Application of Zeolite on Natural Upland Meadow Polluted by Cesium-137

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Abstract. Nuclear pollution of the territory occurred as a result of Chernobyl disaster caused the whole range of issues for agricultural production. One of them was the use of natural meadow ecosystems polluted by cesium-137 as hay fields and pastures. The standing grass crop of natural meadows accumulates more radionuclides than the standing grass crop grown on the soil treated by agricultural tools. Due to this, the search for available, effective and economically beneficial measures providing harvesting of products complying with standard values on natural meadows is important. The purpose of the research work was to study the effect of zeolite from the Khotynetsko quarry on transition of the radionuclide from the soil to the plant on the natural upland meadow. For this, in August, zeolite in amounts of 0.5 and 1% from the top soil weight was introduced on the top soil of experimental plots. Once prepared, the concentration of cesium-137, agrochemical and physical and chemical soil values, crop yield were determined in them. During the research work, it was found out that application of zeolite in amounts of 0.5 and 1% to ameliorate the meadow reduced accumulation of the radionuclide in the standing grass crop (hay), increased Hr, S, EKO, V, pH, potassium and phosphorus and boosted up the crop yield of the hay.

1. Introduction
In the condition of the radioactive pollution, meadow biocenoses become “critical” sites in the radioactive and ecological regard. It is explained by a high level of radionuclides accumulation in the standing grass crop of natural lands in comparison with the standing grass crop grown on the cropland. The well-known measures, such as tilling of the soil at various depths with the consequent grassing-down cannot always be done. As a result, the need arises to search for environmentally safe and economically beneficial technologies to provide the yield of products complying with standard values on these areas. Natural zeolites are suitable for this purpose according to their specific features. They have a high sorption capacity, cation-exchange features and the moisture-retaining ability and also contain a range of macro- and micro-elements needed by plants [1, 2, 3]. As a whole, zeolites may be used to improve physical, chemical and agrochemical features of the soil as well as to yield the environmentally safe products under conditions of the radioactive pollution of the area.

The purpose of our works was to study the effect of zeolite from Khotynetsko quarry when introduced on the top soil of the natural upland meadow, on migration of cesium-137 in the soil-plant system.
2. Methods of studies
The study was conducted on the natural upland meadow in the Novozybkovo District of the Bryansk Region subject to the radioactive pollution as a result of the accident on Chernobyl nuclear power plant.

The experiments were made on the plots with dimensions of 3x4 m in three replications.

Table 1. Experiment arrangement.

| No. of the plot | Amount of zeolite, % of the top soil weight |
|----------------|-------------------------------------------|
| 1              | 0 (control)                               |
| 2              | 1                                         |
| 3              | 0.5                                       |

Once the standing grass crop was mowed down in August, zeolite was introduced on the top soil of experimental plots and one year after duplicate samples of the soil and the standing grass crops were selected.

Afterwards, using the spectrometric complex “Progress”, the specific activity of cesium-137 was determined in the samples. Accumulation coefficients (AC) were calculated using the formula:

\[ AC = \frac{SA_{cr}}{SA_{so}} \]

where:
- AC is the accumulation coefficient;
- \( SA_{cr} \) is the specific activity of hay, Bq/kg;
- \( SA_{so} \) is the specific activity of the soil, Bq/kg.

Soil values, hay yield, its chemical contents and the nutritional value were determined using the common methods.

The data obtained as a result of the research work were subject to the statistical processing using the STRAZ software.

3. Study results
The accumulation of radionuclides depends on the whole range of factors of which the sorption capacity of the soil is principal. In the research work, introduction of zeolite on the top soil of experimental plots assumed that in the future zeolite affected by atmosphere precipitation would be moved into the soil where it would interact with the ions of cesium-137 and as a result, the availability of radionuclides to plants would be reduced. The data about the effect of zeolite on transition of cesium-137 from the soil to the standing grass crop (hay) are shown in Figure 1.
**Figure 1.** Effect of zeolite on the contents of cesium-137 in the hay, Bq/kg.

The figure shows that the contents of cesium-137 in the hay harvested on plots with the introduction of zeolite in comparison with the control plot has the tendency towards reduction [4, 5]. In particular, the contents of cesium-137 in the hay on the plots where zeolite was introduced in the amount of 1% was 1.07 times reduced. This value equaled 1.12 times on the plots with zeolite introduction in the amount of 0.5%.

The insignificant reduction of cesium-137 accumulation in the standing grass crop (hay) where zeolite was introduced can be apparently explained by its low penetration into the soil and the type of the meadow with its specific features (the type of the soil, the contents of humus, the mineralogical soil contents, etc.).

The study showed that introduction of zeolite on the top soil of the natural upland meadow had the positive effect on soil physical and chemical features (Fig. 2) [6].

**Figure 2.** Effect of zeolite on physical and chemical values of the soil.

In particular, the amount of zeolite as 1% increased Hr, S, EKO and V values in 1.18, 1.70, 1.48 and 1.14 times, correspondingly. The amount of zeolite as 0.5% increased these values in 1.18, 1.20, 1.19 and 1.00 times, correspondingly [7, 8, 9].

Increased physical and chemical values of the soil may be explained by features of zeolites themselves (high sorption capacity, cation-exchange features) as well as their amount penetrated into
the soil. During the study it was found out that the application of zeolite as an ameliorate of the meadow gradually had the positive effect on agrochemical values of the soil (Fig. 3) [10, 11].

![Figure 3](image.png)

**Figure 3.** Effect of zeolite on agrochemical values of the soil.

The data shown on the figure mean that application of zeolite on experimental plots increased the pH value in comparison with the control [12]. At this, introduction of zeolite in the amount of 0.5% from the top soil weight increased pH in 1.05 times and 1% in 1.12 times. Potassium and phosphorus values have the tendency to increase. In particular, introduction of zeolite in amounts of 0.5 and 1% increased these values in 1.06 and 1.06 and 1.11 and 1.12 times, correspondingly. At this, introduction of zeolite had no effect on the contents of humus in the soil.

The effect of zeolite on agrochemical values of the soil may be explained by the mineral and chemical contents of zeolites themselves and their features.

Application of zeolite on the natural upland meadow had the positive effect on the growth of the standing grass crop yield [12, 13]. The data about the effect of various zeolite doses on the crop yield are shown in Figure 4.

![Figure 4](image.png)

**Figure 4.** Effect of zeolite on hay yield.
The figure demonstrates that introduction of zeolite on experimental plots in the amount of 0.5% from the top soil weight increased yield of the hay in comparison with the control on 30% and introduction of 1% - on 28% [14, 15, 16].

4. Conclusion
The increased hay crop yield on the plots where zeolite was introduced in doses of 0.5 and 1% of the top soil weight may be explained by specific features of zeolites that are beneficial for growth and development of plants.

Therefore, introduction of zeolite in doses of 0.5 and 1% of the top soil weight provides the reduction of cesium-137 accumulation in the standing grass crop (hay), has the positive effect on physical, chemical and agrochemical soil values and increases the crop yield.

5. References
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