Monitoring of biological activity indicators of forest nursery soils in Siberia

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Abstract. The universality, comprehensiveness and adequacy of biological soil diagnostics methods make them widely used in monitoring studies of anthropogenic effects on the soil. Soil samples of forest nurseries have been studied, directly under seedlings and in the steam field. Anthropogenic loading changes the biological parameters of the soil, leading to a decrease in soil fertility. The results of the assessment of the biological state of forest nursery soils used for the planting material of coniferous seedlings in Siberia by the level of enzymatic activity are presented. Analysis of soil quality by methods of research of oxidative and hydrolytic enzymes was carried out. Monitoring of enzymatic activity indicators of soils of forest nurseries of Krasnoyarsk region showed that by activity of catalase, invertase of urease they belong to medium-enriched. It has been established that in the soil of Uyarsky, Kansky and Kuraginsky forest nurseries scientists there is the highest rate of proteolytic activity. Low level of catalase enzyme activity revealed in Kazatinsky nursery against the background of high soil contamination with phytopathogenic microorganisms.

1. Introduction
Biological activity of soil plays an important role in the process of formation and formation of its fertility. The use of biological indicators allows the most accurate assessment of the condition of soils, the degree of their degradation, as well as the possibility to anticipate disorders and predict changes taking place in them. The study of soil enzymatic activity is the data necessary to study the processes of nitrogen, carbohydrate, sulfur and other types of soil metabolism. The wide range of enzymes studied significantly increases the reliability of the obtained data on the assessment of the ecological condition of the soil and is used in environmental monitoring, especially of soils under anthropogenic load [1, 2, 3].

Forest nursery soils are constantly agrogenic as a result of the treatment and use of pesticides (herbicides and fungicides), as a result of which their overall fertility is gradually reduced, their properties are deteriorated and their gradual degradation occurs. An indicator of soil quality can be both the content of microbial biomass, the number of microorganisms and the pool of enzymes accumulated in the soil. In this regard, one of the possible approaches to solving the problems of soil monitoring is to use indicators of biological activity of soils. Spatial and temporal changes in the biological activity of forest nursery soils located in different natural zones are due to soil-ecological conditions, the period of operation of the nursery, methods of soil treatment and the intensity of their pesticide use [3].
2. Object and methods of research
The object of the study were soil samples taken under Siberian pine seedlings (*Pinus sibirica* Du Tour), as well as to compare the intensity of changes in the steam field. Soil samples were collected during intensive growing of coniferous seedlings in August. To study the changes in the biological activity of the soil, 6 nurseries located on the territory of Krasnoyarsk Territory (Eastern Siberia) were selected. The studies were conducted over a 10-year period. Diagnostics of the biological activity of the investigated substrates was carried out using enzyme activity indicators. The selection and preparation of substrate samples was carried out according to the GOST 17.4.3.01-83 and GOST 17.4.4.02-84. Respiratory activity was determined by incubation of soil samples for 24 hours followed by titration of the solution [1].

Determination of the activity of the catalase enzyme was carried out according to the method of Johnson and Temple (1964) by titration with a 0.1 N potassium permanganate solution, the activity was expressed in ml 0.1 N. KMnO₄ g⁻¹·20 min⁻¹. The determination of urease activity was carried out according to the method of Shcherbakova (1983) by colorimetry at a wavelength of 400 nm and was expressed in mg N-NH₃ g⁻¹·4h⁻¹. The activity of the protease enzyme was determined by the method of Hoffmann and Teicher (1957) at a wavelength of 650 nm and was expressed in mg N-NH₃ g⁻¹·20 h⁻¹. The activity of the invertase enzyme was studied by the method of colorimetry according to Hoffmann and Pallau (1965) at a wavelength of 578 nm and was expressed in mg glucose 1g⁻¹·24 h⁻¹ [4].

3. Research results and discussion
The forest nursery soil biological activity programme is based on interrelated and mutually agreed indicators such as the number of microorganisms, the respiratory activity of the soil, enzymatic activity and the intensity of cellulose destruction. Gradual transition from quantitative analysis of soil microflora to estimation of soil respiration extends the first thread to obtaining data characterizing soil condition. The respiratory activity of the soil is related to the activity of the microorganisms that inhabit it, to the total microbial biomass present in the soil. As an additional diagnostic indicator, respiratory activity is often used to determine the level of anthropogenic impact on the soil, and, in general, the ecological state of the soil. The total amount of carbon dioxide released may vary depending on the soil treatment technology, the level of microbiological activity in general in the soil, indicate changes in soil microbiocenosis under severe anthropogenic effects. In soils of forest biogeocenoses, the amount of biomass is much higher than in arable ones, which also determines their high respiratory activity.

The study of soil in forest nurseries both under seedlings and in steam field soil has proved that the intensity of microbiological processes in the root zone of plants is higher than in the soil under steam, due to the development of roots and the increase in the share of biomass of microorganisms. Many years of studies have shown that average respiratory activity is closely related to the level of microbiocenosis and varies between 0.050 and 0.180 mg of CO₂ per 1 g of soil in 24 hours (figure 1), which is on average 1.5-2 times lower than the background soil selected from under the forest.

It is noted that the lowest indicators are set in Kazansky forest nursery and Kansky forest nursery CO₂ - 0.050 and 0.073 mg of soil per 1 g of soil for 24 hours, respectively, while high values are determined in the soil under Siberian pine seedlings in Emelyanovsky and Kuraginsky Forest CO₂ - 0.180 and 0.128 mg of soil per 1 g of soil for 24 hours, respectively.

Many years of studies show high efficiency of soil cover diagnostics by biochemical methods, namely by means of enzymatic activity indicators. Indeed, the study of enzymatic activity of soils was carried out by researchers for various purposes, this indicator is always considered as an integral expression of the action of environmental factors and mutually agreed processes taking place in soils.
In particular, redox enzymes have always been the focus of researchers due to their large role in soil formation processes. It has been found that in the soil of the Kazachinsky forest nursery, the activity of the catalase enzyme is 2 times lower than in the soils of other studied nurseries. Intensive contamination of soil selected in Siberian pine crops was found in this nursery. A high level of microbiological toxicity provokes a decrease in catalase enzyme activity.

The main role of hydrolytic enzymes in soil is the destruction of complex organic substances to simpler ones. The intensity of these processes is determined by the average pool of enzymes that destroy these compounds.

The averages for the entire study period are shown in table 1. It was determined that the urease activity in the Kazachinsky forest nursery, on the contrary, is 3-4 times lower and averages 0.28 mg N-NH₃ · g⁻¹ · 4h⁻¹. At the same time maximum values of activity of urease enzyme are established in the soil of Uyarsky forestry, which determines its high enrichment with mineral nitrogen-containing compounds - 0.85 mg N-NH₃ · g⁻¹ · 4h⁻¹. High rates are also determined in the soil of Bogotolsky forest nursery, which is likely due to high urea content.

According to the result, the study of enzymatic activity of soils of forest nurseries of Krasnoyarsk region showed that according to the activity of catalase, invertase of urease they belong to medium-enriched.

From the data presented in table 1, it can be seen that the soil of the Uyarsky, Kansky and Kuraginsky forest nurseries has the highest rates of proteolytic activity.

Protease enzyme activity showing soil availability with nitrogen-containing organic substance causes the values to increase to 0.60 and 0.62 mg N-NH₃ g⁻¹ · 20 h⁻¹ in the soil samples of Kansky and Kuraginsky forest nursery respectively (table 1).

In general, proteolytic activity in the test soils was characterized as medium and varied between 0.40 and 0.63 mg N-NH₃ g⁻¹ · 20 h⁻¹.

Table 1. Forest nursery soil enzymatic activity (average over the study period).

| Experiment variants | Catalase, ml 0.1 N. KMnO₄ g⁻¹ · 20 min⁻¹ | Urease, mg N-NH₃ · g⁻¹ · 4h⁻¹ | Protease, mg N-NH₃ g⁻¹ · 20 h⁻¹ | Invertase, mg glucose 1g⁻¹ · 24 h⁻¹ |
|---------------------|----------------------------------------|-------------------------------|-------------------------------|----------------------------------|
| 1. Emelyanovsky     | 0.24±0.05                              | 0.44±0.005                    | 0.58±0.009                    | 19.7±0.63                        |
| 2. Bogotolsky       | 0.30±0.01                              | 0.70±0.011                    | 0.47±0.003                    | 17.5±0.38                        |

**Figure 1.** Respiratory activity in forest nursery soils.
The maximum activity of the invertase enzyme was 20 and 24 mg glucose 1g⁻¹·24 h⁻¹ and is established in the soil variants selected in Kuraginsky and Kazachinsky forestry, which can characterize the high level of soil availability with organic matter. In addition, this indirectly proves the presence of a high number of soil microscopic fungi in these samples. One possible approach to addressing soil monitoring challenges is to identify indicators of soil biological activity. Biological activity of soil plays an important role in the process of formation and formation of its fertility. The use of biological indicators makes it possible to better assess the condition of soils, the degree of their degradation, as well as to anticipate disorders and predict changes in them.

Biological activity of forest nurseries located on the territory of Krasnoyarsk region is characterized by pronounced space-time changes. The detected changes in biological activity of soils characterize the biological community as a mosaic of local indicators of its state, which varies in space and time. Limits of variation of activity of soil enzymes are determined, limits of variation of respiratory activity of soils of forest plants are established. The most pronounced nature of agrogenic effect on soil enzyme activity indicators. The level of changes taking place in nursery soils is related to the period of their operation. The longer the nursery is in one place and the soil experiences agrogenic effects, the lower the level of its biological activity, the accumulation of toxins and the decrease in the pool of enzymes.

4. Conclusion
Thus, the obtained results of biological activity parameters can be used soils of forest nurseries and assessment of their ecological condition (degree of their degradation). The results obtained are included in the database of biological indicators of agropopulation of forest nurseries of Siberia, recommended for bioecological monitoring. Evaluation of enzymatic and respiratory activity of soils allows to propose a systematic approach to the development of methods to increase fertility of agrophytocenoses in nurseries. The obtained results of investigation of structure, dynamics and functional activity of microorganisms can be used in biodiagnostics of direction of soil formation processes and state of soils in forest nursery.

References
[1] Kazeev K Sh, Kolesnikov S I and Valkov V F 2003 Biological Diagnostics and Indication of Soils: Methodology and Research Methods (Rostov on Don: Publishing house of the RSU) p 216
[2] Fomina N V 2015 Journal of Krasnoyarsk State Agrarian University 1 8-3
[3] Fomina NV 2008 Microbiological Diagnostics of Soils of Forest Nurseries of the Krasnoyarsk Territory (Krasnoyarsk: Krasnoyarsk State Agrarian University) p 144
[4] Khaziev F Kh 2005 Methods of Soil Enzymology (Moscow: Nauka) p 250