Biological and Chromatic Characteristics of Plants as a Factor for Monitoring and Management of Production Process When Applying Fertilizing Features of Production Wastes

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Abstract. The localization and intensity of technogenic flows of chemical elements causes the formation of technogenic anomalies and biogeochemical provinces with varying degrees of environmental distress. The purpose of the research is environmental assessment of the effectiveness of the fertilizing properties of metallurgical production wastes in nutrient soils. Studies have been conducted to determine the degree of influence of the fertilizing effect of various types of nutrient soils based on soil, slag and zeolite on germination, growth and development of seedlings of small-seeded lettuce. Seed germination, plant growth and development are affected by the water-physical properties of soils and the number of available macro and trace elements. Visual and computerized assessment of the color range of the lettuce leaves is proven to be effective to assess the level of soil contamination based on the intensity of nutrient consumption by plants.

1. Introduction
Among industry-related changes of the organism’s habitat, the greatest concern is contamination by industrial and household waste. The biggest threat is toxic wastes of various origin.

A contaminator violates the cycles of chemical elements migration and energy transformation and affects the functioning of the ecosystem as a whole. Xenobiotics, or alien chemical compounds, form global, regional and local flows and cycles in the biosphere.

The consequences of technogenesis are removal (concentration) of certain chemical elements (Au, Ag, Pt, Fe), and dissemination of others (Cd, Hg, As, F, Pb, Al, Cr), or a combination of both. Localization and intensity of incoming technogenic flows of chemical elements form technogenic anomalies and biochemical provinces with various degrees of environmental distress. People and animals can develop pathological conditions under the influence of toxic substances on such territories. The transformation of the environment leads to depletion of floral and faunal compisited of geological ecosystems, which is accompanied by biological and geochemical differentiation of life matter of various taxa. There is an increase in the value of the interaction among various chemical elements and compounds within biological and geochemical cycles.

In order to prevent the scale of ecosystem contamination from becoming irrevocable and
It is crucial to change the strategies of ecosystem use (eliminating the paths and sources of further contamination) and to development and introduction of methods and technologies of suppressing the toxicity and decontaminating various components of the geological systems from contaminators, which is the main object of this research.

2. Objective
The objective of this research is ecological assessment of fertilizing features of metallurgic waste in nutrient-reach soils.

3. Research goals
1. To develop substrates with the introduction of slag waste, natural zeolites into their compositions for the manifestation of their protective geochemical barrier properties and the cultivation of seedlings of vegetable crops.
2. To evaluate the effect of the studied compositions of nutrient substrates on the growth and development of plants, their biological productivity.
3. Use the color evaluation of the lettuce plants to indicate their condition and characteristics of the degree of toxic effect of slags.

4. Characteristics of research objects
The breeze of the saline aluminum slag of Mtsensk Metallurgical Plant AOOT “Tsvetnye metally I splavy” (Non-Ferrous Metals and Alloys), is characterized by the following indicators of physical and chemical properties: granular 3mm fraction; light gray color; specific odor; pH of the water extract pH8; the main phases are potassium chloride (KS1), sodium chloride (NaCl), aluminum oxide (Al2O3), silicon oxide (SiO2).

The chemical composition of the saline slag, %: of slag.: Al2O3 50.02; Cu 0.54; Si 3.22; Mg 1.64; Mn 0.21; Ti 0.033; Sb 0.036; Co n/i; As 0.0002; Ca 0.2; Zn 0.49; Fe 0.69; Ni 0.08; Pb 0.08; Sn 0.018; Na 2.39; K 7.37; Cl 8.6; SO4 0.28; Fe meh 1.0/

The breeze of the saline aluminum slag belongs to Class IV of low-hazardous substances in compliance with GOST 12.1.007-76 “Hazardous Substances in Industry. Classification and General Requirements”.

Small 0.5 mm fraction is used in the research tests.

Zeolites are present in the form of zeolite-containing bergmeals of Khotyne ts deposit with the following indicators: pH 8.3, CaO 8.17%, MgO 2.20%, K2O 1.82%, Cu 2.7x10^{-3}%, Zn 7.4x10^{-3}%, Mn 46x10^{-3}%, Co 0.12x10^{-3}%, Mo 0.72x10^{-3}%. The zeolite crystal structure contains: clinoptilolite 35%, cristobalite 27%, montmorillonite 5%, mica 8%, calcite 3%, the cation exchange capacity reaches 600 mEq / 100 g.

The soil is medium-loamy, dark gray forest soil, humus horizon (the content of physical clay is 40-42%; humus is 5.4-5.5%; pH soil - 5.2-5.5; pH water - 5.8-6.0; total the absorbed bases 35 mEq / 100g; P2O5 - 12.5-15.0 mg / 100g, K2O - 12.0-12.6 mg / 100g).

Sheet the lettuce (Lactuca sativa var. Secalina) is an annual plant. High yields of the lettuce are obtained on fertile, nitrogen-rich and sufficiently moist soils. Seed germination begins at +2 ... 4° C, with the optimum at +20-25 °C. The most appropriate temperature for growth is +15 ... 20 °C: it continues to grow at + 5° C. It tolerates frosts down to -8° C. the lettuce roots have numerous branches, located in the arable layer.

A cultivar of lettuce called “Moscow greenhouse lettuce” is the most common cultivar of lettuce of this variety. It is grown in both protected and open soils. Vegetative mass grows better at 9-12 hours daylight.

The experiments are carried out in 300 ml plastic pots. The mass of the substrate in the pot is 450-550 g., humidity is 70 - 75% of the dry mass. The repetition is fourfold. Salad seeds are sown 30 pcs. per pot. The following biometric indicators are measured after 30 days: leaf surface area, root length, number of roots, biomass accumulation. Conducted phenological observations are conducted during
the experiment.

The methods of assessing the deficiency of individual elements is based on color photographs of the leaves color range using Adobe Photoshop according to V.V. Tserling (1990). Monitoring the state of farming ecosystems and the effectiveness of agricultural technology provides a visual quantitative assessment of the color characteristics of plants using digitization of the color scale, since with the growth and aging of plants, and changes in the environment, there is a change in the color characteristics of plants as a result of interrelated physiological processes.

5. Results and discussion

Microelements are necessary for plants during the entire lifetime, from the sprouting to ripening of seeds (grains, fruits, etc.), as the main role of the microevents is to regulate the activity of various biological catalysts (enzymes). In case of low content of accessible microelements in the soil, their introduction is required, especially for small seed plants.

Due to the fact that the sensitivity of seedlings to microelemental salt concentrations is different, and these differences can be significant for different crops, we conducted studies to measure the influence of the fertilizing effect of different nutritive soils. The nutritive soils are composed of soil, slag and zeolite and affect germination, growth and development of lettuce seedlings. The choice of culture is explained by the fact that the lettuce belongs to cultures of increased removal of microelements with low assimilation capacity. Small seeds absorb very small amounts of microfertilizing solution and require an increased dose of microfertilizers or an increase in the multiplicity of microfertilizer distribution.

Since the tested nutrient soils contain not only macronutrients of nutrients, but also a wide range of biophilic microelements, they constitute a favorable nutrient medium for the growth and development of plants.

The study of the growth and development of the lettuce plants on nutritive soil-and-slag soils revealed that the effect of slag waste varies depending on the mass fraction in the composition of the soil. The soils with the highest slag content have low seed germination rates of 43.3-46.7% with little plant growth. The intensity of vegetative mass development in terms of leaf area is 3.2 - 6.6 times below the reference value. The total length of the roots is 24.3 cm in soils with small-fraction slag, which is 3.1 times lower than the reference. The toxicity coefficient in this type of soil is 20.4%, which is close to toxic, while the reduction in root length compared to the reference is 20%.

Table 1. The influence of nutritive soils made of natural soil, slag waste and zeolite on the growth and development of the lettuce seedlings.

| Variation                        | Germination capacity, % | Growth indicators | Toxicity coef., % | Biomass accumulation, g |
|----------------------------------|-------------------------|-------------------|-------------------|-------------------------|
| soil (reference)                 | 93.3                    | 113.4             | 119.3             | 6.55                    |
| soil+slag 1:2                    | 46.7                    | 17.2              | 24.3              | 1.8                     |
| soil+slag 1:1                    | 53.3                    | 27.5              | 85.7              | 2.2                     |
| soil+slag 1:0,5                  | 80.0                    | 85.2              | 91.8              | 5.29                    |
| soil+zeolite+slag 1:1:1          | 93.3                    | 35.1              | 44.3              | 2.62                    |
| soil+zeolite+slag 1:2:1          | 93.3                    | 74.5              | 50.1              | 3.8                     |

Reducing the mass fraction of slag waste in the composition of the nutritive soil decreases the toxic effect of slag. So, in soils made of natural soil and slag in a mass ratio of 1: 0.5, the germination capacity of the lettuce seeds increased by 1.5 times in comparison to soils at a ratio of 1:1, and by 1.7 times at a ratio of 1:2 and totaled at 80,0%. At the same time, intensive development of the root system
is observed in the soil with a reduced proportion of slag. The total length of the roots reached 91.8 cm, which is 93% compared to the reference variation. The leaf surface area is also within the reference value, reaching 85.2 - 128.4 cm². The accumulation of plant biomass on this type of soil is 5.29 g, which is about 2 times higher than on soils with increased doses of slag waste.

Thus, growth and development of the lettuce plants is inhibited with an increased amount of slag wastes in the composition of nutrient soils. In soils composed of natural soil and slag (1: 2), the total length of roots is 4.9 times lower than the reference, and the leaf surface area is 6.6 times smaller. Reducing the weight fraction of slag waste in the composition of nutritive soils decreases toxic effect of slag. At the same time, the indicators of the growth rate of the lettuce plants are within the reference value. The accumulation of plant biomass on this type of soil is 5.29 g, which is 3 times higher than on soils with the increased doses of slag waste.

The addition of zeolite to the composition of nutritive soils made of natural soil and slag causes an increase in the nutrient content, which contributes to the activation of growth processes at the early stages of plant development. An increase in the germination capacity of the lettuce seeds peaks up to 90-93.3%. However, further increased concentrations of the soil solution have a suppressive effect on the development of root systems. The total length of the roots is reduced by 2.5 times, when the ratio of components is 1: 1: 1, and by 1.8 times with a doubled proportion of zeolite in the composition of the soil compared to the reference value. When a double dose of zeolite is added, the growth of the vegetative mass of the lettuce plants is 2.1 times higher compared to the variation of soil + zeolite + slag (1: 1: 1).

It can be concluded that the seed germination capacity, growth and development of seedlings are influenced by the water and physical properties of soils, by the increased density of soil with a slag fraction smaller than 0.5 mm and zeolites, and the amount of available macro- and microelements. The sorption properties of zeolite in the nutritive soils lead to a closer contact between the seed and the nutrient medium and a favorable concentration of macro- and microelements, which increases the germination capacity and growth rate of seedlings.

The color assessment of plants is used to indicate their condition, both in field studies and in remote sensing. In our studies, we have analyzed the color characteristics of the lettuce leaves under the conditions of different contamination of nutritive soils with slag waste.

Table 2. Characteristics of the color range of the lettuce leaves with different levels of soil contamination.

| Variation                        | G   | M   | Color intensity | K   | L   | a   | b   |
|----------------------------------|-----|-----|-----------------|-----|-----|-----|-----|
| soil (reference)                 | 60.2±0.5 | 37.2±1.1 | 45.3±1.9 | 35.4±1.2 | 8.7±0.6 | 6.9±0.9 |
| soil+slag 1:2                    | 16.1±1.2 | 20.7±1.1 | 5.2±0.5 | 76.1±0.5 | 1.7±1.1 | 58.1±1.1 |
| soil+slag 1:1                    | 34.2±6 | 5.5±0.9 | 1.0±0.0 | 81.0±1.5 | 20.2±1.3 | 60.2±1.3 |
| soil+slag 1:0.5                  | 54.3±0.3 | 26.7±3.8 | 27.0±1.8 | 49.3±2.2 | 14.7±3.0 | 17.0±2.7 |
| soil+zeolite+ slag 1:1:1         | 50.0±0.6 | 19.7±0.2 | 19.2±1.7 | 57.0±0.9 | 20.0±0.9 | 32.7±1.9 |
| soil+zeolite+ slag 1:2:1         | 45.0±2.7 | 20.0±3.7 | 17.3±5.9 | 60.0±5.2 | 16.3±1.5 | 31.0±2.9 |

V. Tserling (1990) postulated that the deficiency of certain elements can be revealed by a change in color, which occurs in both whole plant species, leaf parts and leaf layers.

In order to evaluate the level of contamination, we have taken photographs of the leaves and conducted scanning for visual and computer assessment of the color range of leaves. The obtained color images are suitable for in-depth research and computer analysis of the color range. The table shows the data for evaluating the characteristics of the color range of the lettuce leaves with different levels of contamination caused by the introduction of slag wastes into the nutritive soils (fraction smaller than 0.5 mm) with different ratios of natural soil and zeolites, calculated from color
photographs (Rao J.M., 1993) using Adobe Photoshop software. As can be seen from the presented data, the color of the lettuce leaves with disturbed plant nutrition significantly differs from the reference variation. Taking into account color spots, the intensity of colors G and M is higher in the reference variation than in the other variations. The similar trend applies to the intensity of K. In this case, the index of L in all the variations is higher than in the reference. The ratio of colors, characterized by the indicators a and b, varies ambiguously. In the reference, the value of b is lower than in other variations, with different levels of pollution created by slag waste. CJE-Lab system reflects the contribution to the chromaticity of four colors: the redness (+ a) and greenness of the object (s); the yellowness (+ b) and blueness (-b); (ab) and they identify lightness (L). With a deficiency of nutrients for the lettuce, along with a deficiency of copper and nitrogen, a clear decrease in greenness is observed. An increase in greenness occurs in some parts of the leaf, in other parts it decreases.

Thus, the evaluation of color change in the lettuce leaves and computer identification of leaf color range demonstrate the effectiveness of using the method for assessing the conditions of plants grown on human-modified lands and assessing the rates of soil contamination.

6. Conclusion
Nutritive soils, composed of the humus soil layer, slag waste and zeolites, have a stimulating and fertilizing effect on the seed germination capacity, growth, development and productivity of the lettuce plants.

Visual and computerized assessment of the color range of the lettuce leaves is proven to be effective to assess the level of soil contamination based on the intensity of nutrient consumption by plants.

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