experiment 2 of the first growing season (in 1988) was the concentration of ^{137}Cs in spring wheat and barley grown in plots to which sludge was added of the same magnitude as the concentration of ^{137}Cs found in the first growing season (in 1987) in experiment 1 in the plots with the corresponding treatment. There wasn't any significant difference in the concentrations of ^{137}Cs in grain whether the sludge was added in the previous autumn before ploughing or after ploughing in the spring before harrowing.

Table 4.The average dry matter yields of grain and straw in experiment 2 and differences betwwen the treatments.

Cereal/Soil	Year	Grain kg ha^{-1} no sludge	Grain kg ha^{-1} sludge	Grain Difference[1]	Straw kg ha^{-1} no sludge	Straw kg ha^{-1} sludge	Straw Difference[1]
Spring wheat							
clay	-88	1620	1720	NS	790	900	NS
	-89	3530	3730	NS	1290	1500	NS
sandy loam	-88	1980	1990	NS	1110	1200	NS
	-89	3300	3330	NS	1450	1550	NS
Barley							
clay	-88	2200	2230	NS	640	560	NS
	-89	3730	4130	NS	1470	1710	NS
sandy loam	-88	2670	2930	NS	870	1060	NS
	-89	4010	4160	NS	1890	2190	NS

[1] Statistically significant differences in yields
at the 0.05 level of significance are indicated by X
at the 0.01 level of significance are indicated by XX
NS = not significant

The main part of total activity is mostly translocated to the straw in the grain crop. Many earlier experiments have shown that the uptake in the straw is greater than in the grain (ØHLENSCHLAEGER and GISSEL-NIELSEN 1989).

The statistical comparison between the concentration of ^{137}Cs in grain and straw grown in soils fertilized with different way were used in analysis of variance and t-test. Results are given in Tables 5 and 6.

In experiment 1 in 1987, the random variation of the concentration in spring wheat at different plots was so great that the analysis of variance did not show any significant difference (except on sandy loam).

In experiment 2, the differences were statistically significant in both crops and both soil types in both experimental years. In the second experimental year the differences were statistically more significant on sandy soil both in grain and straw. The variations in the yields in different years did not show any significant effect on the concentrations of ^{137}Cs in grain. The more significant effect was the variation in the concentration of ^{137}Cs in soil and the time what ^{137}Cs has been in soil.

The concentration ratio (CR) for radiocesium from soil (down to 40 cm) to grain was defined as Bq kg^{-1} grain per Bq kg^{-1} soil (or soil and sludge). The mean CR values for ^{137}Cs ranged between 0.02 and 0.07 in the first experimental year in both experiments on soils to which sludge was added. In the second experimental year the values ranged between 0.005 and 0.02. There was no statistically significant difference between CR values whether the sludge was added in the previous autumn before ploughing or after ploughing before harrowing in

Table 5. The mean concentrations and the ranges of ^{137}Cs (Bq kg^{-1}) in grain and straw in experiment 1 (sludge applied in spring 1987) and differences between treatments.

Cereal/Soil	Year	Grain			Straw		
		Bq kg^{-1}			Bq kg^{-1}		
		no sludge	sludge	Difference[1]	no sludge	sludge	Difference[1]
Spring wheat							
clay	-87	0.37 (0.24-0.56)	2.2 (0.58-3.6)	NS	0.78 (0.5-1.1)	1.4 (0.73-2.1)	NS
	-88	0.14 (0.098-0.19)	0.26 (0.12-0.47)	NS	0.62	0.57 (0.44-0.65)	-[2]
sandy loam	-87	0.34 (0.15-0.71)	2.9 (1.4-5.3)	X	0.67 (0.39-1.2)	3.9 (1.9-7.8)	NS
	-88	0.42	0.65 (0.30-1.2)	-	0.68 (0.59-0.85)	1.3 (0.68-1.8)	X
Barley							
clay	-87	0.22 (0.12-0.40)	1.0 (0.79-1.1)	XX	0.9 (0.66-1.2)	3.9 (3.4-4.8)	XX
	-88	0.12 (0-0.18)	0.23 (0.15-0.37)	NS	0.59	1.0 (0.95-1.11)	-
sandy loam	-87	0.33 (0.11-0.79)	1.9 (1.1-2.4)	XX	1.2 (0.86-1.5)	5.7 (4.5-6.7)	XX
	-88	0.19	0.66 (0.53-1.04)	-	1.3 (0.92-1.8)	1.3 (0.81-1.7)	NS

[1] Statistically significant differences in concentrations
at the 0.05 level of significance are indicated by X
at the 0.01 level of significance are indicated by XX
NS = not significant

[2] the samples from four replicates are bulked

the following spring. In soil to which no sludge was added the CR values were in 1987 (in the second year after the fallout from Chernobyl) 0.01-0.02, in 1988 0.006-0.03, in 1989 0.004-0.006. The results indicate that sludge has a significant influence on the concentration of radiocesium in grain crops only during the first year after sludge addition.

For the sludge-treated soils varied the average transfer factor (TF) of ^{137}Cs from soil to plant defined as Bq ha^{-1} plant (grain and straw) per Bq ha^{-1} soil (or soil and sludge) in first experimental years (1987 and 1988) from 24 x 10^{-6} to 150 x 10^{-6} and in the second experimental year (1988 and 1989) from 5.6 x 10^{-6} to 52 x 10^{-6} and for the control soils from 10 x 10^{-6} to 58 x 10^{-6} and from 8.4 x 10^{-6} to 52 x 10^{-6}, respectively (see Table 7). In the first growing season there were distinct differences in transfer factors between the treatments where sludge was added and the treatments without sludge addition. In the second year, no differences were found in experiment 1. In experiment 2 there were differences in the TF factor also in the second growing season.

The transfer factors were greater in those plots to which sludge was added. The fact that the sludge was over winter in soil did not change the plant availability of cesium in sludge in the first growing season after addition. In the following year the residual effect of the sludge was little.

There were in the first year large variations in activities of plants between different replicates. These variations diminished during the second year. The differences between the plots treated with different way diminished also during the second year. However, in the experimental plots where sludge was added was also in the second year higher activities in plants than in the plots without

Table 6. The mean concentrations and the ranges of ^{137}Cs (Bq kg^{-1}) in grain and straw in experiment 2 (Sludge applied in autumn 1987) and differences between the treatments.

Cereal/Soil	Year	Grain			Straw		
		Bq kg^{-1}			Bq kg^{-1}		
		no sludge	sludge	Difference[1]	no sludge	sludge	Difference[1]
Spring wheat							
clay	-88	0.16 (0.12-0.20)	1.0 (0.88-1.23)	XX	0.59 (0.44-0.77)	2.2 (1.6-2.8)	XX
	-89	0.080 (0.053-0.10)	0.29 (0.15-0.42)	X	0.32 (0.27-0.36)	0.59 (0.37-0.70)	X
clay loam	-88	0.19 (0.18-0.22)	2.4 (1.6-3.4)	XX	0.64 (0.48-0.77)	3.8 (2.4-5.4)	XX
	-89	0.079 (0.057-0.094)	0.44 (0.20-0.53)	XX	0.27 (0.19-0.32)	1.03 (0.34-1.45)	XX
Barley							
clay	-88	0.39 (0.13-0.81)	0.95 (0.54-1.24)	X	0.97 (0.86-1.10)	3.8 (2.5-5.5)	XX
	-89	0.079 (0.043-0.12)	0.31 (0.20-0.46)	X	0.36 (0.28-0.44)	0.94 (0.34-1.45)	NS
clay loam	-88	0.31 (0.083-0.84)	2.2 (1.2-4.0)	X	0.80 (0.50-1.10)	4.5 (3.0-5.8)	XX
	-89	0.068 (0.051-0.11)	0.81 (0.31-1.07)	XX	0.41 (0.31-0.53)	2.1 (1.2-2.6)	XX

[1] Statistically significant differences in concentrations
at the 0.05 level of significance are indicated by X
at the 0.01 level of significance are indicated by XX
NS = not significant

sludge addition. After the sludge was added, the activities and CR and TF values were lower on clay soil than on sandy loam and clay loam soils, both in the first and second growing seasons. Clay soil fixes cesium added with sludge. Many investigations have also shown that cesium migration and plant availability depend on the content and type of clay and on the organic matter and the potassium content of the soil. The transfer of ^{137}Cs from soil to crop will decrease with increasing clay content and be higher from organic soils (Mascanzoni 1989, Haak 1990, Eriksson 1990).

Table 7. The transfer factor (TF) of ^{137}Cs from soil to plant and differences between the treatment.

Experiment 1

Soil/Cereal	Sludge application t D.M./ha	TF x 10^6 1987 mean	1987 range	1987 Difference[1]	1988 mean	1988 range	1988 Difference[1]
Clay							
Spring wheat	0	35	(25-59)	NS	9.4		[2]
	22	46	(27-69)		5.6	(3.3-8.6)	
Barley	0	32	(24-37)	XX	8.8		[2]
	22	79	(63-110)		6.0	(4.7-6.8)	
Sandy loam							
Spring wheat	0	40	(32-52)	NS	28		[2]
	22	120	(59-230)		20	(11-28)	
Barley	0	58	(23-110)	X	34		[2]
	22	150	(100-190)		24	(16-29)	

Experiment 2

Soil/Cereal	Sludge application t D.M./ha	TF x 10^6 1988 mean	1988 range	1988 Difference[1]	1989 mean	1989 range	1989 Difference[1]
Clay							
Spring wheat	0	10	(6.7-13)	XX	8.4	(7.7-9.2)	X
	22	24	(20-28)		17	(11-23)	
Barley	0	26	(11-49)	NS	13	(8.4-17)	NS
	22	26	(16-34)		16	(9.0-21)	
Clay loam							
Spring wheat	0	20	(15-26)	X	13	(7.7-19)	NS
	22	65	(39-100)		17	(12-22)	
Barley	0	21	(13-29)	X	18	(8.8-35)	XX
	22	74	(44-140)		52	(31-59)	

[1] Statistically significant differences in transfer factors
at the 0.05 level of significance are indicated by X
at the 0.01 level of significance are indicated by XX
NS=not significant

[2] The sample from four replicates are bulked

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Manuscript received June 1991

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SELOSTUS

Viljelymaahan lisätyn kontaminoituneen jätevesilietteen vaikutus kevätvehnän ja ohran radionuklidipitoisuuksiin

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Kenttäkokein selvitettiin jätevesilietteen sisältämän radioaktiivisen cesiumin siirtymistä kevätvehnään ja ohraan savi-, hieta- ja hiuesavimaasta. Kokeet tehtiin Jokioisissa Maatalouden tutkimuskeskuksessa. Osa kokeesta tehtiin levittämällä liete kynnettyyn peltoon keväällä 1987 ennen maanmuokkausta (koe 1), osa lietettä levitettiin syksyllä 1987 ennen kyntöä (koe 2). Kokeet olivat kaksivuotisia.

Käytetty liete oli Kyläsaaren puhdistamolla keväällä 1986 muodostunutta mädätettyä lietettä, joka sisälsi runsaasti Tshernobyl-laskeumasta peräisin olevia radionuklideja. Sen ^{137}Cs-pitoisuus oli 4700-5300 Bq/kg kuiva-ainetta. Lietteessä oli mukana raakavedenpuhdistamolta peräisin olevaa Al-sulfaatilla saostettua sakkaa, jonka radioaktiivisen cesiumin pitoisuus oli korkea.

Lietettä levitettiin pellolle 20 tonnia kuiva-ainetta hehtaarille. Verranneruutuihin, joihin ei lisätty lietettä, lisättiin NPK-lannoitetta, niin että kasvien käytettävissä olevien ravinteiden määrät olivat likimain yhtä suuret kaikissa koeruuduissa.

^{137}Cs:n siirtyminen maasta kasviin oli suurin niissä ruuduissa, joihin lietettä oli lisätty. Jyvän ^{137}Cs-pitoisuudet olivat 2-12 ja oljen 1-6 kertaa suuremmat lietelisäyksen jälkeen kuin ilman sitä. Lietelisäyksen jälkeen savimaassa kasvaneen viljan pitoisuudet ja siirtokertoimet olivat pienemmät kuin hietamaassa kasvaneen. Savimaa pidätti hietamaata voimakkaammin lietteen mukana tulevaa cesiumia. Ensimmäisenä satokautena siirtyi olkeen ja jyvään yhteensä 0.002 - 0.015 % maaperästä olevasta aktiivisuudesta, niissä ruuduissa, joihin lietettä oli lisätty. Seuraavana satokautena määrä oli noin kolmasosa tästä, eli samaa suuruusluokkaa kuin ilman lietelisäystä olevilla pelloilla. Lietteen lisäystapa ei vaikuttanut ^{137}Cs:n siirtymiseen maasta kasviin. Molemmissa kokeissa ensimmäisen koevuoden siirtokertoimet olivat samaa suuruusluokkaa riippumatta siitä, oliko liete lisätty keväällä 1987 vai syksynä 1987 seuraavaa kasvukautta varten.