CAESIUM-137 SOIL-TO-PLANT TRANSFER FOR REPRESENTATIVE AGRICULTURAL CROPS OF MONOCOTYLEDONOUS AND DICOTYLEDONOUS PLANTS IN POST-CHERNOBYL STEPPE LANDSCAPE

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1. Introduction

The accident at the Chernobyl nuclear power plant in 1986 had a large-scale action on more than 2.3 million hectares agricultural lands in Russia. The area of radioactively contaminated chernozems of semi-arid steppe zone with initial levels of Cs-137 185-555 kBq/m^2 in Tula region received the name "Plavsky radioactive hotspot" (fig.1). Nowadays, after the first half-life period of Cs-137 arable chernozems of the region are still polluted with 3-6-fold excess above the radioactive safety standard (126-228 kBq/m^2). Therefore, qualitative and quantitative characteristics of Cs-137 soil-to-plant transfer are currently a central problem for land use on the territory.

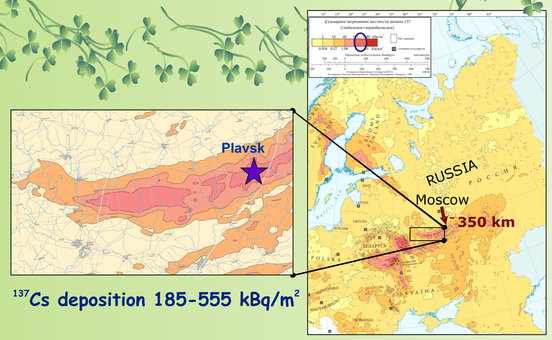
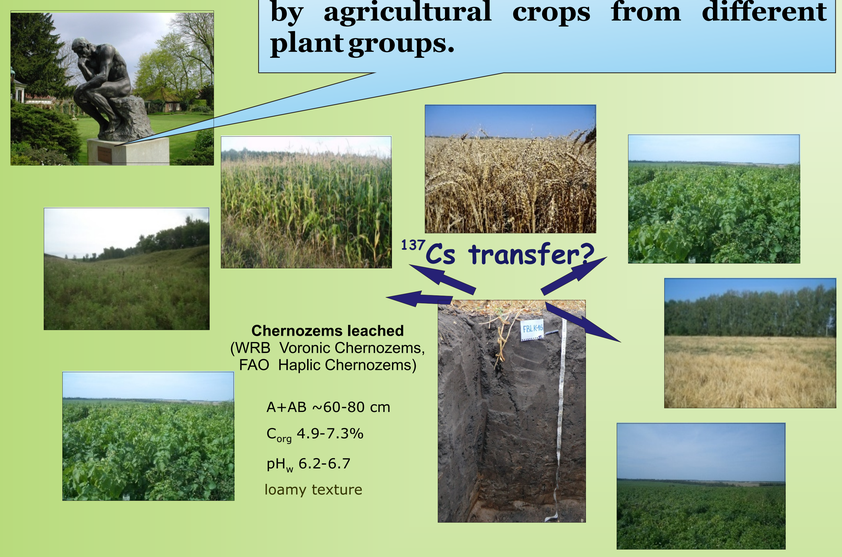


Figure 1. General location of Plavsky radioactive hot spot on a map of generalized levels of the ^{137}Cs pollution in European Russia after Chernobyl accident (Atlas of ^{137}Cs depositon on Europe after The Chernobyl accident / M. De Cort et all., 1998)

The purpose of the study is revealing the biological features of Cs-137 root uptake from contaminated arable chernozems by agricultural crops from different plant groups.



2. Objects and methods

The components of a grass mixture growing at the central part of Plavsky radioactive hotspot with typical dicotyledonous and monocotyledonous plants galega (*Galega orientalis*, *Fabaceae family*) and bromegrass (*Bromus inermis*, *Gramineae family*) respectively were selected for the investigation (fig.2), that was conducted during the period of harvesting in 2015. An important point was that the other factors influenced on Cs-137 soil-to-plant transfer process the level of the radionuclide accumulation in soil, soil properties, climatic conditions of the year, vegetative phase, etc. were equal. So biological features of Cs-137 root uptake could be estimated the most credible.

Bromegrass (Bromus inermis) — Galega (Galega orientalis)

Figure 2. Agrocenosis of investigated cereal-legume grass mixture

Vegetation was collected from a fixed space taking into account above- and belowground fractions (50^{x}50 cm^2 and 10^{x}10^{x}10 cm^3 up to 30-cm depth correspondently). The samples of aboveground biomass as well as belowground biomass of grass mixture were assorted by plant species - bromegrass and galega. The quantitative characteristics of belowground biomass were estimated after washing free from soil particles with a visual control against adhesion process and following analysis of ash content.

Soil samples were collected from the same fixed volume 10^{x}10^{x}10 cm^3 by step 10 cm. The sampled soil profile up to 30 cm was assumed both as rhizosphere space and current depth of >90% ^{137}Cs penetration.

Replication on each soil and vegetation sample was threefold.

3. Results and discussion

As a whole total discrimination of Cs-137 root uptake was clearly shown for both agricultural crops. Whereas Cs-137 activity in rhizosphere 30-cm layer of arable chernozem was 371±74 Bq/kg (140±32 kBq/m^2), Cs-137 activities in plant biomass were one-two orders of magnitude less, and transfer factor (TF) values (the ratio of the Cs-137 activities in vegetation and in soil) not exceeded 0.11 (fig.3). At the same time bioavailability of Cs-137 for bromegrass was significantly higher than for galega: individual TFs in total biomass of crops were 0.11 and 0.01 correspondingly. But the most dramatic difference between the investigated crops was connected with peculiarities of Cs-137 distribution within above- and belowground parts of biomass. While TF in aboveground fraction of galega (0.02) was slightly higher than in belowground fraction (0.01), the main accumulation of Cs-137 in bromegrass was detected not for shoots, but for roots (TFs 0.05 and 0.11 correspondingly).

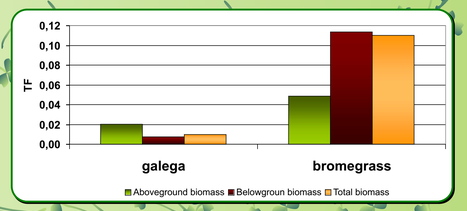


Figure 3. Transfer factors of Cs-137 for above- and belowground biomass of investigated cereal-legume grass mixture

More extensive examination of Cs-137 root uptake in the area of Plavsky radioactive hotspot supported the evidence for differences in the radionuclide behavior in "soil-plant" systems of monocotyledonous and dicotyledonous agricultural crops. All investigated dicotyledonous plants with taproot system (potatoes, soya, amaranth, rape) accumulated 71±14% of Cs-137 supplies in aboveground biomass, whereas monocotyledonous plants with fibrous root system (wheat, barley, maize, cereal pasture species) deposited 94±5% of Cs-137 inventories in their belowground biomass (fig.4). Thus, the first had effective biological root barrier protecting vegetation from general Cs-137 incorporation into biomass, but relatively active radionuclide translocation into shoots, while the second were characterized by some rhizofiltration property, but the occurrence an additional barrier between roots and shoots and only moderate radionuclide translocation into aboveground biomass.

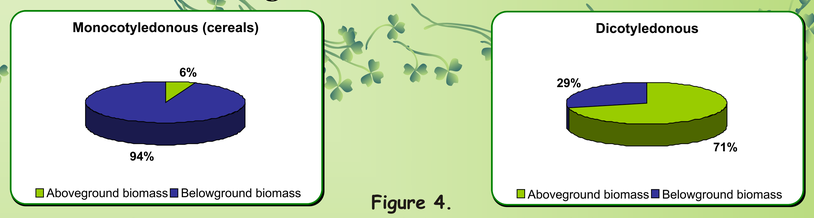


Figure 4. Structure of Cs-137 inventories in monocotiledonous and dicotyledonous plants in the area of Plavsky radioactive hotspot

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