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Physical Status of Soils Developed from Loesslike Loams in the Southwest of the Central Russian Plain (the Belogor'e Reserve)

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Abstract: Soils developed from the Quaternary loesslike loams have been studied in the south of the forest-steppe zone on the Central Russian Upland. A polygenetic nature of the soil profile on the loesslike loams is shown. The modern pedogenetic processes in this soil ensure its eluvial-illuvial differentiation with the development of multilayered coatings in the illuvial horizon. The middle horizons in the studied soil profiles are referred to as textural (clay-illuvial) horizons. Differences in physical soil properties (bulk density, airconductivity, texture, water content, and temperature dynamics) were studied in the soil on the loesslike loam.

Key words: Physical soil properties, bulk density, texture, water content, loesslike loam.

1. Introduction

The GSP (Global Soil Partnership) at the Food and Agriculture Organization of the United Nations recognizes the urgent need to raise awareness to promote sustainability of the limited soil resources and has declared 2015 as the "International Year of Soils". Gray soils are the foundation for food, animal feed, fuel and natural fiber production, the supply of clean water, nutrient cycling and a range of ecosystem functions on the Central Russian Upland. The role of physical soil properties in soil formation is clearly seen upon the study of pedogenesis on different mineral matrices under similar bioclimatic conditions [1, 2]. The Belgorod's Natural Reserve is found in the southwest of the Central Russian Upland (Borisov district of Belgorod's oblast). This is the forest-steppe natural zone. Loesslike loam is the most common parent material in this area. Gray soils (formerly, gray forest soils) develop from this type of sediments under forest biocenosis. The study of soils in the reserve has a long history; their major genetic features have been characterized in detail [3].

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2. Objects and Methods

The soils have been studied under an upland oak grove on the right bank of the Vorskla River within the Belogor'e Natural Reserve. The choice of these key pits used for the further analytical study was based on the preliminary regular-grid sampling in the entire area and the study of several soil catenas. The indices of soil horizons and the taxonomic position of soils were determined according to world reference base for soil resources [4] and according to the new "Classification and Diagnostics of Russian Soils" [5]. Undisturbed soil samples of 100 cm^3 were taken in 10 replicates for laboratory measurements of the bulk density, water permeability, wilting point, and active water range [6]. Under the field conditions, the field capacity was determined by the method of flooded plots; the sampling was performed on the same plots where the bulk density and water permeability were measured. The water permeability of the soil was determined using two different methods: the laboratory measurement of the filtration in undisturbed samples and the in situ measurement of the water permeability at a constant water head. The soil texture was determined by densitometry and using the pipette method, using laser diffraction and sedimentation methods.

3. Results and Discussion

3.1 Morphology of the Soils

Soil pit is an example of a typical gray soil developed from the loesslike loam. The profile of the soil has the following morphology:

- Litter: +2-0 cm. Half-decomposed oak, and maple leaves;
- Horizon AY: 0-15 cm. Dark gray with brownish tint; slightly moist, compact light loam; perfect granular structure of several orders; few skeletans; abundant roots; clear transition by color; slightly wavy boundary;
- Horizon AEL: 15-30 cm. Gray with brownish tint; somewhat heavier texture; structural aggregates of a lower order; the transition is distinct, by color and structure; clear slightly wavy boundary;
- Horizon BEL: 30-35 cm. Fragmentary horizon with the zones of bleached and relatively coarse-textured material against the background of a heavy-textured clay-illuvial horizon;
- Horizon BT1: 35-68 cm. Dark gray with very dark illuviation coatings; moist, compact heavy loam; angular blocky aggregates of several orders; glossy humus-clayey layered films of dark gray and dark reddish brown colors; roots; clear transition by color and structure; wavy boundary;
- Horizon BT2: 68-100 cm. Brownish yellow; prismatic-angular blocky; clayey and humus-clayey illuviation coatings are less thick and somewhat lighter; they are partly covered by siliceous skeletans; clear transition by color and structure; slightly wavy boundary;
- Horizon BT3: 104-133 cm. Pale brownish yellow, with well-pronounced porosity typical of the loesslike loam; medium loam with indistinct prismatic structure; ped faces are partly covered by thin clayey coatings and skeletons; clear transition by color, structure, and effervescence; slightly wavy boundary;
- Horizon BCca: 133-144 cm. Light pale; less compact; clearly pronounced porosity; prismatic structure; effervescent.

3.2 Analytic Characterization of the Soils

The results of determining the particle-size distribution in the studied typical gray soil are given in Table 1.

The results of determining the water content in the typical gray soil are given in Fig. 1.

The results of determining the bulk density in the typical gray soil are given in Fig. 2.

Phases in the typical gray soil are given in Fig. 3.

Empirical formulas for finding the soil parameters for a given bulk density were obtained:

$$\text{Filtration coefficient} = 256.3\,(\text{Bulk density})^{-7.3} - 1.3\,(\text{Bulk density})^{-1.2} \quad (1)$$

$$\text{Porosity} = 62.5 - 34.5\,(\text{Bulk density} - 1) \quad (2)$$

$$\text{Field water capacity} = 22.1 + 21\,(\text{Bulk density} - 1),\ \text{Bulk density} < 1.40\ \text{g·cm}^{-3} \quad (3)$$

$$\text{Field water capacity} = 30.7 - 16.5\,(\text{Bulk density} - 1.4),\ \text{Bulk density} > 1.40\ \text{g·cm}^{-3} \quad (4)$$

for which, with $n = 50$, $R^2 = 0.91$ and $P < 0.01$.

Table 1 Particle-size distribution in the studied typical gray soil on the loesslike loam.

Horizon	Depth (cm)	Content of particles (%)						
		1.0-0.25 mm	0.25-0.05 mm	0.05-0.01 mm	0.01-0.005 mm	0.005-0.001 mm	< 0.001 mm	< 0.01 mm
AY	0-15	1.2	16.7	53.8	10.6	8.7	9.0	28.3
AEL	15-30	1.0	17.2	50.5	9.4	10.7	11.2	31.3
BT1	35-68	0.9	11.9	39.8	8.1	12.1	27.2	47.4
BT3	104-133	0.7	14.8	41.9	5.3	7.9	29.4	42.6
BCca	133-144	1.9	19.8	39.8	5.2	13.8	19.5	38.5

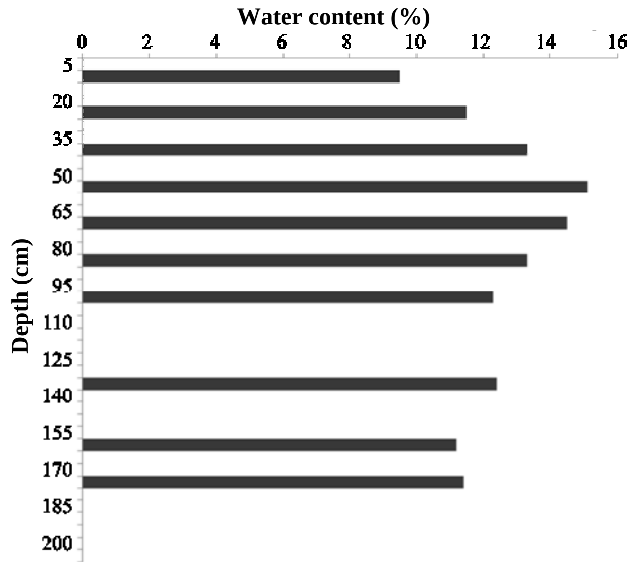

Fig. 1 Water content in the typical gray soil.

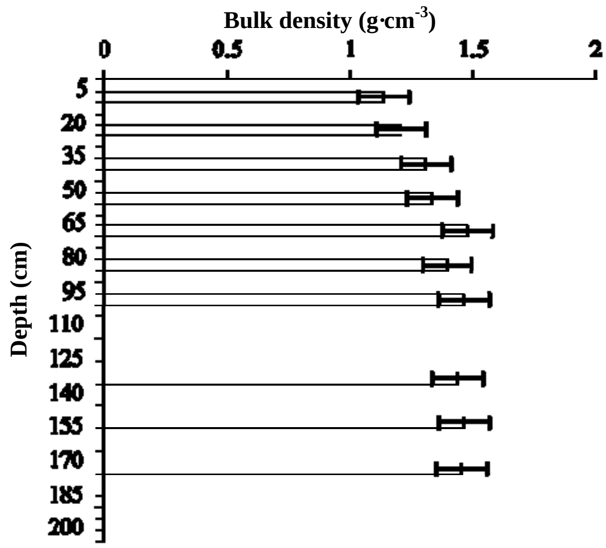

Fig. 2 Bulk density in the typical gray soil.

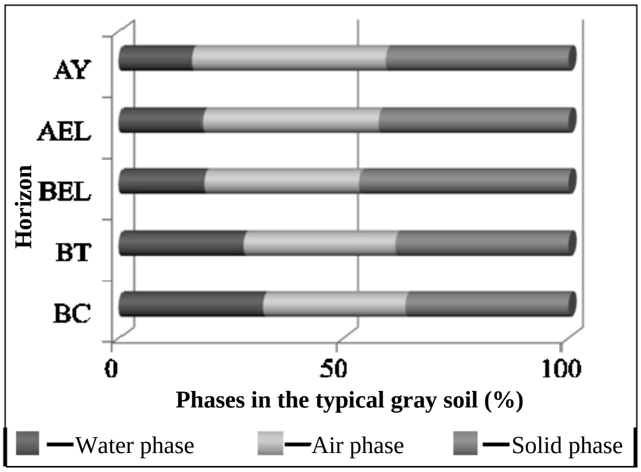

Fig. 3 Phases in the typical gray soil.

4. Conclusions

The interest in this investigation was to see the physical status of soils as gray forest soils, because of their practical, ecological and biological interest [7]. Such studies are important for understanding processes in soils of different genesis and agricultural use [8]. The experiments in question can be considered as model of the changes of soil properties.

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