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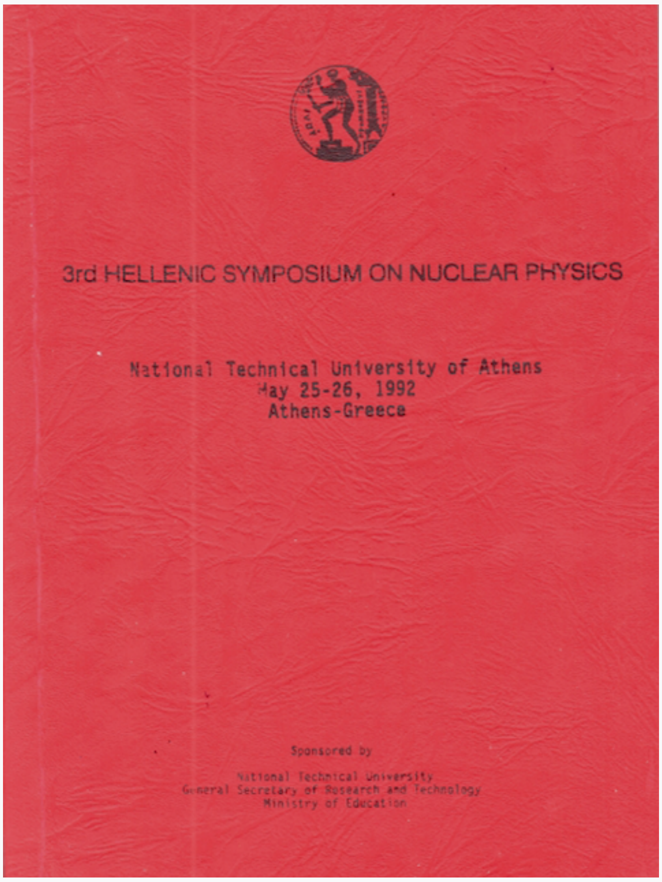

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EXPERIMENTAL INVESTIGATION OF ^{137}Cs AGING IN SOIL

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INTRODUCTION

The purpose of this research was to study the time dependence of the availability of radiocesium in soil for root uptake by plants, the so called cesium aging or in other words the transfer factor of radiocesium from surface soil to plants.

After the accident of Chernobyl two different processes were proposed: Some researchers claimed that there is no ^{137}Cs aging in soil in other words radiocesium remains available for uptake by plants at constant rates. Opposite opinions claimed that after a nuclear fallout radiocesium is gradually trapped in more complex insoluble salts and thus becomes less available for root uptake. In order to investigate which of these two processes is more reliable we took advantage of the continued draught in Greece between 1986 and 1990 to simulate the chemical evolution of ^{137}Cs in soil.

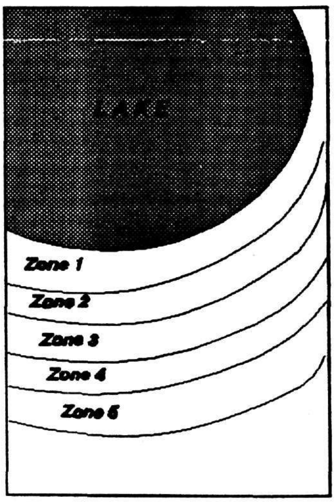

Figure 1.Zones at the shore of a lake representing roughly an annual period of recession of waters during a continued draught.

MODEL

During nuclear fallout radiocesium is deposited on the surface soil where is trapped in the upper 5cm as it was mentioned (Squire, *et al.*,1966). If it is deposited on the surface of a lake at first it is diluted or suspended in the entire volume of the water in the form it was in the fallout cloud. After some time the majority of radiocesium is deposited on the bottom of the lake. We assume that radiocesium is not fixed in complex salts at the bottom of the lake and so it is available to plants. As is shown in Fig.1 if the waters of a lake recede during a long period of draught the bottom of the lake is exposed and gradually gets dry. This exposed area may be divided in zones each one representing roughly an annual recession of water.In the absence of water and the other factors of the ecosystem of the lake which do not allow ^{137}Cs to be trapped in complex salts, radiocesium now is probably fixed in complex salts and becomes less available for uptake by plants.

Thus we expect a decreasing value of the transfer factor as we get away from the lake shore. The transfer factor is defined as the ratio of radiocesium concentration Bq/Kgr dry matter in vegetation samples to the corresponding concentration in soil samples.

MATERIALS AND METHODS

To check the hypothesis we selected two lakes Minor Prespa at the borders of northern Greece with Yugoslavia and Albania and lake Amvrakia at western Greece. Undisturbed areas which have been exposed since 1986 were selected near the lakes. They were divided in five zones for the Minor Prespa and four zones for the lake Amvrakia, as shown in Fig.1, each one representing roughly an annual period of recession of waters. Samples of soil and vegetation were collected from each zone and were dried until steady weight. Then they were ground to coarse powder and measured in 400ml plastic containers. Measurements were conducted in the Nuclear Physics lab of the University of Ioannina using Ge shielded detector and standard electronics.

RESULTS

Results of radioactivity concentration measurements in all samples are contained in tables 2 and 3. The last column in each table contains in addition the value of the transfer factor for each zone, expressed in percentage units. The results for the transfer factor contained in Tables 2 and 3 are plotted in the graph of Figure 2.

The transfer factor for the first and the second zone of lake Minor Prespa is about 50%; it falls by a factor of 5 to 10%, and remains constant in the remaining zones. A similar behaviour is obtain in the Figure 2 for the lake Amvrakia. For the first zone along the lake shore the transfer factor is about 30% and then falls abruptly by a factor of 3 to 12%, where again remains constant in the remaining zones.

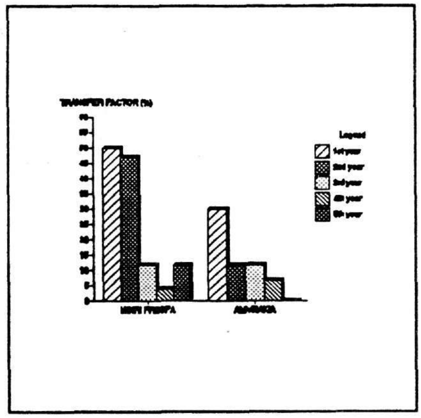

Figure 2 Plot of the transfer factors for the lake Minor Prespa and for the lake Amvrakia.

DISCUSSION

The presence of this high transfer factor for the first two zones here might be due to the fact that each zone does not represent an exact annual recession of waters. Also the difference between the transfer factor for the first zones of the two lakes, might be due to the different physicochemical properties of soils. In Tab. 1 is shown that in lake Minor Prespa the soil is sandy in contrast to the lake Amvrakia where the soil is silt-sandy.

The results presented are in accordance to other authors (Alexakhin, *et al.*, 1990) and tend to support the hypothesis of the radiocesium aging mechanism in soil. The phenomenon may be interpreted by means of the chemical behaviour of radiocesium in the soil. It may be assumed that in the initial fallout ^{137}Cs is in ionic form or in the form of simple chemical compounds. However with the passage of time it becomes trapped in complex, less soluble, compounds and thus becomes less available for uptake by plants. This is in agreement with previous results (Squire, *et al.*, 1966; Cline, *et al.*, 1972) where it was found that radiocesium is gradually trapped in artificially contaminated clay soils.

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Cline, J.F.; Richard, W.H. Radioactive strontium and cesium in cultivated and abandoned field plots. Health Phys. 23:317-324; 1972.

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Table 1. Mechanical analysis for soil of the lakes Amvrakia and Minor Prespa.

Area	Clay (%)	Silt (%)	Sand (%)
Lake Amvrakia	4	51	45
Lake Minor Prespa	2	3	95

Table 2. Radioactivity concentration measurements performed on samples of surface soil and vegetation of lake Minor Prespa.

Zone	Concentration (Bq/Kg)		Transfer factor (%)
	Vegetation	Soil	
1	42.1 ± 2.0	84.8 ± 5.1	50 ± 4
2	49.8 ± 6.0	106.9 ± 6.9	47 ± 6
3	20.1 ± 4.8	172.5 ± 10.1	12 ± 3
4	2.0 ± 0.6	51.8 ± 3.7	4 ± 1
5	18.9 ± 4.0	155.1 ± 9.0	12 ± 3

Table 3. Radioactivity concentration measurements performed on samples of surface soil and vegetation of lake Amvrakia.

Zone	Concentration(Bq/Kg)		Transfer factor (%)
	Vegetation	Soil	
1	19.0 ± 1.3	62.4 ± 1.8	30 ± 2
2	8.4 ± 1.1	72.2 ± 2.3	12 ± 2
3	8.6 ± 0.9	69.5 ± 2.4	12 ± 2
4	4.7 ± 0.6	67.6 ± 2.4	7 ± 1