Environmental radioactive pollution: biogeochemical assessment of ^{90}Sr in trees using geostatistical methods. Theory, methodology and a case study

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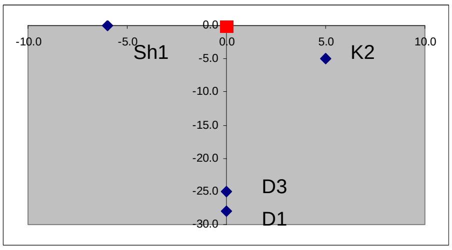
Introduction and Objectives

After Chernobyl accident many radioactive materials were disposed and buried. The piling up of radioactive waste has become an environmental problem because radioactivity has traveled to aquifers, ground waters and soils. It is usual to control the pollution sampling soil, rocks or water. But those direct methods are expensive and difficult to carry out. The indirect monitoring of pollution is easiest to do and cheaper. Nevertheless, to develop correctly the application of indirect methods in the monitoring of the environmental pollution some aspects have still to be studied:

1. The plant that can be more effective for such monitoring.
2. It is necessary to determine what parts of those organisms reflect more faithfully the pollution of the soil.
3. It must be evaluated the depth from where the roots absorb the radioactive pollutants.
4. The dispersion halos in the neighborhood of the waste deposits should be described.

So, indirect monitoring is based on the capability of plants to absorb radioactive pollutants from soils and aquifers. Theoretically, biogeochemical monitoring methods are based on the same laws as usual biogeochemistry. Nevertheless, the piling up of radio nuclei in the soils and their correlation in some parts of the plants has to be carefully studied. It has been stated that some different species of trees can absorb radio nuclei in different amounts and that those amounts are not the same, depending on which part of the tree is analyzed. On top of that, absorption of ^{90}Sr depends strongly on humidity of the soil. In this work some results based on monitoring Chernobyl Exclusion Area during years 1995-2000 are studied; from this study, biogeochemical methods to monitor ^{90}Sr are developed. It must be said that available data set is very small; nevertheless this work is a first attempt on that direction.

Polygon location; distances in km from CCA



^{90}Sr contents (Bk/kg on dry weight) in soils on years 1999-2000

POL	YEA	YCO	OCO	HUM	SO1	SO2	SO3	SO4
D1	1999	2586	3830	5086	536	86	19	
	2000	1730	1790	2260	550	190	70	
D3	1999	3478	2416	4174	2564	288	23	11
	2000	1530	1850	2330	830	150	30	
K2	1999	9973	28319	20576	1280	336	170	44
	2000	9890	21360	40770	2780	920	271	
Sh1	1999	435490	758777	1186412	18539	1874	523	112
	2000	317290	411190	1388670	21070	4190	1845	

POL, polygon; YEA, year; YCO, young cover; OCO, old cover; HUM, humus; SO1, soil at depth 0-5 cm; SO2, soil at depth 5-10 cm; SO3, soil at depth 10-20 cm; SO4, soil at depth greater than 20 cm.

Conclusions

1. ^{90}Sr contents in tissues and organs in pine, birch and oak trees in Chernobyl Zone (Ukraine) is in correlation to soil radioactive pollution.
2. ^{90}Sr in pine trees is greatly influenced by underground water level. In wet conditions (hydromorphic) the storage of 90Sr in pine trees is higher than in dry conditions (automorphic). This feature can also be seen in birch trees, to a lesser extent, but it is not seen in oak trees.
3. The incoming of ^{90}Sr to a plant comes from the polluted soils through the roots and from the air through bark and leaves. Some vegetal tissues react to radical or aerial pollution. The aerial incoming of ^{90}Sr in a tree depends essentially of climatic conditions. In dry periods ^{90}Sr enrichment is seen for high bark (especially for oak which is highly rough).
4. The storage of ^{90}Sr in trees depends on the intensity of metabolic processes. Young organs and tissues, which grow up quickly, store ^{90}Sr with more intensity than older ones. However, in pine leaves just the reverse tendency is seen. There can also be observed that birches absorb better ^{90}Sr than other trees do; this is because birches need more calcium than other trees and so it absorbs it better (Sr is chemically analogous to Ca). When pollution is very high this intensity is relatively less than it is when pollution is mean or low.
5. Looking to trees as a whole, we can observe that birches are better indicator than pine or oak trees of soil and underground water ^{90}Sr pollution.

Polygon D3: variograms of ^{90}Sr contents of studied different parts in pine (a), birch (b) and oak (c) trees.

(a)

(b)

(c)