Agroecological monitoring of soils in the educational and experimental farm of the Ural State Agrarian University

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Abstract. The analysis of the soil cover is carried out to assess the general condition and suitability of soils for agricultural activities on it and is one of the most important indicators in the course of ecological research. The article discusses the main methods of soil cover survey on experimental fields of the Ural State Agrarian University to monitor the state of soils in this area, the results of which will be used for further research within the framework of the Ural Carbon program; the article also emphasizes the need to solve environmental problems such as greenhouse gas emissions into the atmosphere, the destruction of soil cover resulting in its fertility decrease. The necessity of monitoring the soil cover state is described on the example of one of the five test sites laid in the fields of the educational and experimental farm of the Ural State Agrarian University.

1. Introduction

Environmental problems are particularly acute in the agricultural sector, the current economic crisis is escalating and infused with the environmental crisis, which is expressed in the development of erosion processes, the destruction of soil cover and, ultimately, in the reduction of soil fertility, and the issue related to the reduction of greenhouse gas emissions into the atmosphere and climate conservation remain the most important and acute problem.

Violation of soil protection farming systems, lack of modern technologies and agricultural machinery, and land degradation, consequently, all these are the consequences of the lack of proper control and monitoring of soil and vegetation cover state.

To date, it is necessary to systematically monitor changes in the state of soils, identify negative processes in a timely manner and strive to prevent them.

An important role in the regulation of soil fertility is played by monitoring the state of soils, including observations of changes in agrochemical indicators of the arable layer and their effect on the formation of the yield quantity and quality. Based on its results, it is possible to establish the need of plants for nutrition elements and other fertility factors. [1]

In general, it can be said that agroecological monitoring is the most important element of ensuring environmental safety in agricultural production [2].

It should also be noted that information on the state of soils is necessary for further selection of experimental sites to create a polygon on them for calculating the carbon balance of territories, in other words, for creating so-called carbon polygons.
2. Materials and Methods

The experimental farm is a structural subdivision of the Federal State Budgetary Educational Institution of Higher Education "Ural State Agrarian University" and serves as a base for industrial training of students and the organization of the university research work [3]. It is in the Beloyarsk district of the Sverdlovsk region in the village of Studencheshiky.

The farm is in an area with a moderately continental climate and has sufficient moisture, winters are long and cold, snow cover lasts from October to April, ground freezing is up to 1.5 meters. The territory belongs to the junction zone of the mountainous part of the Urals and the West Siberian Lowland, located in the southern subzone of the taiga. In the western part of the territory, a slightly elevated undulated and ridged terrain with gentle forms with absolute surface marks of 257 - 238 m is partially developed. The eastern part is a typical slightly hilly plain [4].

The Brusyansky block is bounded by two submeridional splits, and in the north - by a sublatitudinal fault zone. It is composed of metamorphised paraschists, crumpled into small isocline folds. A granitoid mass is located in the southeastern part of the block.

The soil formation direction is influenced by living organisms: plants, microorganisms, animals. During their joint activity and under the effect of their vital products, the most important processes of soil formation are carried out - synthesis and mineralization of organic substances, a certain accumulation of biologically important elements, migration and concentration of substances and other phenomena that constitute the essence of the soil formation process and determine the formation of the main soil property - fertility. The territory belongs to the forest-steppe zone, which is characterized by the presence of forests and steppe grass vegetation.

The grass cover of the area is represented by a variety of grasses, the most common are the following: common yarrow, milk gowan, sweet plantain, Austrian wormwood. Among the representatives of legumes, the most common are: yellow alfalfa, birdsfoot trefoil, white and aslike clover.

A characteristic feature of the herbaceous vegetation of the meadow steppes is a thick, branched root system that penetrates deeply into the soil (up to 3 m). After dying, meadow grasses leave a significant amount of plant residues. Therefore, chernozems formed under the cover of herb-meadow grassy vegetation have a high humus layer thickness and significant humus reserves.

The work on agroecological assessment began with the study of the terrain, search and analysis of electronic images of fields, soil maps of the area, then work was carried out to determine the sites under study, in total five sites were processed. The survey was conducted in two stages: field and office work. Field work was carried out on the training and experimental fields of the Ural State Agrarian University, soil samples were taken from several experimental sites by dividing the site into a certain number of squares (the number depends on the size of the site) and a sample was taken from each square. In total, 5 experimental sites were processed, from which coordinates were taken using the Garmin GPS receiver and soil samples were taken.

The office processing included weighing, drying, and rubbing of soil samples, all these actions are the preparation of the material for the study and conducting the necessary analyses to determine soil state, also the coordinates of the sites from the GPS receiver were processed to create electronic maps of the fields, as a result, a summary table of work with the sites for 2018, 2019, and 2021 was compiled.

Let's consider in detail the process of work at one of the test sites, the information received on the soil cover state, electronic images, and the selected coordinates of this site will be used for further research of carbon sequestration in the soil within the framework of the Ural-Carbon project.

Soil carbon sequestration is the most promising and cost-effective environmental strategy. Carbon sequestration increases the natural fertility of soils, reduces the risk of carbon return to the atmosphere for many years, creates prerequisites for the development of sustainable agriculture and the production of environmentally safe products [5].

The methodology proposed in the work of A.L. Ivanov et al. [6] in the section "Potential of carbon sequestration by agricultural soils" is taken as the basis for assessing the sequestration potential of soils in agricultural landscapes of the Middle Urals. It is proposed to consider the initial (natural) level of soil
organic matter (SOM) in stable natural conditions, which corresponds to the equilibrium state when SOM changes (Δ) are approaching zero (ΔSOM ≈ 0) (Fig.1).

![Figure 1. The dynamics of the SOM content caused by the transformation and modification of land use [5].](image)

The transformation of the natural ecosystem into arable land is accompanied by a decrease in the SOM content, i.e. ΔSOM < 0. Long-term sustainable use of soils leads to a quasi-equilibrium state of SOM (ΔSOM ≈ 0).

Modification of land use to regenerate the content of SOM (ΔSOM > 0) can be carried out by the introduction of humus/carbon-saving technologies. Their long-term steady use leads to a quasi-equilibrium state (ΔSOM ≈ 0) at a new higher level of the SOM content.

The duration of the transition period of soils to a new quasi-equilibrium state, according to the Guidelines compiled by experts of the Intergovernmental Panel on Climate Change [7], is assumed to be 20 years.

The territory of the educational and experimental farm of the Ural State Agrarian University (village Studencheskiy) based on the soil-geographical zoning of the Sverdlovsk region [8] belongs to the Kochnevsky soil district (0881), is part of the Beloyarsk district of the West Siberian Pre-forest-steppe soil province (Fig.2). The composition of the soil cover is dominated by ordinary chernozems and gray forest soils. Runoff shallows and river valleys are occupied by meadow and wet meadow soils, low-draining runoff shallows and river valleys are occupied by swampy lowland peat soils.

The main factors of soil cover differentiation are denudation-accumulative processes against the background of lithological heterogeneity of the soil-forming cover [8].

3. Results and Discussion

On the experimental fields of the Ural State Agrarian University, trial sites have been laid for various types of agricultural use, on one of them (Fig.2) the field was divided into squares of 15x15 meters (Fig. 4) [9,10]. The site was under the laying of experimental plots of the Faculty of Agricultural Technologies and Land Management, winter rye was grown. Currently, part of the field is occupied by weeds, as well as plowed crop residues.

The coordinates were fixed clockwise. The number in the middle highlighted in the circle is the square number. The value located under the square number is the coordinate defined in the middle of the square.

In each square, mixed soil samples of the arable horizon were selected by the envelope method, as well as samples (in 3-fold repetition) to determine the density of the soil solid phase and field soil moisture. In parallel, the soil temperature was measured at a depth of 0-10 cm. In the office conditions, samples were weighed in raw condition and laid out for drying to an air-dry state. Thus, studies of the
soil cover (taking soil samples, conducting analyses, coordinating the site) at the site were carried out for three years, from the results obtained, it is possible to track the dynamics of the soil cover state at this site.

![Trial site at the experimental field of the Ural State Agrarian University](image)

**Figure 2.** Trial site at the experimental field of the Ural State Agrarian University
(A - location, B - field condition)
Figure 3. The scheme of splitting the field into squares.

The results of field and office work on the test site are shown in Table 1.

Table 1. Results of field and office work on the trial site

| Sample No. | Wet soil weight, g | Dry soil weight, g | Humidity, % | Soil density, g cm\(^{-3}\) | soil t\(^{\circ}\) |
|------------|--------------------|--------------------|-------------|-----------------------------|----------------|
| 1          | 388.4              | 324.2              | 19.8        | 1.98                        | 25             |
| 2          | 365                | 300.6              | 20.8        | 1.83                        | 24             |
| 3          | 377                | 312                | 20.8        | 1.90                        | 24             |
| 4          | 397.8              | 329.6              | 20.7        | 2.01                        | 23             |
| 5          | 408.8              | 340                | 20.2        | 2.07                        | 21             |
| 6          | 372.6              | 310.8              | 19.9        | 1.89                        | 23             |
| 7          | 347.4              | 282.4              | 23          | 1.72                        | 24             |
| 8          | 400                | 323.4              | 23.7        | 1.97                        | 23             |
| 9          | 359                | 296.2              | 21.2        | 1.80                        | 23             |
| 10         | 363.4              | 305                | 19.4        | 1.86                        | 24             |
| 11         | 369.2              | 298.8              | 23.6        | 1.82                        | 22             |
| 12         | 352.4              | 281.8              | 25.1        | 1.71                        | 25             |
| 13         | 341.1              | 272.4              | 25.2        | 1.66                        | 26             |
| 14         | 362.6              | 297.4              | 21.9        | 1.81                        | 27             |
| 15         | 322.8              | 264.6              | 21.9        | 1.61                        | 23             |
| 16         | 467.8              | 382.6              | 22.3        | 2.33                        | 24             |
| 17         | 389.2              | 306                | 27.2        | 1.86                        | 25             |
| 18         | 411.2              | 339                | 21.3        | 2.06                        | 27             |
In addition, soil sections were laid in areas under natural vegetation with sampling along the horizons.

4. Conclusions
The work on agroecological assessment is complex and multifaceted, during the studies conducted at some test sites, there are data for three reporting periods, which allows to track the dynamics of soil cover condition and give an assessment, measurements were carried out at two test sites this year for the first time and in subsequent years soil samples will also be taken for the purpose of monitoring. Work will continue on the creation of a carbon polygon and studies of greenhouse gases absorption by soils.

|   |   |   |   |   |   |
|---|---|---|---|---|---|
| 19 | 369.8 | 317.6 | 16.4 | 1.93 | 25 |
| 20 | 336.6 | 274.8 | 22.5 | 1.67 | 26 |

Figure 4. Dynamics of the vegetation index (NDVI) for the experimental fields of the Ural State Agrarian University for May and August 2021

In the future, analytical studies of samples of natural soils, as well as mixed images from test sites are planned to assess the content of soil organic carbon (SOM). Particular attention will be paid to the use of humus/carbon-saving technologies.

Currently, there are several satellite data on the vegetation index (NDVI) for the experimental fields of the Ural State Agrarian University for May-August 2021. As an example, Figure 4 shows an example of a similar snapshot for the first and last months. The next stage will be the creation of a scale for
decoding biomass based on field research by vegetation phases. It is planned to study CO₂ emissions and carbon sequestration for various types of agricultural land soils.

This work is primarily aimed at conducting agroecological monitoring of the condition of the lands of the educational and experimental farm of the Ural State Agrarian University.

As a result of the work done, knowledge and skills in the field of agroecological monitoring of the condition of lands were obtained, skills in working with GPS equipment were also obtained, experience in team working was acquired, terrain characteristics, soil maps and images were studied, work on carbon polygons was initiated.

The research will be continued to track the dynamics of soil and vegetation cover condition in the experimental fields of the Ural State Agrarian University and to monitor the land condition in this area.

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