Assessment of the soil conditions in the areas of excavation dumps in rock formations

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Abstract. With the help of the method of bioindication, the ambiguous effect of granite dumps on the bioparameters of different species was increased. With the help of experimental research on the soil biototoxicity using the "Growth Test" method a strong correlation between plant bioparameters and distance to the granite dump, and hence the concentration of dust in the soil. It was investigated that the soil in the territory where the population is intensively engaged in agriculture, has mutagenic properties and causes a violation of bioindicators that affects the state of ecological safety and is a source of a threat to the health of the population and the ecosystem in general.

Keywords: *bioindicators, Growth Test, bioindication, natural environment.*

Introduction. Around the granite quarries formed zones of negative impact on the environment. The activity of the mining enterprise affects both the state of the environment of the region as a whole, and the level of soil fertility, the content of harmful substances in agricultural crops grown on them [1-2].

Observation and monitoring of soil condition are usually carried out only with the help of physico-chemical analyzes, which determine the content of individual pollutants. However, these analyzes do not allow to assess the impact of pollutants on living organisms, including humans. Today, biological methods, in particular bioindication, are alternative in studying the soil conditions of adjoining territories of quarries. Bioindication allows to determine the joint biological activity of the influence of physical and chemical factors on the natural environment [3].

The basic principle of bioindication is the search for the indicator of the relevant factor or system that induces. The existence of certain relationships between events, the logic of assertions and the reliability of the facts does not yet mean the possibility and feasibility of using these data for indication. Each bioindicator has a critical level of information, beyond which it not only does not work, but can significantly confuse information and even distort it [4]. Therefore, for the reliability of the results of the study, the stage is important for choosing a test culture and for changing its livelihoods. To date, there is no data on the substantiation of the choice of plant test systems for phytotoxic evaluation of soils adjacent to the quarries of rocky rocks.

An important characteristic of any bioindicator is its reliability. There are many recommendations on the use of one or another type of plant for soil bioindication, but the only commonly used methods for assessing the reliability are not developed.

Research results. When selecting test organisms, it is essential to use biotest, most sensitive to the action of contaminating components. The second important requirement for a test organism is that the action of the toxin on it must necessarily cause an adverse reaction of the organism. In addition, test organisms within a single study should be visually identical. This means that for bioindividual plants, compulsory calibration of the seeds by weight and size is required. Bioindicators are not suitable for organisms damaged by diseases, pests and parasites. [5-6].

In the scientific literature, examples of the use of various plant test objects for phytotoxic assessment of soil condition are given [7]. Taking into account the above mentioned requirements for indicator plants and the analysis of data of literary sources, the most common types of soil indicator plants in the territories of granite quarries in Ukraine (Zhytomyr and Kyiv region) are identified, namely: radish seedlings (Raphanus sativus var. Radicula Pers.), Lettuce (Lepidium sativum L.), onion (Allium cepa L.), wheat (Triticum sativum) and peas (Pisum sativum).

The choice of test organisms for the study of the influence of granite quarries on the soils of adjacent territories was based on the presence of a sensitive test-response to the change in the concentration of pollutants in the studied soils (Cr, U, Th, Zn), structural and functional characteristics of bioindicators (Table 1).

To accomplish the task, a hierarchy analysis method was used which allowed selecting the most optimal test organism [8-9]. Each test organism (P) has a parameter value (H). The ball system evaluated the relative importance of each parameter for each of the test plants (Table 2).

Table 1 - Parameters of tested test organisms [10,11]

Test plant	Parameter				
	Period of ontogenesis, days	Biological productivity, c/ha	Sensitive test-reaction to a chemical element		
			Cr	U/Th	Zn
Radish	25-45	$110 \pm 10,5$	-	+	-
Watercress	15-20	$10 \pm 1,2$	+	+	+
Onions	12-16*	$13,6 \pm 0,9$	+	+	+
Wheat	20-24*	$32,6 \pm 10,2$	+	-	+
Peas	65-85	$35,83 \pm 1,07$	+	-	+

* – 1 and 2 periods of ontogenesis are taken, which is sufficient for bioindication

The calculation of the relative importance of the parameters of the test plants during the soil bioindication is performed. In order to compare the parameters of the test plants and determine the most appropriate test system for assessing the soil state of the adjacent dumps, the corresponding matrices of analysis were compiled [12].

The general importance of test organisms for studying the influence of granite quarries on soils is calculated as follows.:

$$N_i = M_i^1 \times M_0^1 + M_i^2 \times M_0^2 + M_i^3 \cdot M_0^3 + M_i^4 \times M_0^4 + M_i^5 \cdot M_0^5$$

and is: N_1=0,1716; N_2=0,203; N_3=0,2117; N_4=0,1875; N_5=0,1846.

The results of calculating the importance of test organisms using the hierarchy analysis method indicate that the most optimal plant test system for studying the influence of granite quarries on the ecological condition of the soils of adjoining territories is onion bulb (Allium cepa L.).

Table 2 - Matrix of logical comparison of parameters of test plants [12]

Test plant	Parameter				
	Period of ontogenesis, days (H1)	Biological productivity, c/ha (H2)	Sensitive test-reaction to a chemical element		
			Cr (H3)	U/Th (H4)	Zn (H5)
	$a_0^1 = 2$	$a_0^2 = 1$	$a_0^3 = 3$	$a_0^4 = 5$	$a_0^5 = 4$
Radish (P1)	$a_1^1 = 2$	$a_1^2 = 5$	$a_1^3 = 1$	$a_1^4 = 3$	$a_1^5 = 1$
Watercress (P2)	$a_2^1 = 4$	$a_2^2 = 1$	$a_2^3 = 4$	$a_2^4 = 5$	$a_2^5 = 3$
Onions (P3)	$a_3^1 = 5$	$a_3^2 = 2$	$a_3^3 = 5$	$a_3^4 = 4$	$a_3^5 = 5$
Wheat (P4)	$a_4^1 = 3$	$a_4^2 = 3$	$a_4^3 = 3$	$a_4^4 = 1$	$a_4^5 = 4$
Peas (P5)	$a_5^1 = 1$	$a_5^2 = 4$	$a_5^3 = 2$	$a_5^4 = 2$	$a_5^5 = 2$

However, to get a more accurate and objective assessment, it is worth using a few different test objects. Taking into account the calculated levels of importance of test organisms, it is suggested to use additionally the cream salad (Lepidium sativum L.) and wheat (Triticum L.) [12].

An assessment of the biotoxicity of the soils of the territories adjacent to the granite dump was performed according to the method of the "Growth Test" [13]. Sprouting of test cultures was carried out in Petri dishes. For the study, samples of the soil of the territories adjoining the Rokitnyansky granite quarry were selected at 4 points at different distances to the granite dump [14]. Initially, the samples under test and the soil sample were dried to air-dry state, sifted and ground. In each of Petri's cups, they placed a sheet of filter paper, which was filled and evenly distributed 1 g of the prepared mass, added 5-7 ml of water and sown on 30 seeds of the indicator plant. The experiment lasted 96 hours at a temperature of + 24-28° C. The results of germination of onion, lettuce, and wheat are given in Fig. 1

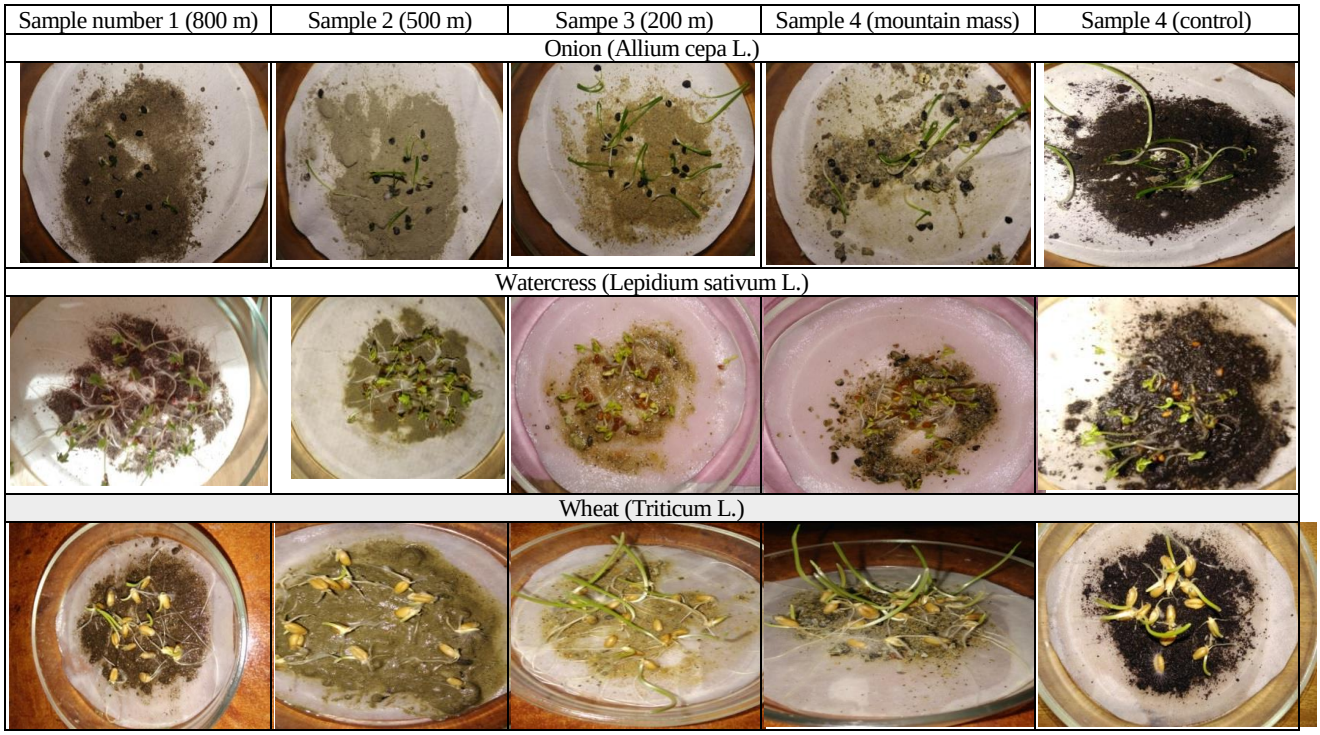

Figure 1 - Germination of onion, lettuce and wheat for 96 hours of experiment

After the experiment, the plants were carefully taken out of Petri's cups, measured the length of the root and stem systems. The results of measuring the growth indices of test plants are presented in Fig. 2. From Fig. 2 it is evident that the test-response of plants on the soil samples under investigation is significantly different. Test reaction onion (Allium cepa L.) and wheat (Triticum L.) tend to stimulate development with a decrease in the distance to the granite dump. In this case, for salmon (Lepidium sativum L.) is characterized by growth inhibition when approaching the dump. The obtained experimental data are processed by the method of dispersion analysis [15].

According to the results of the research, it was found that the length of the underground part of the crested-salad varies from 44.3 mm to 23.07 mm. At the same time, there is an increase in the inhibition of the growth of the root with a decrease in the distance to the waste heap. Absolutely opposite regularities were found for the bioparameters of onions of poppy and wheat, where there was a tendency to stimulate the growth of the root and stem in soil samples close to the dump. At the same time, a different test-response of these bioindicators to the control sample of the soil should be noted. Thus, the average length of the root of the onion in the control sample was the highest value, while for the wheat, the lowest root length was recorded in the control soil. This can be explained by the fact that wheat belongs to a group of plants sensitive to high acidity of soils [16]. The soil used for control is characterized as weakly sour. In general, on the samples of soils selected on the territories adjacent to the granite dump (samples No.1 - No.4), the average length of the wheat root varies from 27,334 mm to 63,004 mm and the average length of the root of the onion is from 0,367 mm to 8,233 mm. Thus, the results of the study indicate an ambiguous effect of granite dumps on the bioparameters of different plant species [14].

The phytotoxic effect was calculated for the relative estimation of phytotoxicity of the soil samples under investigation for plant test systems.:

$$PhE = \frac{M_0 - M_x}{M_0} \times 100\%,$$

M_0 – the value of the bioparameter in the dishes with the control ground;

M_x – the value of a similar bioparametric in dishes with the soil breakdown surveyed.

Unresolved remains the definition of a component, the change in concentration of which stimulates growth in some plants and depresses in others. It is advisable to study the dependence of the response of plant bioindicators on the content of silicon (silicon) Si, since silicon in the form of silicates is the base of rock - granite. It has been established that silicon has a certain effect on plants and on soil fertility. Presumably, silica is a substance that is necessary for the energy growth of most plants, however, it often causes side effects.

Conclusions. It has been determined and grounded that in order to obtain the most complete and objective information about the ecological state of the soils adjacent to granite dumps in the territories it is expedient to use a complex of bioindicative plant test organisms, namely onions of poppy seeds and cress salad. The recommended set of bioindicators will allow determining the cytogenetic effect of granite dumps on plant organisms that grow on adjacent soils. An assessment of the biotoxicity of the soils of the territories adjacent to the granite dump was performed according to the method of the "Growth Test". Test reaction onion and wheat tend to stimulate development with a decrease in the distance to the granite dump. In this case, for cress-salad - on the contrary. For the onion with the approach to the dump phytotoxic effect decreases, for salad – is rising, and for wheat it is completely absent.

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