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Soil Chemistry

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THE ROLE OF ORGANIC FERTILIZERS IN INCREASING THE FERTILITY OF WEST KAZAKHSTAN SOILS

Abstract. The interrelation of regulation methods of soil fertility, agrochemical and agro-physical indicators of dark-brown soil was determined by the complex studies. The increase of the humus and available phosphorus content in the soil was noted at the application of organic fertilizers (manure, siderates), the increase in structural composition was observed. Productive moisture additionally collected in the soil. The use of organic and siderate-organic fertilizers promoted the increase in productivity of grain crops from 16.0 to 33.1% in comparison with the control (without fertilizers).

In recent years, the increasing anthropogenic pressure on land, indiscriminate use of land and lack of measures to preserve fertility has led to the intense soil degradation. In this regard, increasing of productivity and quality of crops while preserving soil fertility by enhancing biological factors that do not disturb the natural ecological balance of nature and agro-ecosystems, is the priority crop production. This must be attributed primarily to the use of organic plant material: manure, straw and green manures [1, 3–5, 7, 8].

MATERIALS AND METHODS

The research was carried out in West Kazakhstan Agriculture and Technology University named after Zhangir Khan in the period 2005–2012 in grain crop rotation with interlaced crops: fallow – winter wheat (*Triticum aestivum*)

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– spring wheat (*Triticum aestivum*) – barley (*Hordeum sativum*). The experiment was founded in 2004. Before the experiment, barley was cultivated in this area.

We studied the different types of fertilizers. The studies comprised the following fertilization treatments:

1. Control – without fertilizers;
2. Mineral fertilizers: fallow (P60) – winter wheat (N30) – spring wheat (N20P20) – barley (N20P20);
3. Organic fertilizers: fallow (manure 40 t/ha) – winter wheat – spring wheat (winter wheat straw) – barley (spring wheat straw);
4. Organic-mineral fertilizers: fallow (manure 40 t / ha) – winter wheat (N30) – spring wheat (N20P20 + winter wheat straw) – barley (N20P20 + spring wheat straw);
5. Green manures: sweet melilot (green manure) – winter wheat – spring wheat (manure 40 t / ha) – barley (spring wheat straw).

The soil test area is dark chestnut heavy loam. Topsoil contains 28–31 g$\cdot$ kg^{-1} of humus. Carbonate compounds occur in the lower part of the horizon. Horizon B2 in light-brown soil is at the maximum (70–80 cm). The content of total absorbed bases content in the layer 0–10 cm is 278–280 mmol(+)$\cdot$kg^{-1} of soil.

The area of plots is 100 m^2, four-time repetition, the location of the plots is randomized. Agrotechnical measures of grain and forage crops cultivation adopted for West Kazakhstan region was applied.

The field experiment comprised the following cultivars of crops: winter wheat – Mironovskaya 808, spring wheat – Saratovskaya 42, barley – 8 Donetsk, melilot – Kaldybansky.

The tillage was performed with depleted plow with coulters to the depth of 25–27 cm. Winter wheat was harrowed with average harrows “ЗБЗТ-1”. Sowing cultivation was done at all the early spring crops after harrowing to the depth of seed placement. The sowing was done with seeder “СЗС-2”, 1 with simultaneous packing of soil.

As mineral fertilizers, we applied ammonium nitrate “N_{aa}” and double superphosphate “$P_{сд}$”.

As green manure, we plowed yellow melilot *(Melilotus officinalis* L.*)*. The sowing was done under the cover of barley. The following year, in the phase of flowering, melilot was plowed to the depth of 25–27 cm. After the plowing, the plot was treated with heavy disk harrows “БДТ-3”, and then consolidated with star-wheeled rollers.

Weather conditions in the years of the research were characterized at the term average indicators.

Plants were grown to the technological maturity. During ontogenesis we did surveillance of their growth and development. The harvesting was done by plots.

In soil samples, available phosphorus was analyzed with the Machigin method, the content of organic matter by Tiurin method, soil moisture – with gravimetric method, soil structure was determined using dry sieving.

For the statistical evaluation we applied standard deviations, calculations were done using the Dospekhov method [2]. For the statistical evaluation of the results, the data package analysis of Excel spreadsheets was used.

RESULTS AND DISCUSSION

Humus

Dark brown soils are located in the climatic zone with limited annual rainfall, sharp daily and seasonal temperature fluctuations and high coefficient of evaporation. There are less organic residues than in black soil zone, and the depth of roots penetration in the soil is shallower. Therefore, the content of humus and thickness of humus horizon here is less than that of black soil.

In the soil, humus formation and its decomposition are in dynamic equilibrium, which is determined by a set of factors. As the research data show, for the period of crop rotation with pure fallow at control there was a decrease in the humus content in the soil layer 0–40 cm by 0.9%.

In the experiment with increasing of crop yields, the removal of nitrogen increased. The loss of nutrients with crop did not become covered by its contents in the soil, and was compensated by the decomposition of soil humus which was intensive in the conditions of the increased moistening.

At the application of mineral fertilizers only, in the crop rotation there was some decrease in the humus content in the soil. Thus, in the layer of 20–40 cm the content of humus by the end of the crop rotation decreased by 0.1%.

The application of manure and annual plowing of straw into the soil led to the entrance of organic matter into the soil. In these options, the stabilization of soil humus level was noted. The decrease of the humus content in the soil at the incorporating of organic and green manure-organic fertilizers into the soil was noted.

At the manure plowing in the soil layer of 20–40 cm, a humus increase of 0.1% was noted. Such insignificant increase of humus is explained by the uneven entrance of the organic substance into the soil which was the effect of the beginning of crop rotation (Table 1).

Weak variation of humus by years should be noted. The humus increase regarding the options during the rotation can only be spoken of in the years after the introduction of manure and green manure plowing into the soil.

Available phosphorus

Phosphorus plays large role in plants' nutrition. Therefore, the size of crop's productivity considerably depends on its contents in the soil in the crop rotation, especially the value of phosphorus as it increases in dark-brown soils where the content of this element is at a minimum.

TABLE 1. THE CHANGE OF HUMUS CONTENTS IN THE SOIL ACCORDING TO THE EXPERIMENT FERTILIZATION TREATMENT, G·KG^{-1} OF THE SOIL MASS

Fertilization treatment*	Soil layer (cm)	Humus content	
		Crop rotation start	Crop rotation end
Control (without fertilizers)	0–20	31.0 ± 0.2	30.0 ± 0.9
	20–40	30.0 ± 0.3	29.0 ± 0.8
	0–40	30.0 ± 0.3	29.0 ± 0.7
Mineral	0–20	31.0 ± 0.6	31.0± 0.6
	20–40	30.0 ± 0.7	29.0± 0.5
	0–40	30.0 ± 0.5	30.0± 0.4
Organic	0–20	31.0 ± 0.5	31.0 ± 0.5
	20–40	29.0 ± 0.4	30.0± 0.7
	0–40	30.0 ± 0.5	30.0 ± 0.6
Green manure organic	0–20	31.0 ± 0.9	31.0 ± 0.2
	20–40	30.0 ± 0.9	30.0 ± 0.4
	0–40	30.0 ± 0.8	30.0 ± 0.3

*For explanation see Materials and Methods.

The greatest content of phosphorus in the soil on average for the years of the first rotation of the crop under winter wheat in spring in the phase of tilling is noted in the objects with application of phosphorus fertilizers.

Manure introduction under the fallow raised the content of phosphorus in comparison with the control in the layer of 0–40 cm by 3.3 mg kg^{-1} of the soil or by 17.1%, and manure together with mineral fertilizer – by 4.3 mg kg^{-1} of the soil or by 22.3%. Plowing of melilot as green manure raised phosphorus content in the layer of 0–40 cm by 4.4 mg kg^{-1} of the soil, or by 22.8%. P60 introduction under the fallow raised the content of available phosphorus by 1.3 mg kg^{-1} of the soil, or by 6.7%. The best phosphoric mode under winter wheat developed on the option with introduction of organic-mineral and also green manure-organic fertilizers (Table 2).

Before the harvesting of winter wheat, the content of phosphorus in the soil was higher under the treatments with organic and organic-mineral fertilizers, despite the higher consumption of this element by plants of winter wheat for vegetation. On the control in the layer of 0–40 cm, the content of phosphorus in the soil decreased at the expense of consumption by its plants by 15.5 mg kg^{-1} of the soil; on the option with manure introduction under the fallow – by 15.9 mg kg^{-1} of the soil; at the introduction of organic-mineral fertilizers – by 11.5 mg kg^{-1} of the soil; at the plowing of green manure – by 16.9 mg kg^{-1} of the soil. Mineral fertilization resulted in an increased content of this compound in the soil as compared to the control objects in the layer of 0–20 cm by 2.8 mg kg^{-1} of the soil, or 23.5%; against manure – 4.5 mg kg^{-1} of the soil or 37.8%; against manure and mineral fertilizers – 9.0 mg kg^{-1} the soil or 75.6%; at the plowing of green manure – 3.3 mg kg^{-1} of the soil or 27.7%. The greatest number of residual phosphorus was also found on the objects with incorporation of both mineral and organic-mineral fertilizers and at the plowing of green manure.

Coefficients of phosphorus variation by years were quite considerable and were in the phase of tilling 0.215–0.317, and during the harvesting – 0.245–0.482.

TABLE 2. THE CONTENT OF AVAILABLE PHOSPHORUS IN THE SOIL (MG KG^{-1} SOIL), AVERAGE FOR YEARS 2005–2012

Fertilization treatment	Soil layer (cm)	Crop rotation plant – winter wheat
		Available phosphorus
Control (without fertilizers)	0–20	220.0 ± 0.2
	20–40	160.7 ± 0.1
	0–40	190.3 ± 0.1
Mineral	0–20	240.1 ± 0.4
	20–40	170.1 ± 0.3
	0–40	200.6 ± 0.4
Organic	0–20	250.3 ± 0.6
	20–40	190.9 ± 0.5
	0–40	220.6 ± 0.5
Organic-mineral	0–20	270.1 ± 0.5
	20–40	200.1 ± 0.4
	0–40	230.6 ± 0.3
Green manure organic	0–20	270.3 ± 0.5
	20–40	200.1 ± 0.5
	0–40	230.7 ± 0.6

Soil structure

Soil structure plays an important role in the life of plants among the agro-physical indicators of the soil.

In the research, by the end of two crop rotations, the share of agronomical valuable aggregates (10–0.25 mm in diameter) fluctuated between the objects from 52 to 81%; 6–3% was the share of blocky units (more than 10 mm), the share of dusty units was 1.9–7.2% (Table 3).

TABLE 3. THE SHARE (IN %) OF AGRONOMICAL VALUABLE STRUCTURAL AGGREGATES OF DARK-CHESTNUT SOIL UNDER THE DIFFERENT PLANTS AFTER TWO FULL CROP ROTATIONS

Fertilization treatment	Soil layer (cm)	Succeeding plant			
		Fallow	Winter wheat	Spring wheat	Barley
Control (without fertilizers)	0–10	55.4 ± 0.4	59.2 ± 0.3	64.2 ± 0.7	54.2 ± 0.5
	10–20	62.4 ± 0.2	64.9 ± 0.3	63.2 ± 0.6	48.9 ± 0.6
	20–30	64.6 ± 0.4	54.6 ± 0.2	53.3 ± 0.5	54.9 ± 0.5
	0–30	60.8 ± 0.5	59.6 ± 0.4	60.2 ± 0.5	52.7 ± 0.5
Mineral	0–10	69.1 ± 0.3	73.8 ± 0.5	62.0 ± 0.4	49.9 ± 0.4
	10–20	59.7 ± 0.4	58.9 ± 0.5	61.4 ± 0.3	61.0 ± 0.5
	20–30	61.1 ± 0.6	55.8 ± 0.7	44.5 ± 0.3	48.5 ± 0.4
	0–30	63.3 ± 0.5	62.8 ± 0.5	56.0 ± 0.5	53.1 ± 0.4
Organic	0–10	79.5 ± 0.6	82.7 ± 0.5	82.7 ± 0.6	86.3 ± 0.8
	10–20	78.9 ± 0.5	80.0 ± 0.7	80.0 ± 0.7	82.9 ± 0.7
	20–30	82.8 ± 0.4	74.8 ± 0.6	74.8 ± 0.6	81.8 ± 0.6
	0–30	80.4 ± 0.5	79.2 ± 0.5	79.2 ± 0.6	83.7 ± 0.6
Organic-mineral	0–10	79.9 ± 0.8	82.7 ± 0.3	84.0 ± 0.6	80.2 ± 0.5
	10–20	80.7 ± 0.8	80.5 ± 0.4	82.9 ± 0.6	75.8 ± 0.5
	20–30	80.8 ± 0.7	77.9 ± 0.5	72.6 ± 0.7	76.1 ± 0.4
	0–30	80.5 ± 0.7	80.4 ± 0.4	79.8 ± 0.6	77.4 ± 0.4
Green manure organic	0–10	79.2 ± 0.6	70.3 ± 0.4	70.3 ± 0.8	77.4 ± 0.7
	10–20	75.9 ± 0.5	70.2 ± 0.6	70.2 ± 0.7	75.2 ± 0.6
	20–30	62.5± 0.4	78.8 ± 0.5	78.8 ± 0.9	76.2 ± 0.5
	0–30	72.5 ± 0.5	73.1 ± 0.5	73.1 ± 0.6	76.3 ± 0.6

Under winter wheat, the smallest number of valuable aggregates in the layer of 0–30 cm was at the control (59.6%). At the end of two rotations, the content of aggregates on crops at the introduction of mineral fertilizers was 62.8%. The greatest number of valuable aggregates was noted at the treatments with organic and organic-mineral fertilizers (79.2 and 80.4%). It is 19.6 and 20.8% more than at the control. The option with green manure (73.1%) conceded slightly. Here, it was 13.5% more valuable aggregates than at the control and 6.1 and 7.3% less than at the manure treatment.

Under the spring-sown field, agronomical valuable aggregates were 60.2% (control), whereas at the object with mineral fertilizers they were 56.0% (4.2% less than at the control). The greatest number of valuable structural units was noted also at the objects with the manure brought under the fallow. Here, their quantity was 79.2 and 79.8% that is 19.0 and 19.6% more than at the control. At the plowing of green manure, valuable aggregates were 6.1–6.7% less than at the manure incorporation.

In barley crops, the best structure was noted at the treatment of organic fertilizers. In this object, the number of valuable aggregates in the soil layer of 0–30 cm was 83.7% or, in comparison with the control, 31.0% more.

Under barley crops at the introduction of organic-mineral and green manure-organic fertilizers, the content of agronomical valuable aggregates in the layer of 0–30 cm was almost identical – 77.4 and 76.3%.

The statistical assessment by *t*-Student criterion on 95% significance value showed the reliable increase in the number of structural units in the soil layer of 0–30 cm at the use of organic, organic-mineral and green manure-organic system of fertilizers. The increase in the number of structural aggregates in the layer of soils of 0–30 cm is noted under all cultures of crop rotation. Comparing the studied treatments with the control, the actual value of the Student criterion was 7.9 and more, at the theoretical value of criterion 2.31. At the application of mineral fertilizers, the reliable reduction of structural units' number in comparison with the objects with the introduction of organic, organic-mineral and green manure fertilizers into the soil was noted.

Moisture reserves in the soil

The positive influence of manure, straw and green manure introduction on water physical properties of the soil promoted the best absorption of autumn-winter precipitation into the soil, the increase of productive moisture reserves, and the increase of precipitation efficiency.

During the years of the first rotation of crops, the greatest reserves of moisture in the soil were in the spring at the fallow. The amount of productive moisture in a 1 meter layer of soil regardless of fertilizers application equaled 112.6–118.3 mm. The introduction of organic and green manure fertilizers increased the moisture reserves in the soil in comparison with the control to 129.3 mm or by 14.8%. In the first rotation, the introduction of organic and green manure fertilizers led to an additional accumulation of 9.1–14.2 mm of moisture in the soil, and in the second rotation – 11.3–15.9 mm, which gave potential opportunity to the grain productivity increase at the expense of moisture reserves accumulation in the soil.

Large reserves of moisture in the soil were in the spring before the crops of the spring-sown field at the option with application of green manure fertilizers – 120.3 mm or 16.9% more than at the control. The introduction of organic and organic-mineral fertilizers increased the content of soil productive moisture to 108.4–118.0 mm.

In barley crops, the introduction of manure increased the moisture content to 130.8 mm (on 16.8 mm or 14.7% more than at the control). The plowing of melilot as green manure fertilizer increased the content of productive moisture to 132.0 mm or by 15.7%.

In the second rotation, the increase of moisture reserves was also observed at the introduction of organic fertilizers into the soil.

Thus, with the improvement of water physical properties of dark-brown soil, the water mode improved. This is important for West Kazakhstan where a limiting factor of growth and development of grain crops is its moisture provision.

Productivity of grain crops

Fertilizers, by improving conditions of plants' mineral nutrition, create favourable conditions for crop formation. As the research data shows, for the years of crop rotation at the control, the productivity of grain crops fluctuated within 1.47–2.14 $t \cdot ha^{-1}$. At the introduction of mineral fertilizers into the soil, the productivity increased slightly, to 1.69–2.26 $t \cdot ha^{-1}$ (Table 4).

TABLE 4. PLANT YIELDS ($T \cdot HA^{-1}$) IN TWO CROP ROTATIONS

Fertilization treatment	First crop rotation			Second crop rotation		
	Winter wheat	Spring wheat	Barley	Winter wheat	Spring wheat	Barley
Control	2.14	1.69	1.88	2.06	1.47	1.54
Mineral	2.26	1.84	1.92	2.25	1.69	1.83
Organic	2.35	1.88	2.00	2.41	1.84	1.97
Organic-mineral	2.42	1.90	2.02	2.47	1.88	2.03
Green manure organic	2.30	1.93	2.05	2.39	1.92	2.05

At the introduction of manure only, the productivity of winter wheat, spring-sown field and barley ranged from 1.84 to 2.35 $t \cdot ha^{-1}$ or more; or by 0.21–0.37 $t \cdot ha^{-1}$ in comparison with the control.

The highest efficiency of grain crops was noted at the joint introduction of oraganic-mineral fertilizers – the productivity was 1.88–2.44 $t \cdot ha^{-1}$ or more; in comparison with the control by 0.3–0.41 $t \cdot ha^{-1}$.

At the introduction of green manure-organic fertilizers, the productivity was also high at the level of 1.92–2.30 $t \cdot ha^{-1}$.

CONCLUSIONS

1. As a result of long-term complex research, it was established that in the conditions of West Kazakhstan, the application of organic and green manure-organic fertilizers promoted the improvement of agrochemical and agro-physical properties of dark-brown soil.

2. The use of organic, organic-mineral and green manure-organic fertilizers allows to increase the effective and potential fertility of dark-brown soils. Steady nature of organic substance accumulation in the soil was thus provided at plowing of manure and straw (+ 0.4 $g\ kg^{-1}$), green manure (+ 0.3 $g\ kg^{-1}$).

3. Phosphoric mode of dark-brown soils was affected optimally by the method with application of manure, straw and green manure. The content of available phosphorus at the end of the second crop rotation in the soil layer of 0–40 cm at the objects with the use of organic, organic-mineral fertilizers and green manure-organic fertilizers was 226.0; 236.0; 237.0 $mg\ kg^{-1}$ of the soil that is more in comparison with the control (without fertilizers) respectively by 33.0; 43.0 and 44.0 $mg\ kg^{-1}$ of the soil.

4. By the end of two crop rotations at the objects with the use of manure, biomass of melilot in combination with manure and straw, the content of agronomical valuable aggregates (10–0.25 mm in diameter) in comparison with the control (without fertilizers) increased to 76.9 and 83.7%.

5. On average for the years of the first rotation, at introduction of organic and green manure-organic fertilizers in comparison with the control (without fertilizers), 9.1–14.2 mm of moisture accumulated additionally. During the years of the second rotation in the specified objects in comparison with the control, the amount of additional accumulated moisture was 11.3–15.9 mm.

6. For the duration of two full crop-rotation periods, the application of organic and green manure-organic fertilizers promoted the increase of grain crops productivity from 16.0 to 33.1% in comparison with the control (without fertilizers).

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ROLA NAWOZÓW ORGANICZNYCH W ZWIĘKSZANIU ŻYZNOŚCI GLEB ZACHDNIEGO KAZACHSTANU

W badaniach kompleksowych analizowano współzależności pomiędzy metodami regulacji żyzności gleb a wskaźnikami agrochemicznymi i fizykochemicznymi na przykładzie gleb ciemno-kasztanowych zachodniego Kazachstanu. Stwierdzono, że zastosowanie nawozów organicznych i organiczno-syderytowych podnosi zawartość związków humusowych, ruchomego fosforu oraz poprawia structure I zdolności retencyjne gleb. Badane nawozy zwiększały plony ziarna od 16 do 33% w porównaniu do obiektów kontrolnych.

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Soil Chemistry

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THE KINETICS OF THE MIGRATION OF LEAD, CADMIUM, COOPER AND ZINC IN THE CONDITIONS OF TURF-PODZOL SANDY LOAM AND CHERNOZEM SOIL

Abstract. In this paper the dynamics of migration of heavy metals (HM), namely Pb, Cd, Cu, Zn, in turf-podzol sandy loam soil and chernozem soil in the presence of impact pollution was investigated. Experimental data were obtained during the period of 1999 to 2006. We applied exponential and Koller models to obtain the ranking of the metals according to their rate of dissipation from a 0–20 cm layer of soil. We also obtain a prediction of the amount of metals present in 20–100 cm layer of soil in mobile form. Our findings are relevant to estimating the metal hazard and controlling the condition of the soil for crop growth.

Investigation of migration processes of heavy metals (HM) in soil in the presence of impact pollution is important because the speed of migration of pollutants in soil profile determines the time and the degree of the disturbance of biogeochemical cycles [6, 7, 11]. Such disturbance causes qualitative and quantitative changes in the agroecosystem which entails reduction in crop growth and quality of the products of agriculture.

Finding patterns of migration of HM in the soil makes it possible to determine not only the length of remediation of the soil (and hence of its effective use in crop growth) but also the time of the appearance of pathological changes resulting from HM pollution [4, 12].

Despite the fact that impact HM pollution constitutes 20–50% of all types of HM pollution, the problem of predicting its consequences often remains unsolved [12]. Such prediction can only be made possible using a mathematical

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model of dynamics and kinetics of migration of HM in the soil. This will allow controlling the quality of the environment more efficiently [12].

HM contamination resulting from impact pollution gradually diminishes due to the uptake of the HM by the plants, HM sorption by the soil, pollutants migration within the soil profile, microbiological activity in the soil etc. The rate of reduction of HM contamination depends on the physical and chemical properties of the metal and the characteristics of the soil (pH, granulometric composition, organic matter, plants canopy, etc.) [3, 5, 9, 13, 14].

The aim of investigation was to construct a model of migration of HM in turf-podzol sandy loam and chernozem soils in the presence of impact pollution by Pb, Cd, Cu and Zn. Turf-podzol sandy loam soil makes up nearly one third of the Ukrainian soil and has a weak buffer capacity [4, 12]. Chernozem soil makes up more than one half of the whole area and is regarded as the most prolific soil in Ukraine.

MATERIAL AND METHOD

The experimental investigation was conducted during the period of 1999 to 2006 at Chernigiv Institute of Agrotechnical of the Ukrainian Academy of Agrarian Science.

The soils under investigation were the turf middle podsol sandy soil (pH_{salt} 5.5; hydrogen acidity 2.7 meq./100g of soil; organic matter according to Turin 0.87%; hydrogen saturation rate 58%.) and the law humus typical chernozem (pH_{salt} 6.2; organic matter according to Turin 2.89%; hydrogen saturation rate 82.3%). The experimental scheme was: 1. – Control; 2. Cu – 50, Zn – 150, Pb – 15, Cd – 1,5 mg/kg; 3. Cu – 100, Zn – 300, Pb – 30, Cd – 3 mg/kg; 4. Cu – 500, Zn – 1500, Pb – 45, Cd – 15 mg/kg. We used the following metals salts: $Pb(NO_3)_2$, $ZnSO_4 \cdot H_2O$, $Cu SO_4 \cdot 7H_2O$, $CdSO_4$. The investigation was conducted in field conditions.

RESULTS AND DISCUSSION

Depending on migrated content Cd, Pb, Cu and Zn, the ranking of the migration paths was obtained. Plant up-taking and vertical migration in soil profile belongs to principal migration paths (makes up more than 10% of the contributed amounts) [3, 5, 9, 12, 13]. Horizontal migration in soil, ruderal species up-taking, and deposition to immobile form in soil belongs to minor migration paths. Evaporation belongs to inessential migration paths and makes up less than 0.001% of the initial quantity [6, 7, 12]. Most of the HM was located in the top layers of soil during the first three years of the experiment (1999–2001). For instance, cadmium amounts in a 0–20 cm turf-podzol sandy loam soil layer were 91.0% (in 1999), 40.1% (2000), 28.2% (2001), 11.2% (2002), 5.6%

(2003), 2.8% (2004), 1.4% (2005), 0.6% (2006) of the initial amount, applied at the start of the experiment. It demonstrates the “principle of active factor refraction within the system” [10]. According to this principle, external action can be weakened by buffer properties of the system. However, in a 20–40 cm soil layer, Cd content declines by 13.1% (1999), 11.4% (2000), 8.5% (2001), 5.1% (2002), 3.8% (2003), 2.0% (2004), 1,1% (2005), 0.8 % (2006).

HM dissipation constant in a 0–20 centimeter layer of soil is described by the exponential model [1, 2]:

$$(k = \frac{2.303}{t} \lg \frac{C_0}{C_t}) \quad (1)$$

where: *Ct* – final concentration; *Co* – initial concentration; *k* – dissipation constant of heavy metal; *t* – time or period, days.

Half life period is calculated according to the following equation [4, 1, 2, 8]:

$$T_{50} = \frac{0.693}{k} \quad (2)$$

Heavy metal mobility in the soil increases with the value of the constant. Cu had the highest speed of dissipation in turf-podzol sandy loam soil in our investigation: the dissipation constant of copper in soil was 1.2 years^{-1} and T_{50} was 0.6 year. The other metal’s dissipation constants were 0.91 (Zn), 0.7 (Cd), 0.64 (Pb) years^{-1} and T_{50} were 0.8 (Zn), 1.0 (Cd), 1.1 (Pb) years^{-1} (Table 1). Similar experimental data were obtained for chernozem soil (see Table).

TABLE 1. DISSIPATION CONSTANTS OF HEAVY METALS IN 0–20 CENTIMETERS LAYER OF TURF-PODZOL SANDY LOAM SOIL AND CHERNOZEM SOIL AND T_{50} (YEARS^{-1})

	Pb	Cd	Zn	Cu
Turf-podzol sandy loam soil				
*Const**-.	0.64	0.70	0.91	1.22
T_{50}	1.10	1.00	0.80	0.60
Chernozem soil				
*Const**-.	0.72	0.80	1.07	1.31
T_{50}	0.96	0.87	0.65	0.53

*r^2 0,8–0,9

According to the value of heavy metals dissipation rate in the 0–20 centimeters layer, the heavy metals can be ranked in the following descending order: Cu>Zn>Cd>Pb.

The dynamics of HM content in 20–100 cm profile through each 20 cm layer was approximated by the Koller function (picture). The general form of the equation is:

$$\acute{o} = a_0 \cdot x^{a_1} \cdot \mathring{a}^{a_2 x} \tag{3}$$

where a_0, a_1, a_2 denote constant indices of each metal migration rate in any examined layer.

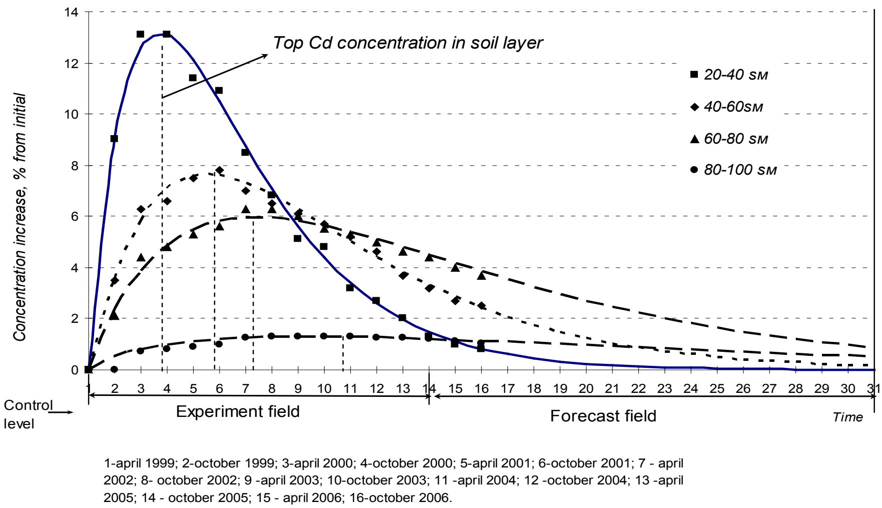

Fig. 1. Dynamics and prediction of Cd concentration in the profile of the turf-podzol soil.

Equation (3) allows to predict the metal concentration in soil (r = 0.87–0.99). For example, 14 years after Cd impact contamination of a 20–40 cm soil layer will present about 1% of the initial amount of Cd.

This simulation model also makes it possible to develop a strategy for safe agriculture on polluted stretches of land.

CONCLUSIONS

1. The migration of Cd, Cu, Zn and Pb in a 20–100 cm layer of soil was described using the Koller model. This model allows predicting the evolution of the amount of metal present in 20–40, 40–60, 60–80 and 80–100 cmlayers of soil after the occurrence of impact pollution.

2. Using the exponential model, we obtained the dissipation constants of Cd, Pb, Cu and Zn in a 0–20 cm layer of turf-podzol sandy loam and chernozem soil. The rate of dissipation of the metal from the 0–20 cm layer of soil increases with the value of the constant. Knowing the value of the constant, one can calculate the length of half-dissipation of the metal in the 0–20 layer of soil.

3. We obtained the following ranking of the metals Cu>Zn>Cd>Pb according the value of their dissipation constant. We conclude that the dissipation constant not only characterizes the migration ability of the metal but also makes it possible to measure the quality of the soil for crop growth.

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KINETYKA MIGRACJI OŁOWIU, KADMU, MIEDZI I CYNKU W GLEBIE DARNIOWO-BIELICOWEJ I CZARNOZIEMIE

W pracy przedstawiono proces migracji metali ciężkich: Pb, Cd, Cu, Zn w lokalnie zanieczyszczonych glebach: darniowo-piaszczystej i czarnoziemie. Dane doświadczalne uzyskano w latach 1999–2006. Stosując model wykładniczy i model Kollera otrzymano szereg metali zgodnie z szybkością ich usuwania z 0–20 cm warstwy gleby. Uzyskane wyniki także pozwalają na prognozowanie wielkości mobilnych form metali ciężkich w warstwie gleby 20–100 cm. Wyniki badań można wykorzystać do oceny zagrożenia metalami ciężkimi i kontroli warunków uprawy roślin w różnych glebach.

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Soil Genesis

ANDRIY KYRYLCHUK, STEPAN POZNYAK*

PEDOGENIC PROCESS ON ELUVIUM-DILUVIUM SOLID CARBONATE ROCKS

Abstract. The article is dedicated to the problem of pedogenic process on eluvium-diluvium solid carbonate rocks and investigation of the formation peculiarities of morphogenetic characteristics of Rendzinas (Rendzic Leptosols, WRB, 2007) under the influence of ligneous and herbaceous agricultural vegetative formations.

One of the most important theoretical and practical problems of contemporary soil science is the pedogenic process on eluvium-diluvium solid carbonate rocks and discovering the main formation peculiarities of morphogenetic structure and functional properties of rendzinas soil profile on different stages of its ontogenetic development, as well as under the influence of various natural-anthropogenic vegetative formations [4].

The constituent part of this problem is the degree of soil change under the influence of soil formation factors which is being determined by their reflectivity (the ability to reflect the influence of a certain factor) and "sensority" (sensitivity to this influence).

Undeveloped soils do not play an essential part in general biosphere's process. Hence, they are not regarded as a category of productive soil resources. However, it's important to study them as they are the initial stage of soil formation on the land surface.

Analyzing the current soil formation on solid and especially carbonate rocks under various vegetative formations, it is possible to study the old-established soil formation on dry land when the autotrophic organism reclamation has just started.

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The study of initial soil formation enables, in general, the revelation of soil formation regularities and, mainly, the interaction of biological and geological circulation of substances, the processes of synthesis and decay, accumulation, take away, and soil formation balance [3].

The problem of initial soil formation and primary soil forming stages has been described in a number of scientific publications [1–6]. However, it has to be taken into consideration that the number of scientific publications on the problem of initial soil formation on eluvium-diluvium solid carbonate rocks and investigation of the formation peculiarities of morphogenetic characteristics of undeveloped soils under the influence of ligneous herbaceous and agricultural vegetative formations is insufficient.

A very interesting publication by Abakumov and Shelemina [1] is dedicated to investigation of soil formation on the monuments of the past. The investigations showed that during the last 300 years, full profile rendzinas (thickness ≈ 26 cm) had been formed on the walls of Coporsk fortress made of local limestone. According to their characteristic features, they are similar to Ordovytsk plateau soils, having been formed on the analogous rocks.

The publication of Chyzhykova *et al.* [2] is also to be taken into consideration as it shows the investigation results of soil formation processes and gives characteristics of morphogenetic properties of undeveloped soils formed during 33 years on the overlying loam under the influence of ligneous, herbaceous and agricultural vegetative formations in terms of the modeling experiment [6].

A new research work by Popa [5] has recently been published defining the regularities and showing the ecological evaluation of initial soil forming processes on the surface of waste heaps of Donbas mines in natural conditions under the influence of different vegetative formations.

MATERIAL AND METHODS

The territory under investigation (Bila Hora tract) in administrative relations is located in the south-eastern part of Bus’k area, Lviv region. According to physical and geographical zoning, Bila Hora tract is located within the boundaries of Voronyatsk natural area of Western Podil’sk Upland of Western Ukraine (Fig. 1).

Podil’sk strata-layer upland landscapes are dominating in the investigation area landscape structure. They are mainly covered with loess-like loamy soils, partially with clear plane carbonate rocks exposed as a result of the outwash.
In the spots where the native cretaceous marl rocks come out on the diurnal surface, formed a widely spread type of surface deposits, which is the eluvia-diluvium crust decay of these rocks. These are the deposit rocks of a mixed loamy-carbonate structure with the content of the loamy material varying from 10 to 30%, calcite – 35–90%. Therefore, the source rock on the territory

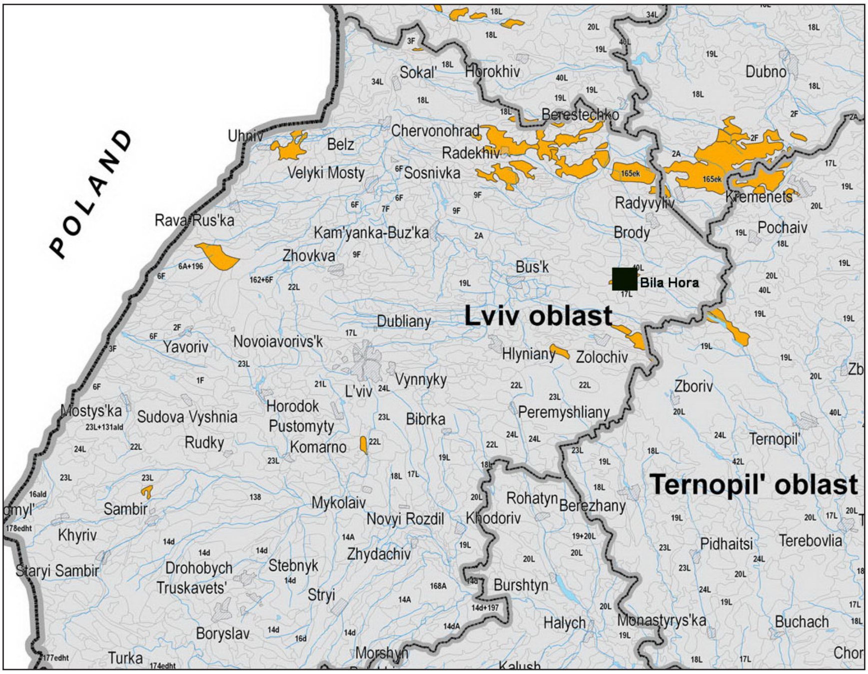

Fig. 1. Localization of soil profiles (Bila Hora – 1 BH–7 BH profiles).

under investigation is the eluvia crust of deposit weathering of the cretaceous system upper section, which is presented by cretaceous marls [3].

Taking into consideration the above mentioned the object of investigation is the initial soil formation processes on the eluvium-diluvium of cretaceous marl.

The subject is the reflective and sensory state of initial rendzinas having been formed on eluvium-diluvium of cretaceous marl under the influence of ligneous, herbaceous and agricultural vegetative formations.

Aiming to study the peculiarities of morphology, the contents and characteristics of rendzinas formed on eluvium-diluvium of the cretaceous marl within the boundaries of Bila Hora tract, we have carried out detailed phytocenotic soil investigations in different geomorphological-hypsometric terms and under different vegetative formations. In 2010, seven modal study sites of phytocenotic soil investigations were laid (each modal study sites is represented by one soil profile) within three geomorphological-hypsometric levels of Bila Hora tract (Table 1).

TABLE 1. SELECTED INFORMATION CONCERNING MODAL STUDY SITES OF RENDZINAS PROFILES

Modal study sites	Profiles	Location	Lithology	Geomorphology	Vegetation
No. 1	1 BH	Bila Hora	eluvium of the cretaceous marl	upper part of the slope of southwestern display with the level of steepness of about 15–20°	perennial herbs; soil surface is turfed
No. 2	2 BH	Bila Hora	eluvium-diluvium of the cretaceous marl	middle part of the southwestern slope with the steepness of about 20°	vegetation is absent; the surface of the soil–broken stone and gravel
No. 3	3 BH	Bila Hora	eluvium of the cretaceous marl	middle part of the southwestern display slope with the steepness of about 10–15°	*Pinus sylvestris* (age ≈ 80 years); within the crown pine (r ≈ 2.0–2.5 m), residues of needles, is observed
No. 4	4 BH	laid on 500 m distance to the south-west from the foot of Bila Hora	eluvium-diluvium of the cretaceous marl	the slope of south-western display with the steepness of about 1–3°	arable land is a fallow; soil surface is turfed (herbaceous cover is up to 30%)
No. 5	5 BH	Bila Hora	eluvium of the cretaceous marl	the lower part of western display slope, with the level of steepness of about 10–12°	*Pinus sylvestris* (age ≈ 80 years); within the crown pine (r ≈ 2.0 m), residues of needles, is observed
No. 6	6 BH	Bila Hora	eluvium of the cretaceous marl	the lower part of the southern display slope, steep about 10°	*Pinus sylvestris* (age ≈ 80 years); within the crown pine (r ≈ 2.5 m), residues of needles, is observed; soil surface is turfed
No. 7	7 BH	Bila Hora	eluvium of the cretaceous marl	the upper part of the northern display slope, steep about 10–15°	perennial herbs with moss admixture; soil surface is turfed

Soil profiles were laid as deep as the parent rock. Morphological structure in the profiles was investigated in detail. The coloring of the soils in the aerial-dry samples was determined according to Mansell's scale. Samples of soil for the laboratory-analytical investigations were chosen according to genetic levels. In the selected samples, hygroscopic water was measused using the thermostatic-gravimetric method, pH_{H_2O} – electrometrically, CO_2 of the carbonates – using the Heisler-Maksymjuk method, humus – using the Tiurin method modified by Nikitin [6].

RESULTS AND DISCUSSION

For the purpose of generalization and analysis, the data concerning the phytocenotic-soil investigations carried out within the boundaries of Bila Hora tract, morphological description of the rendzinas profile of three modal study sites characterized by a well-marked peculiarities of geomorphological-phytocenotic factors of soil formation are presented.

A system of indexes offered by Sokolovsky in 1956, for marking genetic horizons of investigated soils is used in Ukraine. The symbols of genetic horizons according to World Reference Base for Soil Resources (2007) are presented in brackets.

Modal study sites No. 1 (profile 1 BH)

Hd (Ad) 0–2 cm	– turf;
H_{Ca} (A_{Ca}) 2–19 cm	– humus-accumulating horizon, HCl (+), fresh, dark-grey with a marked tint of brown (10YR5/1-5/2), of a small-grained structure, averagely condensed, medium loamy, the roots are of the herbaceous vegetation, gravel inclusions of the initial soil formation rock, transition into the following gradual genetically level;
HP_{Ca} (AC_{Ca}) 19–23 cm	– transiting humus horizon, HCl (+), fresh, heterogeneous color, the upper part is grey touched with white and brown, the white undertone increases downwards (10YR6/1-6/2), of an indistinct smallelodded grainy structure, weakly condensed, broken stone and gravel inclusions of the initial soil formation rock, sudden transition;
P_{Ca} (C_{Ca}) 23–64 cm	– the soil formation rock is presented by eluvium-diluvium of cretaceous marl, in the upper part consisting of broken stone parts d = 3–5 cm, the cavities are filled with a paste-like eroded material, the size of eluvium of cretaceous marl rises downwards.

Modal study sites No. 3 (profile 3 BH)

H_0 (O) 0–2 cm	– forest bedding, consisting of two layers, the upper is 0–1 cm (O1), the previous year defoliation of needles of brown coloration, which didn't lose their anatomical structure; 1–2 cm (O2) – conifer needles half-disintegrated, of dark-brown and dark-grey tint, damp;
H_{Ca} (A_{Ca}) 2–4 cm	– humus-accumulating horizon, HCl (+), fresh, grey with a touch of brown and white (10YP7/1), of a hot solid small-grained structure, weakly condensed, medium loamy, sudden transition to the following horizon;
$P(h)_{Ca}$ (A/C_{Ca}) 4–6 cm	– the fragmentary weakly humused upper part of the soil formation rock, HCl (+), of white coloring with a slightly noticeable grey tint (10YR8/1), unstructured gravel and stone rock parts of the initial soil formation rock, the cavity is filled with a paste-like eroded material of a muddy-yellow coloring, the size of eluvium of cretaceous marl rises downwards;
P_{Ca} (C_{Ca}) 6–12 cm	– the soil formation rock is presented by cretaceous marl eluvium-diluvium, consisting of broken stone parts d = 5–7 cm in the upper part, the space is filled with a paste-like eroded material of muddy-yellow coloring, the size of eluvium of cretaceous marl rises downwards.

Modal study sites No. 6 (profile 6 BH)

H_0+Hd (O+Ad) 0–3 cm	– H_0 (O) – forest bedding (0–1 cm) and Hd (Ad) – turf (1–3 cm);
H_{Ca} (A_{Ca}) 3–13 cm	– humus-accumulating horizon, HCl (+), fresh, grey with a touch of brown and white (10YP7/1), small-grained structure, averagely condensed, medium loamy, herbaceous vegetation roots, gravel inclusions of the initial soil formation rock, gradual transition into the next levels;
$P(h)_{Ca}$ (A/C_{Ca}) 13–20 cm	– weakly humused upper part of soil formation rock, HCl (+), of white color with a noticeable grey tint (10YR8/1), unstructured, consisting of gravel and broken stone parts of the initial soil formation rock, the space is filled with a paste-like eroded material of a muddy-yellow coloring, the size of eluvium of cretaceous marl rises downwards;
P_{Ca} (C_{Ca}) 20–33 cm	– the soil formation rock is presented by eluvium-diluvium of cretaceous marl, the upper part of which consists of broken stone parts, the size of which rises downwards.

On the ground of obtain results the line of macromorphological features of initial soil formation is brought to light:

1. The peculiar horizon of bedding (O) and mineral humus-accumulated horizon (A_{Ca}) were formed under the ligneous vegetation and the upper weakly-humused part of soil formation rock (A/C_{Ca}) is separately distinguished. The general thickness of the profile varies from 12 to 33 cm.

2. Turfed (Ad), humus-accumulated (A_{Ca}) and transit horizons (A/C_{Ca}) were formed under the perennial herbs (with admixture of moss). Their general thickness varies from 23 to 38 cm.

3. Typical rendzinas (A_{Ca}–A/C_{Ca}–C_{Ca}) were found on the fallow. Their general thickness varies from 38 to 60 cm.

4. The washed off-up initial rendzinas (with buried humus-accumulated horizon (B (re)) formed on the bleak study sites.

On the basis of comparative analysis of physical-chemical properties of investigated rendzinas, which according to ontogenetic development of morphologic soil profile can be referred to initial and intensive stages of contemporary soil formation, distinct tendency of profile differentiation of their properties: soil organic matter content and stocks, $CaCO_3$ content, soil environment pH have been revealed. This indicates on functioning and different intensity of predominant biogenic-accumulative soil forming processes in these soils. Investigation results of some physical-chemical properties of investigated soil are shown in Table 2.

TABLE 2. SOME PHYSICO-CHEMICAL PROPERTIES OF RENDZINAS

Profiles	Horizon	Depth (cm)	SOM[a] (%)	SOM[b] (kg m^{-2})	pH$_{H_2O}$ (min–max)	$CaCO_3$ (%) (min–max)
1 BH	H_{Ca} (A_{Ca})	2–19	3.61	15.71	8.12–8.51	31.2–31.9
	HP_{Ca} (AC_{Ca})	19–23	0.52	0.56	8.29–8.73	34.5–36.8
	P_{Ca} (C_{Ca})	23–64	-	-	8.43–9.01	40.8–41.8
2 BH	Ph_{Ca} (A/C_{Ca})	0–10	-	-	8.21–8.39	38.2–39.4
	H_{Ca} (A_{Ca})	10–16	1.23	1.96	7.98–8.08	32.6–35.3
	P_{Ca} (C_{Ca})	16–45	-	-	8.16–8.27	36.9–38.7
3 BH	H_{Ca} (A_{Ca})	2–4	1.17	0.60	8.21–8.31	30.0–32.8
	$P(h)_{Ca}$ (A/C_{Ca})	4–6	0.28	-	8.37–8.98	35.8–36.4
	P_{Ca} (C_{Ca})	6–12	-	-	8.46–9.02	45.7–46.2
4 BH	H_{Ca}op. (A_{Ca}agr)	1–14	2.20	7.15	7.99–8.06	29.4–30.7
	HP_{Ca}п/op. (A_{Ca}agr)	14–28	0.82	2.93	8.18–8.22	33.8–35.3
	Ph_{Ca} (A/C_{Ca})	28–40	-	-	8.29–8.35	40.6–41.8
	P_{Ca} (C_{Ca})	40–65	-	-	8.42–8.47	45.5–47.8
5 BH	H_{Ca} (A_{Ca})	2–5	1.18	0.89	8.23–8.30	28.3–30.0
	$P(h)_{Ca}$ (A/C_{Ca})	6–22	-	-	8.76–8.98	35.0–36.2
	P_{Ca} (C_{Ca})	22–35	-	-	8.97–9.02	44.9–46.8

6 BH	H_{Ca} (A_{Ca})	3–13	2.59	6.55	8.21–8.29	25.8–27.6
	$P(h)_{Ca}$ (A/C_{Ca})	13–20	0.41	-	8.84–8.96	36.3–37.5
	P_{Ca} (C_{Ca})	20–33	-	-	8.92–9.00	39.7–41.4
7 BH	H_{Ca} (A_{Ca})	3–17	3.60	12.80	8.47–8.51	30.1–31.9
	Ph_{Ca} (A/C_{Ca})	17–24	0.05	0.09	8.68–8.73	35.6–36.8
	P_{Ca} (C_{Ca})	24–38	-	-	8.98–9.01	39.5–40.8

a – soil organic matter, %; b - stocks of soil organic matter, kg m^{-2}.

CONCLUSIONS

1. The analysis of field and laboratory-analytical investigations data showed that in various geomorphological-phytocenotic conditions of Bila Hora tract on eluvium-diluvium of cretaceous marl, according to morphogenetic characteristics, different initial rendzinas were formed.

2. It is stated that the soil formation process on eluvium-deluvium of cretaceous marl is connected with parcelarous structure of phytocenoses and phytogenetic study site of some herbs.

3. It was discovered that the formation of genetic profile of initial rendzinas occurred under the impact of biogenous-accumulated processes of soil formation, among which the determinant factors were humus formation *in situ*, bedding-formation and turf processes.

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PROCES KSZTAŁTOWANIA SIĘ GLEB NA SKAŁACH WAPIENNYCH

W artykule przeanalizowano problem kształtowania się gleb na szczelnych skałach wapiennych. Przedstawiono osobliwości kształtowania się morfogenetycznych właściwości rędzin inicjalnych (Rendzic Leptosoils) pod wpływem drzewiastych, trawiastych i rolniczych formacji roślinnych.

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Obituary

PROFESSOR DOCTOR JAN BORKOWSKI (1923–2011)

Professor Jan Borkowski was born July 12, 1923 in Hawryłowce (near Bracław, now in Belarus), from where he emigrated after WWII to western Poland. He completed his higher education in the years 1947–1951 at the Faculty of Agriculture, University of Wroclaw. His professional career at the university, in the Department of Soil Science led by Prof. Dr. Jan Tomaszewski, started on March 1, 1950. In the same department, over time transformed into the institute, he obtained all professional degrees. He earned a PhD in agricultural and forest sciences in 1960 based on the thesis „Studies on the silt materials and soils in the Silesia“, and his Habilitation in 1967 based on the dissertation „Brown earths of the Sudeten Mountains“. In 1979, he was awarded the title of associate professor and in 1993 he was appointed full professor. Between 1972 and 1982 he served as head of the Department of Soil Science at the Institute of Agricultural Chemistry, Soil Science and Microbiology. After the separation of the Institute of Soil Science and Agricultural Environment Protection, he served as head of the Department of Sod and Mountain Soils (in the years 1987–1996).

Main research topics of Prof. Borkowski always focused around the current problems of modern soil science and agriculture, in particular those in mountain areas. The scientific achievements of Prof. Borkowski can be classified into four subjects: the origin and genetic classification and evaluation of soils, soil cartography, degradation of soils, the specifics of grassland soils and the factors influencing their fertility and productivity, as well as the specifics of mountain soils in the Sudeten Mountains.

Professor Borkowski was an expert in the soils of the Lower Silesia region. His experience and knowledge resulted primarily from the work on the soil map of Poland at a scale of 1:300 000 and on the general evaluation of agricultural land in Poland. One of his first papers, published in 1959, concerned the reasons for the different productivity of arable soils in the mountains and the need for the division of agricultural space in the Sudeten Mts. on altitude zones. This distinction was soon introduced to the classification practice in all mountainous areas and Borkowski was invited to contribute to the writing of a regional guideline for soil evaluation - valid and used to this day.

Loess and loess-like soils have a great importance for the Lower Silesian agriculture. Problems connected with analysis and classification of the particle-size distribution in these soils have become a canvas for a doctoral thesis and publications of Prof. Borkowski. He revealed serious shortcomings of this classification and repeatedly advocated for necessary changes on various scientific fora of the Polish Society of Soil Science (PTG). However, his demands were taken into account only in 1998.

Properties of mountain soils and their management in the Sudeten Mountains were in the focus of his scientific interests almost from the beginning of scientific work. One of the most important works of Prof. Borkowski was a monograph book on the morphology, physical and chemical properties, and productivity of brown earths in the Sudeten Mountains as affected by parent rocks variability and the zonality of environmental conditions (altitude, climate and vegetation). This work even today is the starting point for new studies on the soil cover of the Sudeten Mts. and the factors affecting its variability, as well as for the consideration of soil genesis in the mountainous areas. In the 1970‘s and 1980‘s Borkowski, in cooperation with other soil and crop scientists, led the studies on the content, dynamics and availability of micronutrients in mountain meadow soils, microelement turn-over in the „soil - plant – animals" chain, the occurrence of crop field – forest border, the interdisciplinary criteria for land use in the Sudeten Mountains, and the grassland management under soil and climate conditions of the mid-mountain depressions.

The large-scale "ecological disaster" in mountain forests turned his attention to the effects of industrial emissions on properties of mountain soils, especially in the Karkonosze Mountains. Based on the comparisons with a survey made in the 1960‘s, Borkowski was one of the first to write about the increasing content of sulfur and some trace elements in the soils of the higher mountain zones, but also questioned the acidification of mountain soils allegedly resulting from the acid rain.

Professor Borkowski was the author or co-author of over 100 original research papers. Among his works, the contributions in scientific monographs of the Karkonosze Mountains are highlighted. Notable is also his co-editorship of the soil map of Poland at the scale of 1:300 000, maps of soil districts of the

Lower Silesia in the scale of 1:100 000, soil map of the Karkonosze Mountains at the scale 1:10 000, as well as the new soil map of the Lower Silesia region at a scale of 1:100 000.

Professor Jan Borkowski was a member of the Scientific Board of the Karkonosze Mountains National Park and co-founder of the Society for Development of the Mountain Regions. He belonged to the Polish Geographical Society, the Polish Agronomic Society, and the Polish Society of Soil Science, where he was a member of the main board and the president of the Wrocław branch. He was also a member of the Mountains Areas Management Committee at the Polish Academy of Sciences, where he served as Vice-Chairman and Chairman of the Sudeten branch. He was awarded by the Rector of Agricultural University in Wrocław, Ministry of Science and Higher Education and the Polish Academy of Sciences for his achievements in scientific work and teaching. Borkowski was also decorated with the Gold Cross of Merit, the Polonia Restituta Medal, and the Medal of the National Education Commission.

Professor John Borkowski approached teaching with great passion. He supervised four PhD theses, including a student from Syria. He conducted lectures, tutorials, seminars and field practice for various specialties at the Faculty of Agriculture (Agricultural University) and the Faculty of Natural Sciences (University of Wrocław). In class, he strived to use all available audio-visual methods to facilitate the perception of knowledge. Students liked his calm and logically organized lectures and seminars conducted with sensitivity and great culture. His examination methods became the stuff of legend: he believed that it was a feat to give a student a failing grade upon the first stumble. The trick was to force the student to pass the exam with a grade of 4 (on a scale of 2 to 5; 5 being the highest grade)! Sometimes the student achieved this on the third, sometimes only on the sixth attempt.

In the memory of his colleagues and students, Professor Borkowski remains an experienced soil scientist, balanced and fair in judgment, and a man of great knowledge.

Leszek Szerszeń
Tadeusz Chodak
Cezary Kabała

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Obituary

PROFESSOR DOCTOR JERZY MELKE (1941-2013)

On March 4, 2013, Professor Jerzy Melke, experienced and particularly thorough scholar of soil chemistry, revered pedagogue and a generous man has passed away in Lublin, Poland. He was the organizer of the laboratory of soil chemistry in the Faculty of Soil Science of the Institute of Earth Sciences in the Department of Biology and Earth Sciences of the Maria Curie-Sklodowska University in Lublin (since 2011 - Department of Soil Science and Soil Protection of the Faculty of Earth Sciences and Spatial Management of the Maria Curie-Sklodowska University in Lublin). He was a participant and co-organizer of many scientific expeditions to Spitsbergen (Svalbard).

Professor Jerzy Melke was born on December 4, 1941 in Vilnius. After coming to Poland with his family, he lived, among others, in Bydgoszcz, Białystok, Ełk, Olsztyn and Hrubieszów, where he attended the Stanisław Staszic High School. He studied Pharmacy at the Medical Academy in Lublin and earned his title of Master of Pharmacy in 1964.

Directly after finishing his studies, Prof. Jerzy Melke began his work at the Faculty of Soil Science at the Maria Curie-Sklodowska University (UMCS) in Lublin. Here, he passed through all of the levels of an academic career, from a scientific and technical assistant to a professor of Earth sciences. He was awarded a position of senior lecturer after defending his doctoral dissertation in the Faculty of Biology and Earth Sciences of the UMCS in 1976. The title of his dissertation was “The Impact of Soil Properties on the Alkaloids of Selected Medicinal Plants”. He achieved the degree of habilitated doctor in biology with the specialization in biology-soil science in 1997 based on the habilitation dissertation entitled “Selected Properties of the Chemical Composition of Brown Soils of Various Geographic Regions.” In 2003, he advanced to the position of associate professor of the UMCS in Lublin, followed by receiving the title of full professor of earth sciences in 2008.

Professor Jerzy Melke’s research interests were focused on the soil environment of Eastern Poland and Spitsbergen. It is, however, noteworthy that natural environment of the Arctic was of special interest to Professor Melke. Beyond the soil-related research, he also meticulously photographed the nature of Spitsbergen, so different from that of Poland, and yet so beautiful. In the years 1987-2009, he participated in 9 polar expeditions to Spitsbergen, including 2 expeditions of which he was the director. Specific scholarly interests of Professor Melke were related to the genesis and chemical properties of brown soils occurring in various bio-climatic zones (from the Hungarian Lowland, through Poland and Sweden, to Western Spitsbergen), as well as the dynamics of the chemical, physical-chemical and biological properties of the arctic tundra. He also studied the macro- and micro-elements in soils and plants, as well as the impact of soil properties on active substances in medicinal plants. His scholarly activity is complemented by manuscripts related to the hygiene and contamination of soil with heavy metals. He has generated over 90 publications, almost 50 of which are original scientific works. Some of his most valuable contributions are arguably the already mentioned monograph related to the brown soils (habilitation dissertation) - crucial in recognizing some of the chemical properties of soils depending on the different bio-climatic conditions, as well as the co-authored monograph entitled “Soils of the North-Western Part of the Wedel Jarlsberg Land on the Background of the Natural Environment of Spitsbergen”, which is the first (relatively comprehensive) work on the soils of the Spitsbergen peryglacial zone in the region of the southern bank of Bellsund.

Professor Melke perfected his scientific skills through numerous specialized courses and research scholarships, including a stay at the Faculty of Soil Science of the Agricultural University in Prague (Czech Republic).

Professor Jerzy Melke was a valued and well-liked academic teacher. His lectures always generated great interest. He was a co-author of a soil science textbook “Studying Soils in the Laboratory and in the Field”. Professor Jerzy Melke was the promoter of 2 doctoral dissertations. Under his supervision, 46 students (mainly those majoring in environmental protection and geography) completed their Masters’ theses. He actively participated in the scientific activities of Poland. He was a member of the Polish Society of Soil Science (he presided over the Committee “Soil and Human Health”), International Union of Soil Science Societies (IUSS) and the Polar Club of the Polish Geographic Society. He was also an avid stamp-collector and a “bicycle tourist”. For his accomplishments in scholarship and didactics, he was given the UMCS Rector's Award. He was also awarded the Golden Cross of Merit and the Gold Medal of Service.

Professor Jerzy Melke was a collegial and generous man, although he always expected the best performance (mainly with regard to himself). He was very responsible and always kept his word. He was very easy to work with in the field, especially in the difficult conditions in Spitsbergen. We have very fond memories of our field research studies, in which, next to our Colleague Jerzy, we also had the privilege to be accompanied by Professor Stanislaw Uziak - a man of great moral and scholarly authority. Each day, after completing our field work, we spent hours (usually late into the night) discussing a variety of topics not only of scientific nature.

To us, his colleagues at the Faculty of Soil Science and Soil Protection of the UMCS in Lublin, Professor Jerzy Melke was a man of great heart and mind and a sincere Friend - honest and direct, generous, but also critical and meritorious in scientific discourses. So will he be thought of and remembered.

Jacek Chodorowski
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Zbigniew Klimowicz

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