Effect of Clay and Zeolite on Cd Migration in Soil-Plant Systems on Various Types of Natural Meadows

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Abstract. Nowadays, the special focus is placed on heavy metals. It is explained by the scope of their release into the environment and high toxicity. Moreover, heavy metals are able to enter into biological migration chains and, while entering into a body, affect it causing various types of mutations. Therefore, the search for measures to limit migration of heavy metals in various parts of the biological chain leading to the human has a great significance. The purpose of this paper was to study the effect of local clay and zeolite in the Khotynetskoe quarry of the Orel Region on Cd migration in the soil-plant system on natural meadows. To assess migrations, absorption indices were used that were calculated as the relation of average element contents values in plants (hay) to average values in the soil. During the studies it was found that not only applied ameliorates (clay, zeolite) but also their number affects Cd migration in the soil-plant system (hay).

1. Introduction

Nowadays, there are more than 40 heavy metals. Their level of hazard make them take one of first positions among such pollutants as carbon dioxide, sulfur compounds, waste of nuclear power stations etc. At the same time, taking into account their scope of release into the environment, the level of toxicity and the ability to accumulation into life forms causing various types of mutations, Co, Ni, Cu, Zn, Sn, As, Se, Pb, Cd, Hg, Te, Sb, Bi and Mn deserve the special focus. As they are included into the biogeochemical cycle, they affect natural ecosystems while causing their degradation, make harm to agricultural areas and in some cases decrease the harvest and its quality (S.E. Golovatiy, 2002). At this, such heavy metals as Pb, Cd and Hg are super-toxic agents as they are especially hazardous for humans. Their accumulation in life forms in increased numbers affect their growth and development. Moreover, their cancer-inducing and mutagenic activity manifests that results into emergence of congenital deformities (V.V. Kovalskiy, 1974; I.M. Trakhtenberg, V.S. Kolesnikov, V.P. Lukovenko, 1999; S.E. Golovatiy, 2002).

Heavy metals released into the soil are partially absorbed by the soil and retained in the condition unavailable for plants. The other part remains in the soil solution and is available.

The migration of heavy metals in the soil-plant system depends on a range of factors such as mineralogical and granulometric contents of soils, the contents of the organic matter in them, acidity etc. For example, Cd adsorption in the sod-podzol loam soil is 25-29% more than in the sod-podzol sandy-loam soil (S.E. Golovatiy, 2002).

According to the data (Barrer R. M., 1978; Jenne E. A., 1977; Kenniburgh D. C., Jacson M. L.,...
1976; Madrid L., Diaz Barrientos E., 1992; Schwertmann U., Toulor R. M., 1977) sorption features of the soil are mostly related to the contents of clay minerals and clay fractions of soils. In particular, when the physical clay increases in the soil, availability of heavy metals to plants decreases (O. A. Ryazanova, 2002; Shi W.Y., Li H., Du S., Chen Y. P., Wang K. B., 2015; Shaheen S. M., Rinklebe J., 2015). This specific feature of clay minerals in regard to heavy metals was used in the research work.

The purpose of this research was to study the effect of the local clay and zeolite from Khotynetskoe quarry on Cd migration in the soil-plant system (hay) on various types of natural meadows (upland, lowland and flood meadows).

2. Methods of study
Studies of the effect of natural ameliorates (clay, zeolite) on Cd migration in the soil-plant system (hay) on various types of natural meadows were carried out in Klintsovo District of Bryansk Region.

Microplot experiments were carried out in three replications.

For this purpose, clay and zeolite were introduced on the surface of experimental plots in amounts of 0.5 and 1 % of the top soil weight. Ameliorates were not introduced on control plots.

| Scheme of the experience |
|--------------------------|
| Type of the meadow       |
| Upland                   |
| Lowland                  |
| Flood                    |
| Clay, zeolite put, % of the top soil weight | 0.5 | 1,0 |

One year after ameliorating, duplicate samples of soil and plants were selected on experimental plots. Once samples were prepared, the Cd contents was determined in them using the method of inverse voltammetry.

Indices of absorption used to determine Cd migration in the soil-plant system (hay) were calculated as the relation of average values of the element's contents in plants (hay) to average values in the soil (A.S. Metelkin, 2008).

3. Results of the study
During the research work it was found out that the Cd contents in the standing grass crop does not exceed standard values (0.3 mg/kg). The data about the effect of the clay on Cd migration in the soil-plant system (hay) on various types of natural meadows are shown in Figure 1.

![Figure 1. Effect of clay on Cd migration in the soil-plant system (hay).](image-url)
The data shown in the figure prove that in the control Cd accumulation in plants (hay) on various types of natural meadows has insignificant variations. In particular, indices of Cd absorption for upland and lowland meadows are equal and if compared with the flood meadow, 14 and 14% higher, correspondingly.

Addition of clay to natural meadows decreased Cd transition from the soil to the standing grass crop (hay) of meadows. In particular, introduction of the clay in the amount of 0.5% from the top soil weight reduced the Cd transition to plants on upland, lowland and flood meadows on 28.9 and 21% correspondingly if compared with the control plot. Introduction of 1% of the clay reduced Cd transition into the standing grass crop of meadows on 46, 33 ad 32% correspondingly, if compared with the control plot (S.E. Golovatyi, 2002). Moreover, introduction of the clay on plots in the amount of 1% from the top soil weight has the great effect on reduction of the Cd contents in the standing grass crop if compared with the amount of the clay that is 0.5%. At this the difference was 25% on the upland meadow, 15% on the lowland meadow and 13% flood meadow on the flood meadow.

Reduced Cd migration in the soil-plant system is explained by the increased amount of the physical clay in the soil as a result of its inward penetration from the surface and, therefore, its increased sorption capacity and reduced availability to plants (Yu.G. Baykenova, Yu.L. Baykin, 2015; Yu.L. Baykin, 2008; Yu.L. Baykin, Yu.G. Baykenova, M.E. Buraev, 2006; Yu.L. Baykin, Yu.G. Baykenova, M.E. Buraev, V.V. Kotomtsev, L.P. Lutskaya, E.P. Ustich, A.A. Korionov, A.M. Buraev, 2009).

The data about the effect of zeolite on Cd migration in the soil-plant system (hay) are given in Figure 2.

![Figure 2. Effect of zeolite on Cd migration in the soil-plant system (hay).](image)

The data show that introduction of zeolite on experimental plots in amounts of 0.5 and 1% from the top soil weight reduces Cd accumulation in the standing grass crop (hay) of upland, lowland and flood meadows if compared with the control (Chen Z.S., Lee G.J., Liu J.C.,2000; Rehakova M., Cuvanova S., Dzivak M., Rimar J., Gavalova Z., 2004; M.B. Suyundukova, G.E. Islamgulova, 2010). In particular, introduction of zeolite in the amount of 0.5% reduced Cd accumulation in the standing grass crop of meadows on 19, 14 and 53% correspondingly. Introduction of zeolite in the amount of 1% reduced accumulation on 23, 18 and 68% correspondingly. Differences in Cd accumulation during introduction of zeolite in the amount of 0.5 and 1% from the top soil weight were 6% on the upland meadow, 5% on the lowland meadow and 33% on the flood meadow (A.S. Ogluzdin, Yu.V. Alekseev,
N.I. Vyalushkina, 1996).

Thus, it was stated that introduction of clay and zeolite on experimental plots in the amount of 0.5 and 1% of the top soil weight reduced Cd accumulation in the standing grass crop (hay). At this, the greatest effect was obtained when ameliorates were introduced in the amount of 1%. In particular, Cd accumulation on upland, lowland and flood meadows was reduced if compared with the control plot and was 46, 33 and 32% for clay and 23, 18 and 68% for zeolite, correspondingly.

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