***Yu. Mandro, PhD student***
***M. Vinichuk, Dr. of Biology, Prof., research advisor***
*Zhytomyr State Technological University*

# WOOD ASH AS A COUNTERMEASURE TO REDUCE $^{137}$Cs UPTAKE BY COWBERRY: ACHIEVEMENT OF EQUILIBRIUM IN SOIL-PLANT SYSTEM

As a result of the Chernobyl accident in 1986, a significant amount of radioactive material was released in the environment. Radioactive contamination spread throughout Europe. The depositions of radioactive cesium ($^{137}$Cs) were 15 PBq in Belarus, 13 PBq in Ukraine and 29 PBq in Russia: a further 27 PBq was deposited in other European countries [1, pp. 37-38]. In natural and semi-natural environments, including forest, even many years after the fallout$^{137}$Cs is mostly concentrated in the upper 0-10 or 0-15 cm soil layers being potentially available for root uptake over the next years. The relatively long period of physical decay and high bioavailability of $^{137}$Cs in forest soil make it potentially dangerous for wild animals feed by forest products as well as for humans eating MEAT that comes from WILD ANIMALS. Many countermeasures have been developed and applied for arable soils while countermeasures in forest ecosystems received less attention. There is a need for development of effective methods aiming to minimize radionuclides transfer form soil to forest vegetation, especially those species that serve as a food for wild animals and such reduce $^{137}$CS body BURDEN of humans. One of the countermeasures to reduce uptake of radiocaesium by plants and fungi in forest ecosystems can be application of potassium fertilizers. Potassium is a chemical analogue of radiocaesium and, therefore, can compete with cesium when it enters the plant. Application of wood ash may be another alternative to counteract radiocaesium uptake by forest vegetation. Biofuel ashes have relatively high potassium content (3-6 %) and if there is an excess of plant-available potassium ions in the soil, the plants take up the potassium ions instead of cesium. The aim of this study was to investigate the effect of wood ash application (both contaminated and uncontaminated with $^{137}$Cs) on $^{137}$Cs transfer from soil to forest plants, particularly cowberry (*Vaccinium vitis-idaea* L.).

The experiment was performed in forest ecosystems of Bazar forestry, Zhytomyr region and began on April 2012. The $^{137}$Cs deposition in this area is between 185-370 kBq/m$^2$. The experimental plots (200 m$^2$ each) were randomly designed within the area of about 0.6 ha. There were 3 treatments: 1 - Control (no ash was applied), 2 – "clean" wooden ash (uncontaminated by $^{137}$Cs ash denoted here as Ash), 3 – $^{137}$Cs-contaminated wooden ash (about 17.2 kBq/kg, denoted here as $^{137}$CsAsh). Each treatment had 4 replicates. Both "clean" (Ash) and "contaminated" ($^{137}$CsAsh) ashes were spread by hand on the forest floor once on April 20$^{th}$ 2012 at a rate corresponding 100 kg/ha potassium. Wood ash with potassium content about 3 % was used for the experiment. Samples (leaves and annual shoots) of cowberry (*Vaccinium vitis-idaea* L.), were taken monthly from

May 17 till September 21 from each plot. In the laboratory collected samples were air-dried, crushed, mixed thoroughly and placed into plastic containers for gamma spectrometric measurements. The soil samples were taken by using metal sampler with a diameter 57 mm and a length of the working section 150 mm. Measurements of $^{137}$Cs activity concentration in samples of plants and soil were performed at radioecological laboratories in University of Agricultural Sciences (Sweden) by using HPGe detectors and Zhytomyr State Technological University (Ukraine) by using NaI detector. Each sample was measured to achieve the error below 5% but not longer than 24 hours. The results were processed using Windas, Minitab and Microsoft Excel software. $^{137}$Cs transfer factors (TF) were calculated according to equation 1:

$$TF = \frac{Am}{As} \quad (1)$$

where: Am – activity concentration of $^{137}$Cs per unit dry weight of plants (Bq/kg); As - density of soil contamination by $^{137}$Cs, (kBq/m$^2$).

Results of our studies showed a gradual increase of $^{137}$Cs TF on Control treatment during the growing season with a maximum mean value in June about 15,53 ± 1,01 (range between 14,77and16,68). In July there was slightly decreased of $^{137}$CsTF 12,28 ± 4,09 with a range between 6,15–14,40 and remained almost unchanged until September (11,39 ± 2,96 with a range between 7,23–14,17) (Fig. 1). $^{137}$Cs activity concentrations in cowberry plants grown on plots with contaminated ash ($^{137}$CsAsh) were higher than on Control. Relatively high $^{137}$Cs TF values on these plots in the beginning of vegetation could be due to ash particles were deposited on above ground plant parts at the time of ash spreading on the soil surface. Thus the maximum values of $^{137}$CsTF in cowberry were observed on $^{137}$CsAsh treatment on May. The average TF value was about 19,55 ± 14,54 (7,57–38,28). There was a gradual decrease of $^{137}$CsTF values in the period from May till the end of vegetation. In August the TF values for cowberry plants on the treatment with "contaminated" ash were at the level of values for the control plants (Fig. 1).

On the treatment with "clean" ash (Ash) TF of $^{137}$Cs from soil to plants was higher only in the beginning of vegetation, namely in May (mean 14,62 ± 5,33 with a range 9,15–19,80), then there was a trend to lower values of $^{137}$Cs TF compared to Control. Thus, during June, August September $^{137}$Cs TFsfrom soil to plant cowberry on Ash treatment were significantly lower than on the Control treatment (Fig. 1).

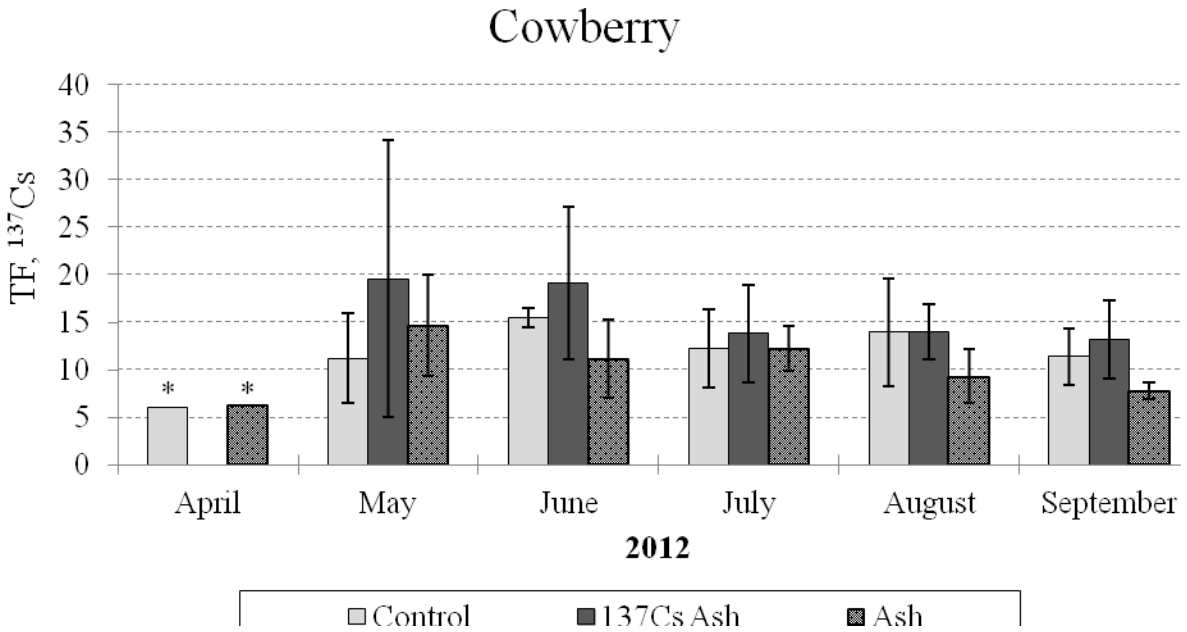


*Figure 1.[137]Cs TF values (n =3 - 4) for cowberry (Vaccinium vitis-idaea* L.*) on treatments Control (no ash was applied), Ash cont. ([137]Cs contaminated ash) and Ash (uncontaminated by [137]Cs ash) during the growing season in 2012.*

** - denote data obtained from 1 replicate;*

The results obtained in this study clearly show that a single wood ash application of "uncontaminated" ash was able to reduce $^{137}$Cs uptake by forest plants (leaves and annual shoots of cowberry) already during the first year. $^{137}$Cs TFs from soil to studied species appeared to be lower compared to that on Control already in June, just about 2 months after ash application. Application of "contaminated" ash facilitated radiocaesium transfer to cowberry during the first months, compared to control plants; however this difference was less pronounced and disappeared at the end of vegetation period. In the end of vegetation(August and September)$^{137}$Cs uptake by plants grown on plots with "uncontaminated" ash was clearly lower compared to both Control (33% and 31% respectively) and "contaminated" ash (34% and 41% respectively) treatments. Thus, the equilibrium in forest soil-plant system after fertilization with "uncontaminated" ash is seems to be achievable already within one-two mouths, when fertilization with ash contaminated by $^{137}$Cs seems to be require longer time – 4-5 month.

Based on the results of the first year of study it can be concluded that application of wood ash, both $^{137}$Cs "contaminated" and "uncontaminated" in forest may be a feasible countermeasure to reduce radiocaesium uptake by forest plants: the effect seems to be achievable already within the first year after soil fertilization by wood ash.

## REFERENCES

1. Jim T. Smith, Nicholas A. Beresford - Chernobyl - Catastrophe and Consequences. – Chichester, UK: Praxis Publishing, 2005. – 327 pp.