Biochemical potential indicators of the transformed sod-podzolic soils of the forest-steppe of the Altai region

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Abstract. The paper presents results of a study focused on the biochemical potential of anthropogenically and naturally transformed sod-podzolic soils of the forest-steppe of the Altai Region, depending on the activity of soil enzymes. The research reports that the soils of this territory are affected by forest fires to the greatest and profound changes. Indicators of enzymatic activity serve as an indirect witnesses of the transformation of soil organic matter, the orientation of the soil-forming process. They can be used in the process of biomonitoring the state of the soil cover of forest sod-podzolic soils.

1. Introduction
The territory of the Altai Region is located in the southeast of the West Siberian Lowland in the transboundary limits of the Prealtay and Altai-Sayan soil provinces. A wide range of climatic conditions, in which more than thirty types of soil were formed, is a wide-known characteristic of this area [1]. Their comprehensive study is necessary for understanding the genetic aspects of modern soil formation, and the conditions for the formation of optimal soil properties for the functioning of natural and anthropogenic landscapes.

The study of intrazonal sod-podzolic soils is of particular interest. In addition to the climatic conditions, a number of additional factors affect them, which are actually atypical for zonal chernozem soils of the forest-steppe zone. These factors include: windfalls, forest fires, logging, soil surface mineralization, and a number of other. These processes lead to changes in the morphological structure and physicochemical properties of these soils. Already in the early stages of landscape transformation, the biochemical potential of daytime soil horizons changes significantly, subsequently leading to fundamental changes in the biogeocenosis [2]. Biomonitoring allows one to quickly assess the state of the soil cover, focusing solely on enzymatic activity.

The aim of this research was to determine the biochemical potential of sod-podzolic soils, which are transformed as a result of anthropogenic and natural effects.

2. Materials and Methods
In 2018, field studies were carried out on the territory of Priobsk boron, as well as within the north-eastern part of the Barnaul Ribbon Boron. The object of our research is the sod-podzolic soils that have been subjected to various forms of exposure, such as windfall soils, shifts of the main species from coniferous to deciduous (planting age of 55-60 years), lower forest fires, as well as selective logging. Background, natural sod-podzolic soils served as controls. Full-profile and half-profile soil
cuts were used in the studies. In the course of work, the morphological structure of the soil was described in detail, and the sampling from each genetic horizon was carried out. Agrochemical parameters were determined according to generally accepted methods [3].

To assess the soil biochemical potential, we determined the activity of enzymes: (a) the catalase according to A. Sh. Galstyan (gasometric method); (b) the protease by applying the method of decomposing a gelatin layer according to E. N. Mishustin, D. N. Nikitin and I. V. Vostrov; (c) the urease by changing the reaction medium. Also, we determined the activity of polyphenol oxidase and peroxidase for soil according to K. A. Kozlov [4].

More than that, we determined the coefficient of humification relying on the ratio of “polyphenol oxidase activity” to “peroxidase activity.”

3. Results
The contemporary scholarship clearly shows that the multifaceted transformation of sod-podzolic soils in the forest-steppe of the Altai Region occurs as a result of various anthropogenic and natural processes. During the field research phase, a change in the morphological structure of the soil profile was noted [5]. Windshields provoke the manifestation of pedoturbation processes [6]. Timber harvesting harms the soil profile because of destructing sod and humus-accumulative horizons; numerous technologies lead to an increase in soil density. When changing the main species from coniferous (Pinus Sylvestris) to broad-leaved (Quercus robur), we note the structuring of soil aggregates to walnut and granular. A pyrogenic effect on the soil leads to the destruction of forest litter and the development of soil deflation. Also, among the soils prevalent in the watershed areas of the bottom fires, the second humus horizons buried under aeolian sediments were found. Data on the distribution of humus in the soil profile confirm the presence of second humus horizons. The humus content reaches 1.04–2.78% in the horizons lying between the eluvial and illuvial sequences at different depths (from 14 to 36 cm).

In soils of the forest cutting areas, the humus content is reduced to 1.22%, if compared with a background indicator of 2.37%. When changing the main species from coniferous to broad-leaved, with the age of trees at 55-60 years, the content of humus corresponds to the background indicators. In the soils of windfalls, the elluvial horizon A2 is exposed when a tree falls out. As a result, the humus content in the day horizon does not exceed 0.05%.

A soil solution reaction of the transformed soils under study is close to the background, ranging from acidic to slightly acidic (pH_КCl of 5.35-5.98). Weak alkalization of the soil solution to pH_КCl=6.23 (close to neutral) was observed in soils when changing the main rock.

In humus-accumulative and second humus horizons, the low and very low provision with mobile phosphorus P2O5 (close in values to background, natural soils) is noted. The content of exchangeable potassium KCl is also low (1.96-4.48 mg / 100 g of soil).

In transformed soils, changes in the activity of soil enzymes (catalase, protease, urease, polyphenol oxidase, and peroxidase) are observed (Table 1).

| Soil horizon, depth | Catalase, O2 cm³ / g * min | Protease, % | Urease | PPO / PO |
|--------------------|---------------------------|-------------|--------|---------|
| **Sod-podzolic soil, background** | | | | |
| A1 (5-15 cm) | 4.2 | 94 | 1.9 | 0.18 |
| A1A2 (20-30 cm) | 1.7 | 87 | 0.4 | 0.14 |
| **Sod-podzolic soil, windfall** | | | | |
| A1 (5-15 cm) | 7.2 | 100 | 2.0 | 0.14 |
| A1A2 (20-25 cm) | 2.4 | 97 | 0.5 | 0.14 |
| **Sod-podzolic soil, the change of the main species from coniferous to deciduous** | | | | |
| A1 (6-16 cm) | 5.0 | 100 | 2.5 | 0.21 |
| A1A2 (16-23 cm) | 1.9 | 96 | 2.0 | 0.25 |
| **Sod-podzolic soil, cutting** | | | | |
In the humus-accumulative horizons of windfalls, 30 days after tree falling, the biochemical potential increases due to the increased activity of the detected enzymes in comparison with the background soils (Table 1). In soils after forest felling, catalase activity decreases, but urease and protease activities increase.

Limits in the activity of polyphenol oxidase (PPO) and peroxidase (PO), the coefficient of humification of the PPO / PO ratio in windfall and logging soils are within the activity of these enzymes in soil horizons of the background sod-podzolic soil (Table 1).

A decrease in the biochemical potential of soils was noted in a layer of 0–20 cm, similar to the humus-accumulative horizon of background sod-podzolic soils, in the watershed areas of the 2004 ashes. Soils with a buried second humus horizon have a feature related to the structure of the biochemical profile, which consists in increasing the activity of PPO and PO down the soil profile, having with a peak in the horizon Ah and an increase in the humification coefficient of PPO/PO. Also, an increase in the coefficient of humification is observed in soils in the territory with changes in the main breed.

4. Discussion
The greatest changes in the biochemical potential were observed in soils with the second humus horizon in the watershed areas of the 2004 ashes. The sod horizon is poorly developed in the territory affected by pyrogenic influence (anthropogenic origin). As a result, deflationary processes are activated; also, inspired soils are formed with a low content of organic matter necessary for the functioning of soil biota and microorganisms. At the same time, the activity of soil enzymes largely depends on the qualitative and quantitative microbiological composition. We assume that preserving the second humus horizon in the eluvial profile is caused by a small amount of coniferous plant litter on the surface of the inspired horizons. The second reason is the ratio of the activity of polyphenol oxidase to peroxidase, higher than in humus-accumulative horizons of background soils. Probably, an increase in the activity of polyphenol oxidase is associated with a qualitative change in the microbiological composition and concentration of oxygen acceptors.

An increase in enzyme activity in sod-podzolic soils with an impaired morphological structure and a structure of genetic horizons (windfall soil) is associated with an increase in aeration and water permeability as a result of the turbulence in genetic horizons during mechanical impacts on the soil.

An increase in the biological potential and an increase in the PPO/PO ratio in the humus-accumulative soil horizons (which are common in the area with the changing main species from coniferous to broadleaf) indicates a change in the direction of transformation of organic matter.

The enzymatic activity of protease and urease in cutting soils is close in meaning to background soils. Catalase activity is an indirect indicator of the quantitative composition of soil microflora. The decrease in the activity of this enzyme in our soil cuttings indicates the suppression of microorganisms’ activities. A number of authors [7, 8] also speak about a decrease in the microbial and enzymatic potential of cutting soils. A simultaneous increase in the percentage of gelatinous film layer decomposition is a consequence of an increase in the percentage of fungal microflora. The set of indicators of enzymatic activity reflects changes in the total biological activity of these soils. They indicate a shift in soil-forming processes towards podzol formation.

5. Conclusion
In the course our research on the activity of soil enzymes of sod-podzolic soils in the areas subjected to anthropogenic and natural transformations, it was possible to establish the following:

|  | A1 (2-12 cm) | 100.0 | 2.0 | 0.15 |
|---|---|---|---|---|
|  | A1-A2 (15-25 cm) | 98.2 | 1.0 | 0.20 |
| Sod-podzolic soil with a second humus horizon, ashes | | | | |
| Second horizon (0-10 cm) | 0.9 | 94 | 0.1 | 0.00 |
| Second horizon (0-20 cm) | 0.9 | 92 | 0.0 | 0.04 |
| Ah (25-35 cm) | 0.2 | 98 | 0.5 | 0.28 |
1. Pyrogenesis, or the effects of forest fires, have the greatest impact on the biological potential determined by soil enzymatic activities.

2. In the first year, a mechanical effect on the soil, as a result of windfalls, leads to an increase in enzymatic activity.

3. When changing the main species from coniferous to broad-leaved, progradation of enzymatic activity is noted, as well as changes in the direction of transforming soil organic matter.

4. A decrease in catalase and an increase in protease activity in the soils of selective forest felling indirectly indicate a change in the quantitative and qualitative composition of the soil microflora.

Research on the soil biological potential of enzymatic activity reflect the nature of changes not only in the general biological activity, but also in the direction of soil-forming processes. Along with indicators of microbiological analyzes, these studies can be used as the basis for biological monitoring of the transformed forest sod-podzolic soils.

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References
[1] Burlakova L M, and Tatarintsev L M 1988 Soils of the Altai region (Barnaul, Russia: Altai Agricultural Institute)
[2] Tarasov P A, Mikhno A S, and Sizina A F 2011 Evaluation of the pyrogenic effect on the soils of Altai belt pines Vestnik of Krasnoyarsk State Agrarian University 1 pp 26-31
[3] Arinushkina E V 1970 Soil chemical analysis guide (Moscow, Russia: Moscow State University Publishing House)
[4] Zvyagintsev D G 1991 Methods of soil microbiology and biochemistry (Moscow, Russia: Moscow State University Publishing House)
[5] Zavalishin S I, Sokolova L V, Chernyshkov V N, and Karelna V S 2017 Influence of soil morphology on the number of Pinus Sylvestris L. seedlings under the conditions of the right coast of the Ob river in the Altai region Vestnik of the Altai State Agrarian University 9(155) pp 24-27
[6] Zavalishin S I, and Patrushev V Yu 2014 Changing the morphology of sod-podzolic soils of strip forests of the Altai Region as a result of windfall Forestry Bulletin 1 pp 161-164
[7] Caldwell D 2005 Enzyme activity as component of soil biodiversity Pedobiologia 49 pp 637-644
[8] Vinogradova Yu A, Lapteva E M, and Perminova E M 2014 Microbial communities of podzolic soils in clearings of middle taiga spruce forests Izvestiya of the Samara Scientific Center of the Russian Academy of Sciences 16(3) pp 74-80