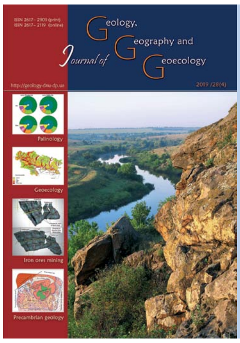

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Ecological and geological determination of the initial pedogenesis on devastated lands in the Kryvyi Rih Iron Mining & Metallurgical District (Ukraine)

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Abstract. In our time, a very urgent problem is the cessation of negative impacts on the environment and the return to the practical use of the territories of devastated lands. In this regard, it is important to find out the basic laws of primary soil formation in the area of these man-made neoplasms. The initial soil formation conditions were analyzed on 19 experimental sites which represent the main varieties of devastated land in the Kryvyi Rih Iron Mining and Metallurgical District (Central Ukraine): (i) waste rock dumps of old iron mines (old name “Forges”), (ii) tailing storage facility of underground iron mines, (iii) waste rock dumps of the Iron Ore Mining and Dressing Plant, (iv) waste rock dumps of the Granite Quarry Plant. It was established that on the devastated lands in Kryvyi Rih District, the initial soil formation occurs in very difficult conditions. Therefore, over 25-100 years only very primitive soils were formed. The following features are inherent to them: (1) primitive soil profile (thickness 10-100 mm), (2) low levels of soil organic substance content (9.5-11.5 %), (3) alkaline indicators of the soil solution (pH_{H2O} – 8.08-8.92, pH_{KCl} – 7.42-8.23), (4) low levels of cation exchange capacity (6.34-8.47 mMol /100 g). By results of correlation calculations, among the factors of soil formation time (duration of soil formation) and input of plant ash elements’ fall are characterized by the maximum number of statistically significant correlation coefficients and their numerical values. In terms of chemical composition of the technosol, the values of organic matter content and exchangeable acidity (pH_{KCl}) were the most predictable soil formation factors. Generally physical / chemical characteristics of geological rocks (as parent material) and time were the two most important factors in determining the initial pedogenesis on devastated lands in the Kryvyi Rih Iron Mining & Metallurgical District (Ukraine).

Keywords: devastated land, initial pedogenesis, technosol, embryozems, Kryvyi Rih Basin

Екологічна та геологічна зумовленість ініціального педогенезу на девастованих землях Криворізького гірничо-металургійного регіону (Україна)

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Анотація. Дуже актуальною проблемою сьогодення залишається припинення негативних впливів на довкілля людини та повернення у практичне використання територій девастованих земель. У зв’язку з цим важливим є з’ясування провідних закономірностей первинного ґрунтоутворення на теренах цих техногенних новоутворень. Умови початкового ґрунтоутворення було проаналізовано на 19 дослідних ділянках, які репрезентують основні різновиди девастованих земель Криворізького гірничо-металургійного району (Дніпропетровська область, Центральна Україна): (i) породні відвали старих залізних копалень (старі назви «кавалери»), (ii) хвостосховища залізорудних шахт, (iii) породні відвали залізорудного гірничо-збагачувального комбінату, (iv) породні відвали гранітного кар’єру. Встановлено, що на девастованих землях Криворізького гірничо-металургійного району початкове ґрунтоутворення відбувається в дуже складних умовах. Тому за 25-100 років утворилися лише дуже примітивні ґрунти. Для них притаманно: (1) малопотужний ґрунтовий профіль (товщина 10-100 мм), (2) низький вміст органічної речовини ґрунту (9,5-11,5%), (3) лужні показники ґрунтового розчину (pH_{H2O} – 8,08-8,92, pH_{KCl} – 7,42-8,23), (4) низькі рівні ємності катіонного обміну (6,34-8,47 ммоль / 100 г). Ці молоді ґрунти девастованих земель Криворізького гірничо-металургійного району можна класифікувати як Сполік Техносол (за даними Всесвітньої референтної бази для ґрунтових ресурсів) або Ембріоземи (згідно з українською системою класифікації). Серед факторів формування ґрунту час (тривалість формування ґрунту) та надходження зольних елементів рослин характеризується максимальною кількістю статистично значущих коефіцієнтів кореляції та їх числовими значеннями. Результати кореляційних розрахунків довели, що серед показників хімічного складу Техносолу значення вмісту органічної речовини та обмінної кислотності (pH_{KCl}) були найбільш передбачуваними. Загалом, фізико-хімічні характеристики геологічних порід (як материнського матеріалу для ґрунтоутворення) та час були двома найважливішими чинниками, що детермінують початковий педогенез на девастованих Криворізького гірничо-металургійного району.

Ключові слова: девастовані землі, ініціальний педогенез, пехносол, ембріозем, Криворіжжя

Introduction. Devastated lands are a widespread phenomenon in all industrial regions of the world, Europe and Ukraine. Their area reaches impressive values. In particular, in Ukraine the area of devastated lands is hundreds of thousands of hectares, in the Dnipro industrial region it is more than 50 thousand hectares, in the Kryvyi Rih Iron Mining & Metallurgical District (Kryvorizhya) more than 20 thousand hectares (Antrop, 2006; Cortina-Segarra et al, 2016; Malahov, 2003).

Devastated land negatively affects the quality of human life. They are a source of additional pollution of atmospheric air, groundwater and soils. In addition, they negatively affect the microclimate and the aesthetics of industrial regions (Aronson & Alexander, 2013; Hlava et al, 2015; Malahov, 2009).

However, in our country virtually no large-scale and complete restoration of the devastated lands in accordance with the current legislation and the available scientific achievements has been carried out. The main reason for this is the lack of funds and non-compliance by industry with current legislation (Berger et al, 2011; Demidov et al, 2013 Kumar, 2013; Mazur et al, 2015; Savosko, 2011a).

As a result of this situation, the land devastated has been left entirely neglected. On their territories there are spontaneous processes of self-healing of the vegetative cover and the processes of initial soil formation (initial pedogenesis) proceed gradually. An important component of such vegetation is trees and shrubs, which have a positive effect on the state of the environment in industrial regions (Lykholat et al, 2016a; Lykholat et al, 2016b; Savosko & Tovstolyak, 2017; Savosko et al, 2018; Tereschenko, 1992). However, the processes of self-healing of the film of life on devastated lands are exceedingly slow sometimes taking hundreds of years. Therefore, it is very important to identify the patterns of initial soil formation and to find out the leading factors of this process (Resulović & Čustović, 2007; Savosko, 2011a; Savosko et al, 2010; Savosko, 2011b).

On the devastated lands of the Kryvyi Rih Iron Mining & Metallurgical District the elucidation of the laws of ecological and geological processes of initial pedogenesis has fundamental scientific and practical significance. The consideration of this problem was chosen for the purpose of our work.

Materials and methods. The materials of our research were the results of the surveys conducted by us during 2006-2018 on the devastated lands in the Kryvyi Rih Iron Mining & Metallurgical District (Figure 1).

The objects of research were the primitive soils from the devastated lands, which appeared on Kryvyi Rih during the twentieth century: 1) waste rock dumps of old iron mines (old name “Forges”), 2) tailing storage facility of underground iron mines, 3) waste rock dumps of the Iron Ore Mining and Dressing Plant, 4) waste rock dumps of the Granite Quarry Plant.

Methods of research - classical field and laboratory research by soil science, agrochemistry and biogeochemistry (DSTU-ISO 10381-8:2006; DSTU-ISO 10390:2001; DSTU-ISO 10694-2001; DSTU-ISO 11664:2006; DSTU-ISO 11260:2001; DSTU-ISO 11664:2006).

The obtained results of researches were processed by classical mathematical statistical methods at the level of significance $P < 0,05$ (Lakin, 1990; MCdonald, 2014).

Results and discussion. *The pedogenetic features on devastated lands*. In natural conditions, soils, soil properties and soil formation are strongly affected by: 1) parent material, 2) vegetation, 3) climate, 4) topography, 4) man and 5) time (Jenny, 1994; Breemen, & Buurman, 2003). *Therefore, to understand* the *pedogenetic features on* the devastated lands, at first it is necessary to analyze the actions of soil formation factors under these conditions.

Parent material. I*nitial soil formation on* devastated lands in the Kryvyi Rih area *occurs* on different rocks. According to the estimation technique, rocks on the devastated lands are organized into three groups: 1) highly favourable to i*nitial soil formation, 2) moderately favourable* to i*nitial soil formation, 3) minimally favourable* to i*nitial soil formation.* The rocks which are highly favourable to initial soil formation are represented mainly by loess and loess-like loams, as well as by loams and sandy loams from the sedimentary cover. The rocks that are moderately *favourable* to i*nitial soil formation* are represented by medium clay, heavy clay from the sedimentary cover, as well as finely fractional (less than 10 mm) rocky deposits of different genesis. The rocks which are most favourable to initial soil formation are following: large-fragment rocky rocks (over 10 mm), phytotoxic rocks by various genesis, as well as waste from the mining and metallurgical industry. It is important to note that on the devastated lands in

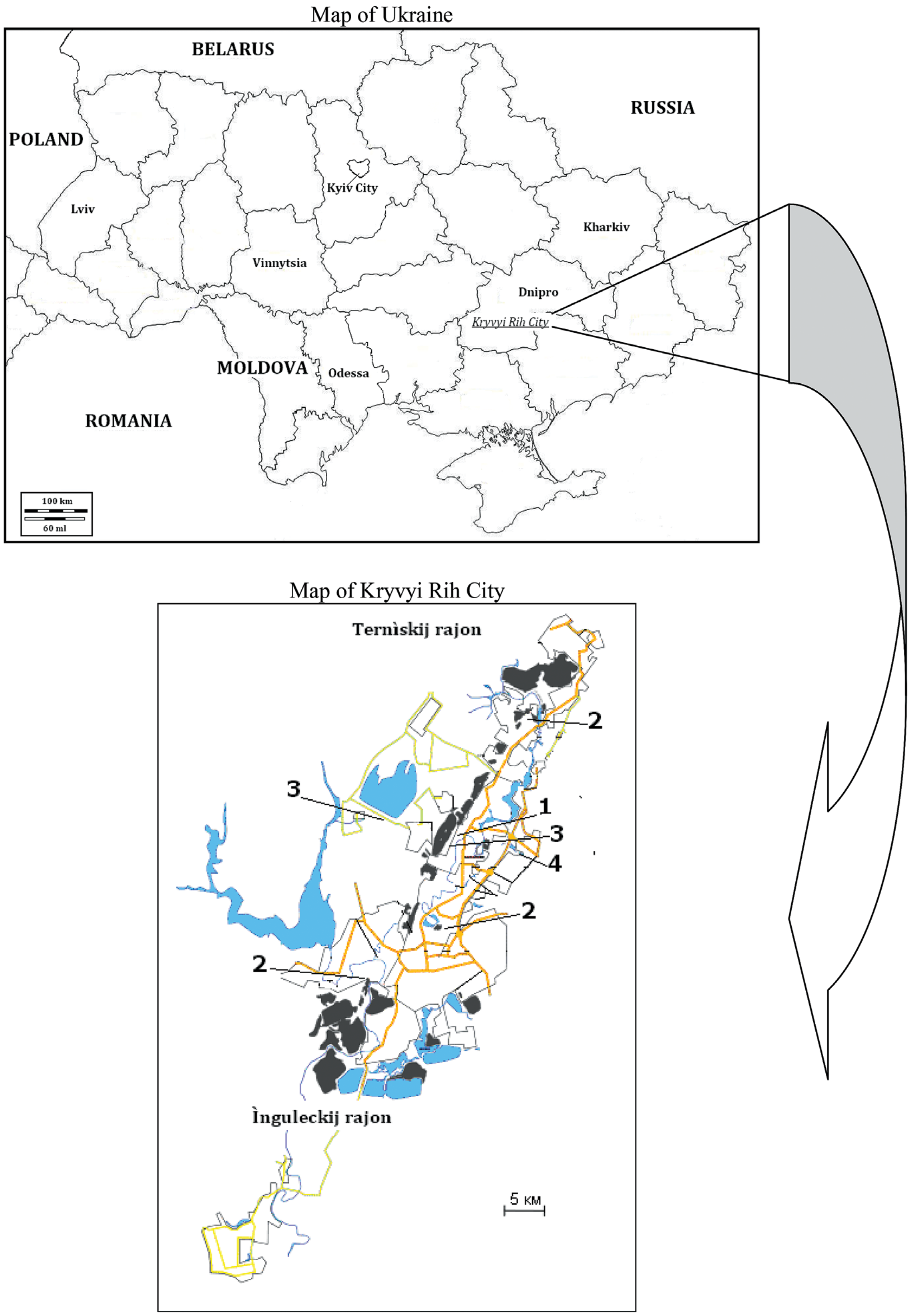

Fig. 1. Location of study areas
1 – waste rock dumps of old iron mines (old name "Forges"), 2 – tailing storage facility of underground iron mines, 3 – waste rock dumps of the Iron Ore Mining and Dressing Plant, 4 – waste rock dumps of the Granite Quarry Plant

the Kryvyi Rih area, there are various variants of rock prevalence (Manyuk, 2016; Savosko et al, 2018; Shvaiko & Manyuk, 2017). Thus, in some cases, an extraordinary mosaic and chaotic pattern of soil-forming rocks is observed (e.g. dumps, dams and different embankments).

However, on other devastated lands, even and uniform parent material are widespread (e.g. tailings and sludge storage). It was *established that on devastated lands in the* Kryvyi Rih Iron Mining & Metallurgical District t*he initial pedogenesis is carried out on the following* parent material (Table 1):

1) iron quartzite (various geological composition and granulometric size), 2) loess loam (non-carbonate and carbonate), 3) shist (usually a large particle size – more than 100 mm).In general, the parent materials on the devastated lands in the Kryvyi Rih area form different conditions for i*nitial soil formation. L*oess and loess-like loams, as well as loams and sandy loams from the sedimentary cover, are highly favourable to initial soil formation.

Vegetation. On the devastated lands in the Kryvyi Rih area, there are three main vegetation types. These vegetation types determine the main three soil formation strategies: petrophilic, woody and grassy plant community. The main vegetation features as a factor of i*nitial soil formation* can be mentioned as follows: 1) grasses are dominant *in the plant community*, 2) *vegetative communities have a syngenetic character*, 3) type of vegetation determined by rocks. We have found that (Table 1) input of plant litter fall on these devastated lands varied from 100 g*m^{-2}*year^{-1} to 600 g*m^{-2}*year^{-1} (average values: 170-270 g*m^{-2}*year^{-1}). These values are 3-5 times less in comparison with the steppe ecosystem values. Also we established (Table 1) that input of fall of plant ash elements on these devastated lands varied from 7.50 g*m^{-2}*year^{-1} to 22.10 g*m^{-2}*year^{-1} (average values: 12-17 g*m^{-2}*year^{-1}).In general, the vegetation on the devastated lands in the Kryvyi Rih area form do not very strong or favourable conditions for i*nitial soil formation.*

Table 1. Factors of soil formation on devastated lands in Kryvyi Rih Iron Mining & Metallurgical District

Devastated lands	Parent material	Characteristics of herbaceous vegetation: Input of plant litter fall, g*m^{-2}*year^{-1}	Characteristics of herbaceous vegetation: Input of plant ash elements fall, g*m^{-2}*year^{-1}	Topography	Time, years
Waste rock dumps of old iron mines (old name "Forges")	Hydrohematite iron quartzite – 90 % Loess loam – 10 %	250	14.2	Dump plateau	90-100
Tailing storage facility of underground iron mines	Hydrohematite iron quartzite	100	7.50	Tailings beach	50-55
		230	17.1	Tailings beach	50-55
	Martite & hematite-martite iron quartzite	100	8.95	Tailings beach	30-35
		150	12.8	Tailings beach	30-35
		120	10.7	Tailings beach	30-35
		140	12.1	Tailings beach	25-30
	Loess loam	160	10.4	Tailings beach	25-30
	Martite & hydrohematite iron quartzite	200	13.1	Tailings beach	40-45
		180	12.9	Tailings beach	40-45
		140	8.12	Tailings beach	40-45
Waste rock dumps of Iron Ore Mining and Dressing Plant	Loess loam	240	21.6	Foot of dump	55-60
	Poor magnetite iron quartzite 50% Loess loam 50 %	330	16.4	Dump berm	55-60
	Shist 40-45%, Poor magnetite iron quartzite 20-30%, Loess loam 20-25%	380	21.3	Dump berm	40-45
	Shist 45-50%, Poor magnetite iron quartzite 20-30%, Loess loam 15-20%	270	14.4	Dump berm	30-35
	Poor magnetite iron quartzite 60-70%, Shist 10-20%, Loess loam 5-10%	110	9.11	Dump plateau	25-20
Waste rock dumps of Granite Quarry Plant	Loess loam	420	22.1	Dump plateau	40-50
	Carbonate loess loam	380	18.8	Dump plateau	40-50

Climate. The Kryvyi Rih area is located in the semi-arid climate zone, called the northern steppe. The average annual precipitation is 450 mm, concentrated between April and October. Average temperatures vary between -6°C in January and 21°C in July. But on devastated lands of this region a special microclimate was formed. This microclimate naturally has an impact on initial soil formation. In most cases, this effect has a negative effect on soil formation: since there is an elevated temperature of the devastated land surface, which in turn drains the atmospheric air very much. But there is another opinion, as shown by studies by V.K. Tereshchenko (Tereshchenko, 1992), rocky rocks can condense moisture from the atmospheric air during darkness. As a result, their humidity significantly increases, which has a very positive effect on soil formation. In general, the microclimate on the devastated lands at Kryvyi Rih area forms very severe conditions for *initial soil formation.*

Topography. The *unique mesorelief* forms are an important feature of the devastated lands in the Kryvyi Rih area. In these territories, the main forms of mesorelief are: a smooth surface and micro-depressions of the waste rock *dumps* berms, low hills (1.0-1.5 m) of the waste rock *dumps, steep slopes* of the waste rock *dumps and a* perfectly flat surface of the tailings pond beaches. It should also be noted that the exposure of the waste rock *dumps* slopes determines the redistribution of heat fluxes while micro-depressions and low hills determine the redistribution of water flows. By topography, the most favourable areas for initial soil formation are micro-depressions on berms and on the plateau of the waste rock dumps, as well as in the lower part of the slopes at waste rock dumps. It is here that the accumulation of precipitation occurs. On devastated lands of the Kryvyi Rih Iron Mining & Metallurgical District, initial soil formation was investigated by us in the following topographies: 1) the foot of the *dump, 2) dump berm, 3) dump plateau and 4) tailings beach (Table 1).*In general, the topography of the devastated lands in the Kryvyi Rih area is an important factor that limits the success of initial soil formation.

Man. We believe that the primary and secondary effects of human activity on the initial soil formation on devastated lands should be distinguished. The primary effect of humans determined the geological and topographical "framework" on devastated lands. Therefore, this human influence predetermines the basic conditions for initial soil formation on devastated lands. The secondary human effect has a positive and negative impact on the initial soil formation in these areas. The positive secondary human impact is possible by the implementation of the restoration and reclamation of these lands. The negative secondary human impact is possible with air pollution and storage of garbage in these areas.

Time. In Kryvyi Rih region, the first devastated lands began to form in 1881. Due to archival materials and scientific publications, it is possible to assume the starting time of the soil formation with an accuracy of up to 5 years. This fact is very important for basic soil science. In general, the duration of soil formation on the devastated lands is known, and the soil is very young in these areas (table 1).

Chemical composition of young soils from devastated lands. The data in Table 2 indicate that the chemical and physical properties of young soils from devastated lands in the Kryvyi Rih Iron Mining & Metallurgical District are characterized by unfavourable indicators. Thus organic matter content varied from 7.93 % to 22.10 % (on average – 9.10 %-12.88 %). These values are 2.5-3.5 times lower than in the zonal soils of chernozems. It should also be noted that the accumulation of organic matter in the soil from the tailing storage facility of underground iron mines does not occur. This fact can be explained by the geological characteristics of the parent material materials, in particular, their grain size distribution.

In the zonal soils of the Kryvyi Rih Iron Mining & Metallurgical District, soil acidity is 7.00-7.15 in ordinary chernozems and 7.25-7.55 in southern chernozems. But in soils from devastated lands these characteristics have higher values: for actual acidity – from 7.08 to 9.19 (on average – 8.18-8.81), for exchangeable acidity – – from 7.60 to 8.06 (on average – 6.74-8.59). Thus, initial pedogenesis on devastated lands is carried out in very alkaline conditions. This fact significantly slows down the humus accumulation in the soil profile .

As is known, cation-exchange capacity (CEC) is a measure of how cations can be retained on soil particle surfaces. CEC is defined as the amount of positive charge that can be exchanged per mass of soil, usually measured in mMol /100 g soil. In the zonal soils of the Kryvyi Rih Basin, CEC can obtain 35-40 mMol /100 g in ordinary chernozems and 30-35 mMol /100 g in southern chernozems. But in soils from devastated lands this characteristics is 2-20 times less, it varied from 2.01 mMol /100 g to 25.12 mMol /100 g (on average – 5.62 – 10.18 mMol /100 g). It is important to note that in natural soils 75–80% of CEC is calcium and, 15–25% is magnesium. As the results of our research show, in the young soils the share of calcium varied from 35.77 % to 89.03 % (on average – 56.16-71.81%) and the magnesium portion varied from 10.97 % to 64.23 % (on average – 28.19-43.84%). In some soils, the amount of magnesium was greater in comparison with calcium.

Soil classification of the devastated land. Soil classification is a very important and very difficult task at the same time (Charzynski et al, 2013; Sere et al, 2010; Sobocka, 2008). At present, the introduction of the ideas and philosophy of World Reference Base for soil resources (WRB) in the classification of world soils is taking place. According to WRB, the soils on devastated lands in the Kryvyi Rih Iron Mining & Metallurgical District can be classified as "Technosols" (WRB, 2015).

When specified, these soils are termed: 1) spolic technosol (ochric) on the waste rock dumps of the old iron mines (old name "Forges"), 2) spolic technosol (phytotoxic, arenic, aridic, magnesic) on the tailing storage facility of underground iron mines, 3) spolic technosol (humic, loamic, calcaric), spolic technosol (ochric, loamic) and spolic technosol (arenic, aridic, magnesic) on waste rock dumps of the Iron Ore Mining and Dressing Plant, 4) spolic technosol (ochric, loamic, dolomitic, calcaric) on waste rock dumps of the Granite Quarry.

In our opinion, the concept of embryozem and its groups is the most acceptable among the classification systems common in Ukraine for young soils on devastated lands. The word "embryozem" is formed by analogy with the word "chernozems" and means "young soil" (from Greek "ἔμβρυον, fetus or germ and from Ukrainian "zem", earth or soil).

In our opinion (Savosko, 2010; *Savosko, 2011a*), there are four groups of embryozems on devastated lands in the Kryvyi Rih Iron Mining & Metallurgical District: Initial embryozems, organic-accumulative embryozems, turf embryozems and humus-accumulative embryozems. It should be noted that the basis of this differentiation is the intensity and quality of humus formation. This is naturally reflected in the structure of the soil profile. We believe that these young soils have the following distribution: 1) turf embryozems on the waste rock dumps of old iron mines (old name "Forges"), 2) initial embryozems on the tailing storage facility of underground iron mines, 3) initial embryozems, organic-accumulative embryozems and humus-accumulative embryozems on the waste rock dumps of the Iron Ore Mining and Dressing Plant, 4) turf embryozems on the waste rock dumps of the Granite Quarry.

Determination of initial pedogenesis on the devastated lands. An analysis of the mathematical calculations results showed that between factors of soil formation and chemical composition of the technosol from devastated lands in the Kryvyi Rih

Table 2. Chemical composition of the technosol from devastated lands at Kryvyi Rih Iron Mining & Metallurgical District (M±m)

Devastated lands	Organic matter content, %	pH		Cation-exchange capacity		
		pH_{H2O}	pH_{KCl}	Total, mMol /100 g	Ca, % from total	Mg, % from total
Waste rock dumps of old Iron Mines (old name "Forges")	9.97 ± 1.05	7.58±0.01	6.74±0.02	6.62±0.26	59.67	40.33
Tailing storage facility of Underground Iron Mines	-	8.81±0.02	8.10±0.01	7.80±0.35	85.88	14.12
	-	8.79±0.01	8.09±0.02	7.93±0.32	89.03	10.97
	-	8.92±0.01	7.92±0.01	8.47±0.38	88.55	11.45
	-	9.01±0.01	8.23±0.02	7.00±0.31	83,86	16.14
	-	9.14±0.02	8.23±0.01	6.34±0.21	73.66	26.34
	-	9.19±0.01	8.59±0.02	6.00±0.19	62.17	37.83
	-	8.90±0.01	8.38±0.01	6.74±0.25	60.39	39.61
	-	7.72±0.01	8.06±0,02	2.60±0.13	35.77	64.23
	-	7.51±0.02	7.64±0.01	2.06±0.11	54.85	45.15
	-	8.82±0.01	8.34±0.02	4.14±0.19	45.17	54.83
Waste rock dumps of Iron Ore Mining and Dressing Plant	16.20±0.89	8.83±0.01	7.88±0.01	25.12±1.25	52.75	47.25
	11.16±0.86	8.51±0.02	7.35±0.02	6.66±0.20	68.32	31.68
	12.85±1.02	8.08±0.01	7.22±0.04	9.57±0.38	56.53	43.47
	9.53±0.78	7.66±0.02	7.49±0.01	9.14±0.39	53.06	46.94
	8.75±0.99	8.57±0.01	7.79±0.01	11.56±0.42	49.05	50.95
	7.93±1.11	8.45±0.01	7.99±0.01	7.72±0.23	43.91	56.09
Waste rock dumps of Granite Quarry Plant	11.44±1.14	8.72±0.02	7.42±0.02	7.42±0.27	73.58	26.42
	11.09±1.19	9.18±0.02	7.35±0.02	7.30±0.25	79.45	20.55

M – arithmetic mean (average), m – mean absolute error, «–» – organic matter is absent in the roots soil layer (0-20 cm)

Iron Mining & Metallurgical District statistically significant correlation dependence was established (Table 3). Thus 8 coefficients (from 18 theoretically possible) were statistically significant (P<0.05). Among these coefficients, 4 (50 %) were greater than 0 (r>0) and indicated a positive relationship between two phenomena (values of two variables changing with same direction). While the other 4 (50 %) coefficients were less than 0 (r<0) and indicated a negative relationship between two phenomena (the values of variables change with opposite direction).

Table 3. Pearson Correlation between factors of soil formation and chemical composition of the technosol on devastated lands of the Kryvyi Rih Iron Mining & Metallurgical District

Chemical composition of the technosol		Factors of soil formation		
		Time, years	Characteristics of herbaceous vegetation	
			Input of plant litter fall	Input of plant ash elements fall
			$g*m^{-2}*year^{-1}$	
Organic matter content, %		0.461*	0.643**	0.662**
pH	pH_{H2O}	-0.382*	-0.112	-0.089
	pH_{KCl}	-0.719***	-0.568**	-0.474*
Cation-exchange capacity	Total, mMol /100 g	0.173	0.161	0.453*
	Ca, % from total	0.061	0.001	0.018
	Mg, % from total	-0.061	0.001	-0.019

* – level of statistical significance P<0.05; ** – level of statistical significance P<0.01;

*** – level of statistical significance P<0.001

The numerical values of correlation coefficients analysis established the following patterns for degree of correlation: 4 correlation coefficients indicate a weak degree of relationship between phenomena (0.3<│r│<0.5); 3 correlation coefficients indicate a moderate degree of relationship between phenomena (0.5<│r│<0.7); 1 correlation coefficients indicate a strong degree of relationship between phenomena (│r│>0.7). Among factors of soil formation time (duration of soil formation) and input of plant ash elements fall are characterized by the maximum number of statistically significant correlation coefficients and their numerical values. While another factor of soil formation (input of plant litter fall) is characterized by lower numerical values and approximately the same number of statistically significant correlation coefficients and their numerical values. Among chemical composition of the technosol, the values of organic matter content and exchangeable acidity (pH_{KCl}) were the most predictable by chemical composition of the technosol.

Conclusions. In the devastated lands at Kryvyi Rih Iron Mining & Metallurgical District (Ukraine), the initial soil formation occurs under very severe and difficult conditions. Parent material is very unfavourable for the vegetation's development. Therefore, the vegetation cover is fragmentary and is characterized by very insignificant values of plant litter fall and of input of plant ash elements fall. During 25-100 years only very primitive soils were formed. For these soils the following features are characteristic: (1) unformed soil profile (only thickness 10-100 mm), (2) low levels of organic substance content, (3) alkaline indicators of the soil solution, (4) low levels of cation exchange capacity. According to the World Reference Base for Soil Resources (WRB, 2015), young soils in the devastated lands can be classified as spolic technosol with different supplementary qualifiers such as arenic, aridic, calcaric, dolomitic, humic, loamic, magnesic, ochric, phytotoxic. However, according to the Ukrainian young soils' classification system, these soils can be classified as embryozems which are represented by: (1) initial embryozems, (2) turf embryozems, (3) organic-accumulative embryozems, (4) humus-accumulative embryozems. Among factors of soil formation , time and input of plant ash elements' fall are characterized by the maximum number of statistically significant correlation coefficients and their numerical values. In chemical composition, the values of organic matter content and exchangeable acidity (pH_{KCl}) were the most predictable soil formation factors.

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