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THE PRIMARY PROCESSES OF SOIL FORMATION IN TECHNOGENICALLY DISTURBED TERRAINS OF KOKZHON PHOSPHORITE DEPOSIT

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ПЕРВИЧНЫЕ ПРОЦЕССЫ ПОЧВООБРАЗОВАНИЯ В ТЕХНОГЕННО – НАРУШЕННЫХ ЛАНДШАФТАХ ФОСФОРИТОВОГО МЕСТОРОЖДЕНИЯ КОКДЖОН

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КӨКЖОН ФОСФОРИТ КЕН ОРЫНДАРЫНЫҢ ТЕХНОГЕНДІ БҮЛІНГЕН ЛАНДШАФТАРЫНДАҒЫ АЛҒАШҚЫ ТОПЫРАҚТҮЗІЛУ ҮРДІСТЕРІ

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Abstract

Research works on primary processes were conducted on soil dumps of phosphorite deposit Kokzhon. Vast areas of disturbed land, devoid of vegetation are the main area of carbon emissions, leading to increasing global changes in the biosphere. Studying of the process of soil formation on natural areas overgrown fields in Kokzhon dumps showed that the bulk of the territory of the dump is occupied by initial embryosoils. So, on the deposit dumps restoration of vegetation and soil surface stopped at the first stage. This is primarily due to the arid conditions of this area, in the second – unfavorable soil – forming properties of the substrate (high density and rocky character). Restoration of properties of initial biological soils showed that natural growth of plants on dumps is difficult and is represented by poor species composition. Micromezofauna is represented by collembola from the kind Isotoma, Onychiurus, Hypogastrura and hard ticks (Oribatea) kind Zygoribatula in small quantities and samples. On the site were found the representatives of macrofauna such as bugs – soldiers – (Hemiptera), they are found often in large clusters. Among filamentous fungi the predominant species are – Penicillius, Aspergillius. The highest quantity of bacteria, actinomycetes and filamentous fungi were observed in the layer of 0 – 5 cm, in depth (5 – 10 cm), their number decreased regularly.

Key words: initial embryosoils, dump, phosphorite deposits, soil – forming substrate, micromezofauna, bacteria, actinomycetes.

Аннотация

Исследования по изучению первичных процессов почвообразования проводились на отвалах фосфоритового месторождения Кокджон. Огромные территории нарушенных земель, лишенные растительного покрова, являются основной зоной выброса углерода в атмосферу, что приводит к увеличению глобальных изменений в биосфере. Изучение процесса почвообразования на естественно зарастающих участках отвалов месторождений Кокджон показали, что основную часть территории отвала занимают инициальные эмбриоземы. Так, на отвалах месторождения восстановление растительности и почвенного покрова остановилось на первой стадии. Это обусловлено в первую очередь засушливыми условиями данной территории, во вторую очередь неблагоприятными свойствами почвообразующего субстрата (высокая плотность и каменистость). Восстановление биологических свойст инициальных почв показала, что естественное освоение отвалов растениями затрулднено и представлено бедным видовым составом. Микромезофауна представлена коллемболами из родов *Isotoma, Onychiurus, Hypogastrura* и панцирными клещами (*Oribatea*) род *Zygoribatula* в малых количествах и экземплярах. На участке из представителей мезофауны встречаются клопы – солдатики – (*Hemiptera*), они собираются часто большими скоплениями. Среди мицелиальных грибов преобладали виды – *Penicillius, Aspergillius*. Наиболее высокие значения численности бактерий, актиномицетов и мицелиальных грибов отмечены в слое 0 – 5 см, с глубиной (5 – 10 см) их количество закономерно снижается.

Ключевые слова: инициальные эмбриоземы, отвал, фосфоритовое месторождение, почвообразующий субстрат, микромезофауна, бактерии, актиномицеты.

Аңдатпа

Көкжон фосфорит кен орындарының техногенді үйінділерінде алғашқы топырақ түзілу үрдістері бойынша зерттеу жұмыстары жүргізілді. Өсімдік жамылғысынан айырылған техногенді бүлінген жерлердің үлкен аудандары атмосфераға көміртегі шығарындыларының негізгі аймағы болып табылады. Бұл үрдістер биосферадағы жаһандық өзгерістердің өсуіне алып келдеді. Көкжон кен орындарынында табиғи жолмен өскен өсімдіктердің түрлері мен топырақтүзілу үрдісіндегі рөлін зерттеу барысында үйінді аумағының негізгі бөлігінде бастапқы эмбриоземдардың өсіп жатқаны байқалады. Кен орындарының үйінділерінде өсімдік жамылғысының қалпына келуі табиғи жолмен қалыптасуда және топырақ түзілу үрдістері алғашқы кезеңде. Бұл біріншіден облыстың құрғақ климаттық жағдайына, екіншіден, топырақ қалыптастыратын субстраттардың (жоғары тығыздығы мен тастығы) қолайсыз қасиеттеріне байланысты. Үйіндідегі бастапқы топырақтүзілу кезеңіндегі топырақтың биологиялық белсенділігі өте төмен деңгейде, сондай – ақ үйінділерді өсімдіктердің табиғи жолмен қалпына келуі арқылы игеру үлкен қиндықтар тудырады. Алынған үлгілерде микромезофауналар аз мөлшерде кездеседі. Олар, Isotoma, Onychiurus, Hypogastrura және сауытты кенелер (Oribatea). Мезофаунаның өкілдерінің туысынан *Hemiptera* анықталынды. Олар жиі және ірі кластерлерде жиналады. Мицилиальдық саңырауқұлақтар арасында – Penicillius, Aspergillius түрлері басым болды. Бактерия, актиномицет және жіп тәрізді саңырауқұлақтар санының ең үлкен мәндері 0 – 5 см терендікте (5 – 10 см) кездеседі, олардың саны табиғи түрде төменгі қабаттарға қарай азайғаны байқалады.

Түйінді сөздер: Бастапқы эмбриоземдер, үйінді, фосфорит кен орны, топырақ құраушы субстраттар, микромезофауна, бактериялар, актиномицеттер.

Introduction

Ever since the Industrial Revolution beginning in the mid – 18th century, the global socio – economic development has depended heavily on mining industry for provision of mineral resources. Mining activities impose various degrees of impacts on ecosystems and landscape connectivity through land clearance and transport, and by generating a vast amount of mine wastes on top of existing vegetation. This is causing a series of environmental and ecological consequences and health problems [1 – 2].

Various smelting activities are of major concern for metallic pollution in former industrial regions. Metal smelting technology, especially the primitive variety used in the past, has resulted in large quantities of wastes which were deposited in post – industrial areas as dumps. Because matter from such dumps consists primarily of artificial slag, these wastes are the most dangerous and toxic for local environments [3 – 4]. This is a large and still unresolved environmental problem in many industrial regions in the world, especially in countries with developing industry [5]. Such severe habitat conditions could lead to the emergence of ecosystems that function under stress conditions with new competitive systems between pioneer organisms that generate a specific species composition [6].

The study of soil formation processes in technogenesis is a theoretical basis for reclamation of disturbed lands and return them to the secondary use of the national establishment (economy), as well as the overall restoration of disturbed landscapes. Consequently, the study aimed at studying the processes of soil formation – (1) natural vegetation species, (2) young soils chemical, physical properties, (3) soil biological properties of the technogenesis are relevant in the Kokdzhon phosphate mining of the Zhambyl region (a semi – desert mining area of Kazakhstan).

Study area

A characteristic feature of dumps in "Kokdzhon" deposit is their multi – level feature. Upper part of the site is mainly sloping or has a slight sloping, the middle part has a slope or shelf with angle of $3 – 4^0$, the lower part has a slope of 7 ° [7].

«Kokzhon» – is phosphorite deposit of sedimentary origin belonging to the Proterozoic age, lower Paleozoic, and Quaternary system. The productive horizon is structured by carbonate phosphorite. The entire thickness of the bedrock is covered by Quaternary sediments, the Lower Paleozoic rocks are deformed into folds of northwestern stretch. Incidence of rocks north – east at an angle of 26 – 60°, the angle of incidence is reduced in a northwesterly direction. Start of development of the field «Kokzhon» – is 1991. Rock dump 5 of site «Kistas unit 1» is operating, but on the remaining dumps the works are temporarily suspended at various times from 1992 – 1997. Method of development is open. The length of the unit 1 – 3.5 km; Unit 2 – 2.3 km. Rock 5 – area of 45 hectares, rock dump 3 – area of 27 ha, rock dump 6a – area of 22 hectares, rock dump 6 – area of 16 hectares. Total area covered by dumps is 110 hectares. Minerals – dolomites, dolomite limestone, phosphate – siliceous shale, silicon. Non – metallic minerals – dolomite, chalcedony, quartz, feldspar, calcite [8 – 9].

The severity of environmental problems is largely attributed to the fact that so far in the production sphere, the processes of natural resource management have not been an independent element in control system. Sometimes production tasks were addressed without taking into account its impact on the environment, which resulted in some imbalance in nature. The studies were conducted on the dump 2 of unit 1 in «Kokdzhon» field. By the degree of overgrowth and terrain, at each outlined dump site, sections were allocated for study of the initial soil formation processes .

Soils and soil – forming rocks

The territory of the region has a diverse soil surface. Takyr soil and takyrs are common in the lower reaches of the Chu and Talas rivers, as well as in desert depressions. Deserts are characterized by gray – brown soils, loose sand and sand gray soils, the foothills – by gray soils. Terrain diversity and climatic features of the territory determine the species composition and distribution of flora and fauna. The soils in the north and northeast of deposit – are gray – chestnut and gray – xeromorphic, gray – chestnut underdeveloped on crash stone eluvium and eluvial – deluvial solid rock. In the east – northern xeromorphic ordinary gray soils. The soils on the south side – are mountain gray soils ordinary. According to the particle size distribution these soils are medium loamy.

The southern part of Karatau foothill plain is composed of rocks of carboniferous age composed mainly by conglomerates, lime – gypsum – bearing rocks underlain by red arkose sandstones and limestones with interbedded shale and sandstones. These rocks are covered with a low capacity layer of 0.5 – 1 m eluvial – deluvial, loamy crashed stone quaternary structures.

The eastern part of the plain is formed by alluvial – proluvial and deluvial deposits and loess loam. The base of the thick is gravel, which goes up to the surface in modern cones of mountain rivers. Coating formation of loess deposits increases in capacity as the distance from the mountains.

Materials and Methods

At different aged naturally overgrown areas the researches were conducted on soil formation processes, their speed and direction. Different aged waste sites are distinguished by natural overgrowing phytocenoses. Researches on soil formation processes include expedition – field method, experimental and laboratory analyzes, as well as comparison method.

Capacity of «young soils» is characterized by their «dwarfism» in comparison with the full – profile soils, soil ground samples were selected on soil horizons, sampling for determining physical, mechanical, and chemical properties of soil.

In selected samples by outlined and described genetic horizons the following was determined:

Most of soil analyses were carried out following Russian Handbook on Chemical Analysis of Soils [10]. Soil particle distribution was analyzed according to Kachinsky [11]; total carbonates was determined by gas – volumetric method [12]; total potassium was determined according to Michigan [13] ; soil moisture and soil density was determined using the methods [14]. Soil samples to test microfauna were taken by Gilyarov M.S. standard procedure [15]. As for the layers 0 – 5 cm and 5 – 10 cm. At each site 2 or 4 soil samples (2 – 4 repeats) have been taken. Extraction of representatives of microfauna was done in field conditions in Tulgren termoeklektor. Determination of microarthropoda was carried out according to USSR determination of Fauna (springtails – Collembola) and determinants mites inhabiting in soil (SancoptiformesTrombidiformes). Taxonomic groups were identified before birth. The number of animals is given per 1 m^2.

Microorganisms were determined on nutrient media: Meat – peptone agar 2 %; Starch – ammonia agar (2 %); Czapek medium for fungi (2 % agar) [16].

Results and Discussion

Soil – geobotanical research of dumps territories. The conducted research showed a significant diversity of plant species in the disturbed areas. Projective cover of dumps in 25 years did not exceed 5 %, soil formation processes are undeveloped, therefore dominate physical weathering processes that occur through destruction of coarse material. Fine particles formed in the process of destruction of rocks, mainly sand fraction, cannot stay on the dump surface, as in this territory windy weather is frequent. From tops of dumps small particles are easily blown away to the surrounding landscapes. Therefore, there is no accumulation of fine earth on mainland dumps. Sparse vegetation, poor species composition of plant communities and specifics of dumps had a direct impact on natural inhabitance and development of disturbed terrains. Thus, according to herbarium material plants from natural overgrown dump sites were identified (Table 1). The definition of plants showed poor phytocenoses composition inhabiting dumps from surrounding undisturbed terrains. Plants are represented by 10 kinds with small quantity of species. This has reflected in plant bio – productivity in overgrown dump sites.

Table 1 Plants from Kokdzhon dump (natural growth)

Pland species	***Families***	**(*Latin name*)**
Rabbit Barley	*Cereals Poaceae*	*Hordeumleporinum* Link.
Fire silky		*Bromussericeus* Drob.
Fire roofing.		*Bromus tectorum* L
Feather grass Gogenakker		*Stipa hohenacheriana* Trin. et Rupr.
Coniferous medium	Coniferous– *Ephedraceae*	*Families Ephedra intermedia* Schrenk
Kurchavka princky	*Families Buckwheat PolygonaceaeJuss*	*Atraphaxispungens* (M. B.) Jaub. et Spach.
Cow Turkestani	Burrow– *Scrophulariaceae*	*Verbascumturkestanicum* Franch.
Toadflax		*Linariapopovii* Kuprian.
Clove prickle leaf	*Clove*–Caryophyllaceae	*Dianthus acicularis*Fisch. exLedeb.
Smolevka bushy		*Silenefruticulosa* (Pall.) Schischk
Hondrilla shortnose	Aster Asteraceae	*Chondrillabrevirostris*Fisch. exMey.
Kozlets downward		*Scorzonerapubescens* DC.
Sagebrush Semirechie		*Artemisia heptapotamica*Poljak.
Heteroderis white head		*Heteroderisleucocephala* (Bunge) Leonova
Cat Ukraine	*Labiatae*	*Nepetaucrainica* L.
Heterokariy hard	*Boraginaceae*	*Heterocaryumrigidum* DC.
Woofruff bristly	*Rubiaceae*	*Asperulasetosa*Jaub. Spach
Schrenkia wrapped	*– Apiaceae*	*Schrenkiainvolucrata*Regel. etSchmalh
Fenugreek primrose	*Fabaceae*	*Trigonellageminiflora* Bunge
Oxytrope Kapu		*Oxytropis capusii*Franch.
Astragal Semenov		*Astragalus*semenovii Bunge
Sainfoin Khorassansky		Onobrychischorassanica Bunge

The bioproductivity of the surface biomass of herbaceous plants was accounted by method of mowing fields (1x1 m2) in a 4 – fold repetition. The root system was selected by monolith method (25h25sm^2) in a 4 – fold repetition followed by washing through a screen D1 mm [17]. On the dump 2, P – 2 and P 3 underground mass exceeds soil surface organs mass this ratio of soil surface and underground plant organs are more adverse are living conditions, the plants develop relatively stronger underground organs.

Determining of surface and underground phytocenoses productivity showed that main root mass of young soils is concentrated in layer in depth of 0 – 10 cm [18]. Statistical analysis revealed a significant diversity of above ground and under – ground vegetation that characterizes uneven feature of (mosaic feature) of plant cover.

By the degree of natural overgrowing of technogenically disturbed lands, the outlined sections vividly illustrate the results of biological productivity of plants involved in natural development of disturbed ecosystems and primarily reflect initial process of soil formation and role of vegetation in the development of technologically – disturbed lands.

In 2014 the researches also showed that on the surface of dump (without remediation), projected plant cover has not changed. Therefore, soil formation processes are at a very early stage of development. Only 3 % of the dump territory can be assumed that initial stage of soil formation has transferred into organic – accumulative, although process of accumulation of coarse organic matter (litter) in these conditions is difficult, due to inability to secure the litter on the dump surface, as well as sufficiently high biotic biological activity, which almost completely recycles the remaining plant remnants.

As field survey of disturbed soils showed, soil – forming processes are developed more intensively in the habitats which have conditions for fixing crop residues and fine earth. It is basically between moldboard ridges and cusps, where small amounts of fine earth and water are accumulated. In these places fine earth carried by wind are accumulated. These conditions are formed in micro – depressions and in the windy parts of the mounds on the dump surface.

Therefore, making protective embankments along the perimeter of the dump will help to reduce the intensity of wind on the dump surface, thereby creating favorable micro – climatic conditions for plant growth.

In open areas with heavy wind conditions, soil formation processes do not occur. First of all, this is due to the lack of fine earth, and secondly, with water stress (top layer dries out much), and thirdly, on such a surface it is very difficult for plant seeds to grow. Therefore, natural overgrowing of such dumps is very slow. During remediation it is necessary to create conditions enhancing regulation of wind conditions, as in such areas, along with water regime it can act as a limiting factor in plant development and consequently soil formation.

To control wind and water regime we can offer to form ridge mesorelief at mountain technical stage of remediation. Ridges should be placed across the prevailing winds. This will contribute to further accumulation of moisture, both in summer and in winter.

Soil – cartographic studies conducted by Russian scientists in technogenic terrains in Kuzbass implemented on theoretical basis of profile – genetic soil classification of technogenic terrains identified a number of important soil formation features [19 – 21]. First, soil surface of technogenic terrains of Kuzbass is represented mainly by four types of embryo – soils: initial, organic – accumulative, turf and humus – accumulative. In second, they represent a common evolution chain that allows to differentiate soil formation into four stages, of which each stage is syngenetic to biocenosis succession phase. Third, soil formation rate in certain technogenic habitat, depending on rock quality and location in surface topography can be evaluated by the type of embryosoil, which has formed for a certain period of time. On the territory of Russian Siberia natural and climatic conditions are favorable for plant growth on dumps. Abundant rainfall, rich trees and vegetation cover around the damaged terrains contribute to the inoculation of disturbed areas and therefore soil formation processes are more intensive. In the context of Kazakhstani desert and semi – desert soil formation processes take place in conditions of insufficient moisture, scarce vegetation, but abundant soil fauna populations. Living organisms in desert hide in soil and find conditions for life. For example, a number of insects, their holes and larva were found in mountainous zonal gray soils section. Generally gray soils are biogenic (Figure 3).

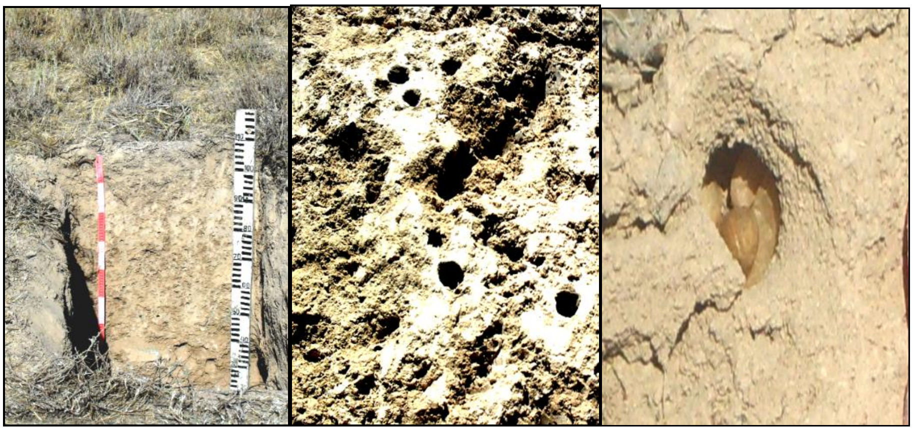

Figure 1 Section 1, zonal mountainous gray soil

The technogenically disturbed terrains have more stringent conditions than in the desert or semi – desert. Thus, in the dumps built of loam rocks which are coarsely fragmented and mixed with rocky gravel, located at different heights, blown by strong winds, devoid of vegetation, with insufficient rainfall, soil formation process is slowed down and the rate of formation of zonal soils is impossible. Research has shown that in general, in conditions of technogenic dumps in phosphorite deposit Kokdzhon, soil formation the process is at the initial (embrio – soil) stage [22]. Morphogenetic description of «young soils» vividly illustrates the soil formation rate (Table 2). These are miniature profile and indistinct color horizons and their shortening and scarcity of spread of plant root systems, rocky, dry and dense profile (Figure 2 a, b, c, d).

In the peripheral part of the dump the planning was not carried out. Relief is macroporous. In the lower parts, in mezo depressions with accumulation of fine earth, organo – accumulative embryosoils are formed with mild or even complete absence of organic horizons A_0. There is no vegetation in high parts of the mounds. Here soil formation processes are at initial stage, so main area is occupied by initial embryo soils.

Table 2 Morphological description

Close to the dumps 6A on the plain we made a section 1 on zonal soil. The vegetation is mostly wormwood – cereal. The projected coverage 78 – 80 %. Ephemera have burn out. All profile boils. (43°32’45.94’’ N; 69°32’22.64’’ E).	
Depth, cm	Description
0–12	Dark gray, loose, laced with root system, mostly fine roots, dry, loose, granular and dusty, lots ofcaprolytes of earthworms, medium loamy, all laced with caprolytes of worms. Transition is expressed vividly on structure and color.
12–25	Grey with brownish color, dense, fresh, lumpy – granular – dusty, have plant roots, fewer fine roots, taproots occur. Many nests of insects, worms coprolites, fine pores, transition is expressed vividly on structure.
25–46	Gray – brown, loose, fresh, fine – lumpy – dusty, medium loam, there are roots, taproots penetrate, rare fine roots are found, a lot of insect nests, caprolits, on top of lumps there are powder lumps. Transition is expressed vividly on structure and color.

46–90	Gray – brown, fresh, nutty – lumpy – dusty, lots of tap root, root hairs are found, sometimes more compact, sometimes loose, there are insect nests white carbonate veins, plaque, fine pores. Transition differs on color and structure.
90–120	Light – gray with brownish color, plate – lumpy – nutty, fresh, fine pores, heavy loam, decomposed remains of roots, root hairs, carbonate veins found.
Section 2 was done in place where grows safflower and herbs. Safflower grows in hills. The surface is broken – stony, there are many large stones. All profile boils. (43 ° 33'.193. " N; 69 ° 32'013 " E).	
0–2	Turf layer, dry loose, rocky – broken stony – gruss, consists of fine root hairs.
2–7	Dark gray, loose, dry, compact, stony – broke stony – gruss, granular – dusty, vivid transition.
7–17	Brown, slightly compacted, scaly – dusty, dry loam, stony – broke stony – gruss. Beginning with 15 cm there are carbonate powder, lots of root hairs. Transition is clear on color and structure.
17–30	Pale yellow, with brownish tinge, dense, fresh, broke stone interlayers, gravel and stones. Permitted with fine roots and root hairs. Between broken stone, wood and stones there are loam interlayers, granular – dusty.
Section 3 is located where grows wormwood, cereals, tausagyz, ephedra. On the surface of dump grows moss. All profile boils. (43°33’.218.’’ N; 69°32’042’’ E).	
0–2	Dark, sod felt, loose, dry.
2–7	Dark gray, loose, dry, loam, silty – powdery, stony – debris – gruss, laced with root hairs, transition is clear on structure and color.
7–17	Brown, tight, fresh, stony – broke stony – grass, fine – nutty – granular – dusty, sometimes loose due to loams that fill the spaces between stones of overburden rocks, there are root hairs, transition is clear on structure and color
17–32	Brownish – gray, to the bottom there are dark spots due to the dark rocks, fresh, very heavy, rocky – broken stony – woody, there are carbonate veins, grainula, occasional root hairs.
Section 4 was done on the lower tier of section № 2. The plot is slightly overgrown. Basically there are feather grass, sagebrush. On the surface, a lot of litter of feather and sagebrush. All profile boils. (43°33’.383.’’ N; 69°31’809’’ E).	
0–3	Felt of plant residues, all permeated with roots, sod layer.
3–13	Grey with pale brown color, dry, lumpy – granular – powdery, permeated with roots, stony – debris – woody, on root hairs there are carbonates in the form of granule, veins, and mycelium. Sharp transition on structure and color.
13–27	Brownish – gray, fresh, not dense – loosely crumpled – powdery, root hairs, sometimes occur roots. Carbonate neoplasms in form of grains, powders, mycelium, fine pores, crystals of gypsum shine on the sun, transition clear on structure and color.
27–31	Pale brown, fresh, dense, composed of layers of crushed stone, gruss and stones, not dense – lumpy – granular – powdery, coarse sandy, loam mixed with gravel and gruss, on the profile there are root hairs, carbonates in form of granule, streaks and plaque.

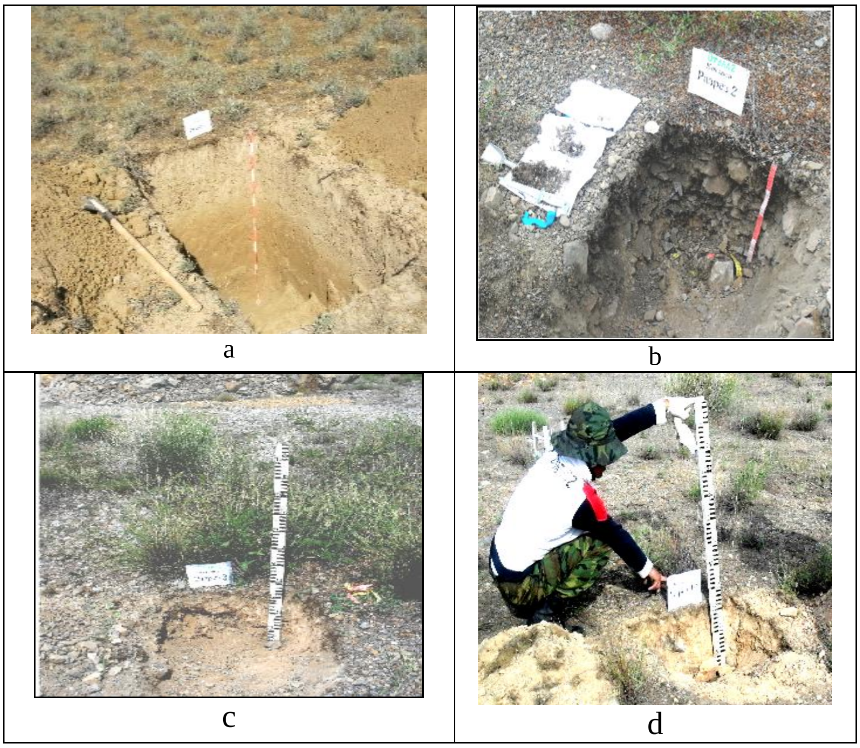

Figure 2 Soil profiles a: P – 1; b: P – 2; c: P – 3; d: P – 4

Research on moisture have shown insignificant and low content of field moisture in the top of the profile, both in zonal and «young soils» of the dump (Table 3).

Table 3 Moisture and volume weight of dumps and zonal soils

Soil profiles	The depth of the sample, cm	field moisture, %	volumetric weight, g/ cm^3
1	0–12	4,94	1,39
	12–45	7,95	1,45
	25–46	9,28	1,5
	46–90	11,2	1,51
	90–120	5,77	1,56
2	0–7	2,94	–
	7–17	6,95	–
	17–30	6,50	–
3	0–7	3,18	–
	7–17	4,87	–
	17–32	8,64	–
4	0–13	4,43	–
	13–27	9,20	–
	27–31	12,4	–

Moisture content in a dump is a fluctuating parameter which is influenced by the time of sampling, height of dump, stone content, amount of organic carbon, and the texture and thickness of litter layers on the dump surface [23].

Rocks forming the dumps, on technogenic stage are exposed to the most drastic changes during explosive works and under the influence of vehicles – mining excavators and heavy vehicles. As a result of physical destruction of debris, hydration of mineral particles or dissolution of cementing material, the process of disintegration develop, which intensity depends essentially on the amount of cement, its composition and packaging of clastic material. Rocks with argillaceous cement break quickly, slowly – with carbonate [24].

Table 4 Particle size analysis and chemical data of the dumps and zonal soils

Pedon	Depth cm	Humus %	N		P_2O_5		pH		K_2O		Texture	Clay	$CaCo_3$ %
			total (%)	hydrolyzable (mg kg−1)	total (%)	Mov. (mg kg−1)	H_2O	$CaCI_2$	total (%)	Mov. (mg kg−1)			
1–1	0–12	1.28	0.08	39.2	0.044	16	8.20	8.0	2.11	590	Silt loam	12.2	6.20
	12–25	0.71	0.06	36.4	0.108	6	8.23	8.1	1.89	380	Silt loam	13	6.39
	25–46	0.51	0.04	33.6	0.108	6	8.25	8.14	1.78	300	Silt loam	12.6	7.48
	46–90	0.49	0.04	30.8	0.092	4	7.95	7.80	1.73	100	Silt loam	15	9.58
	90–120	–	0.03	22.4	0.072	3	7.79	7.61	1.89	80	Silt loam	13.9	7.73
1–2	0–7	0.71	0.04	33.6	0.204	10	7.58	7.23	1.83	200	Loam	15.6	8.57
	7–17	0.17	0.03	28.0	0.172	3	8.20	8.12	1.44	80	Silt loam	16.7	12.7
	17–30	–	0.03	28.0	0.204	3	8.50	8.27	1.38	80	loam	12.2	7.54
1–3	0–7	0.86	0.07	22.4	0.324	25	8.56	8.32	1.61	210	loam	13	7.10
	7–17	0.10	0.02	16.8	6.16	–	8.46	8.22	1.44	90	loam	16.8	9.84
	17–32	–	0.02	14.0	0.380	2	8.28	8.1	1.25	70	Clay loam	14.7	8.31
1–4	0–13	0.88	0.06	30.8	0.288	20	8.13	8.0	1.44	200	Silt loam	18.5	12.2
	13–27	0.27	0.03	19.6	0.060	3	7.55	7.25	1.35	60	Silt loam	20.9	6.68
	27–31	–	0.03	–	0.084	3	7.58	7.36	1.25	50	Silt loam	17.9	11.8

Of clay minerals and humus; in lessivage and other processes, sludge or its breakdown products is transferred from upper to lower horizons. On granulometric composition of soils and especially on content of silt fraction it is possible to judge on the dynamics and characteristics of soil – formation process. In the investigated areas the increase of finer fractions is observed, which may accumulate as a result of water erosion and weathering of surface overburden rocks.

The development of young soils of regenerating ecosystem through time, is accompanied by changes of mineral part of soils, which are diagnosed by substance and total chemical composition pH, physical clay content and silt in fine earth of soil grounds. According to some researchers, the study of particle size distribution and soil microaggregate composition occupy a large share in the overall picture of soil formation process in conditions of technogenesis because almost all physical and mechanical soil properties depend on mechanical composition. Over time, chemical disintegration begins influencing on abiotic processes of rock differentiation and biochemical weathering action occurs when vegetation appears [25]. Particle size distribution of emerging young soil testifies the initial signs of soil formation process. Thus, the movement of silty – clay fractions in the profile and their accumulation in the lower horizon is observed. By particle size distribution soils of the research object are loamy soils (Table 4).

Humus formation in young soils during first years has accumulative character. In this regard, it is considered that humus, which is formed during the initial stages of pedogenesis, is not humus, but is an intermediate product of organic matter transformation, so it should be called «organic matter», and acids which are prior to formation of humic and fulvic acids, should be called «pre – humus» [26].

Particularly important components that determine soil formation process in conditions of dumps are degradation of humic substances, humus formation, humus accumulation and humification. It was found that humus formation in young soils of technogenic ecosystems occurs on mechanisms, in many ways similar to those in zonal soils [27 – 28]. The basis of this statement is the concept that accumulation of humus and stabilization of its fractional composition occur at close biochemical linkage between technogenic terrains and adjacent zonal ecosystems [29 – 30].

Results of initial soil samples from dump of deposit «Kokdzhon» showed that by humus content and rock dumps soil formation process is very weak. It should be noted that there is very bright connection of humus with distribution of vegetation in conditions of self overgrowing. Results on humus content indicate that soil formation processes affect the upper soil layers of the dump. Since in the lower horizons humus content ranges from 0.2 to 0.5 %, which corresponds to overburden rock dumps (Table 3). The content and distribution of carbon dioxide in soil profile provides quantitative characteristics of carbonate features of soil, as dumps are made of carbonate rocks, mainly of dolomite.

By qualitative and quantitative composition of pedobionts in remediation of dumps we can say about restoration of biological soil and environmental functions on dumps of phosphorite deposit Kokdzhon.

Studying the role of microbiocenoses on experimental plot

Having got to the day surface, overburden rocks are exposed to weathering, and inhabited by various organisms (microorganisms, plants, animals), and their combined effect results in changing of agro – ecological properties of the upper layer of dumps. The success of remediation works at the dumps depends on composition of overburden rocks and extent of their suitability for biological development and possibility of creating soil layer [31].

Income of organic matter into the ecosystem and its transformation determine many characteristics of soil formation, including for emerging soils and restoration of their soil ecological functions in technogenically disturbed terrains [32 – 34] . Microorganisms and soil biota play a crucial role in transformation processes of crop residues and formation of humus in soil. Microflora activity and activity of soil animals in many ways determine morphology of soil profile, physic – chemical properties of soil, intensity of its biochemical processes and speed of circulation of substances. The research on structural – dynamic and functional response of microflora to parameters of media in technogenic soils and reaction of small invertebrates allow us to evaluate the intensity and direction of soil – formation processes in juvenile soils.

Soil mesofauna – is a faunal complex, consisting of large invertebrates. The importance of studying soil invertebrates populations is due to their enormous role in soil life, which they inhabit but also actively form structure of soil horizons [35]. Status of soil fauna reflects the processes occurring in soil, and information on soil population helps to understand soil characteristics in different soil types [36]. The intensity and direction of processes in soil block are the important indicators of ecosystem dynamics. For decades zooindication of soil processes is one of the priority areas of research in ecology [37 – 38]. The basis of analysis of ecological structure of living organisms community is a life form [39] .

The ecological diversity of animal population is the basis of information value of animal complexes [40]. The knowledge of spatial inhomogeneity of animal population of tehnosoils may be a new direction in the development of zoological method of soil diagnostic. Research on soil zoofauna is of great interest due to the urgency of land development, which were disturbed by human industrial activity. Soil is inhabited by various animal groups, whose representatives have their own influence on soil processes and soil properties.

Therefore, different size groups require independent research methods. In this regard, there is division of all soil animals in size groups: soil simple – nanofauna; soil microarthropods – microfauna; large soil invertebrates – mesofauna; soil vertebrates – macrofauna. Microarthropoda (armored, trombidiform and other mites, springtails, small insects and others) form to a certain extent an autonomous complex of organisms which have certain specific interactions with the environment. They are sensitive and responsive to all forms of human impact on the environment, including industrial and radioactive pollution, application of organic fertilizers, pesticides, soil reclamation. High population, rich diversity of species, widespread presence of representatives of various life forms, the variety of life cycles, not complex collection methods make microarthropods a convenient object for soil zoological, soil – ecological and biogeographical research. *Collembola*, *Collembola*, includes small initially wingless insects, widespread, diverse groups, actively involved in life regulation of soil community, mineralization and humification of organic matter. Due to the fast response to any changes in soil conditions, they are the perspective object of environmental monitoring. The population of springtails is tens of thousands of organisms per square meter. In sharp anthropogenic disturbance of soil, it decreases to hundreds of insects. Collembola are one of the first groups of animals that populate the lifeless soil and begin the formation of pioneer communities. The nature of structure and population dynamics of springtails can serve as a reliable indicator of recovery processes in disturbed areas. When moving, they push soil particles, crush soil, mix lower soil layers with top layers, taking plant residues deep into soil, that contribute to changes in chemical composition and structure of soil surface, increasing humus content, their excrements become fine grained structural soil aggregates. Eating decomposing substances, they play an important role in mineralization of animal and plant residues, and in enrichment of deep soil layers [41].

In the spring the research of loam rocks (used in remediation) from experiment section Kokdzhon showed that micromezofauna is represented by collembola of genus Isotoma, Onychiurus, Hypogastrura and hard ticks (Oribatea) genus Zygoribatula in small quantities and smaples. Of representatives of macrofauna on the site were found bugs – soldiers – (Hemiptera), they often gather in large clusters (Figure 3).

Figure 3 Bugs – soldiers – (*Hemiptera*) at experimental site

Sometimes on the site surface were observed moving single samples of spiders and ground beetles, and black ants (*LasiusnigerLinnaeus*). In the autumn substrate samples microarthropods are missing. The lack of microarthropoda in samples, apparently is due to dry upper soil layers, as for microarthropoda most important factor is moisture conditions. This is also due to the change of hydrothermal conditions, as well as change of nutrition, which deteriorates conditions for saprofil groups – oribatid mites and collembola. The best conditions of nutrition, hydration and aeration are in the upper layers of 10 – 15 cm, in which inhabit most of the invertebrates.

The study of the role of microorganisms in nature and its diversity is necessary due to the fact that they are a vital part of the ecosystem of the Earth and its biosphere. Microorganisms have big functional diversity and represent major gene pool, which oppose to changes in the environment. Microbocenosis has been separately outlined by V.N. Sukachyov due to the fact that microscopic organisms are very specific by research methods and by interaction with other organisms [42].

In terms of our experiment, the dominant place is occupied by bacteria. The highest quantity of them is observed in the layer of 0 – 5 cm in application of biochar + urea under the elm. Noticeably smaller quantity of bacteria was determined under haloxylon at a depth of 5 – 10 cm. The largest quantity of actinomycetes, as well as bacteria was observed under angustifolia, their number reached 106 cells per 1 g of soil, which is one order higher than in the soils of row spacing, as well as under tamarisk. Among the explored soils, the lowest number of actinomycetes was observed under saxaul. The highest number of filamentous fungi was observed in the layer of 0 – 5 cm under angustifolia and elms. Among micelial fungi the predominant species were – Penicillium, Aspergillus. The highest numbers of bacteria, actinomycetes and filamentous fungi was observed in the layer 0 – 5 cm, in depth (5 – 10 cm), their number consistently decreases. A few representatives of microbial zoocenosis under different phyto meliorants on remediated experimental plot suggests the initial soil formation stages in short term (2 years), whereas in the dumps an initial process of soil formation in natural overgrowth lasts 25 – year period of development of the deposit. By qualitative and quantitative composition of pedobionts in remediation of dumps we can say about restoration of biological soil and environmental functions on dumps of phosphorite deposit Kokdzhon.

Conclusion

– Natural overgrowing on dumps is observed between ridge sloping and hilly terrain where fine earth of weathered rocks and moisture accumulate, and there is scarce phytocenoses species composition;

– Bioproductivity of surface and underground plant mass is low, there is a large mosaic of plant communities distribution on industrial waste dumps;

– Rather poor plant species composition of zone mountain gray soils affects natural overgrowing of industrial dumps and restoration of their soil – ecological functions;

– In technogenically disturbed terrains of phosphorite deposit, soil – forming processes in the desert and semi – deserts are in initial (embriosoil) stage;

– The distribution of size fractions in the profile, accumulation of silt fraction in the upper part of profile, humus content and distribution of nutrients shows that upper soil layers of soil of the dump are subjected to soil – formation processes.

– In terms of remediation of dump with alluvium of loam rock and cultivation of various phytomeliorative crops the rate of soil formation reduces, and restoration process of soil – ecological functions on dumps of phosphorite deposit Kokdzhon takes place.

References:

1. Cooke J.A, Johnson M.S (2002) Ecological restoration of land with particular reference to the mining of metals and industrial minerals: a review of theory and practice. Environmental Reviews 10:41 – 71.
2. Li M.S (2006) Ecological restoration of mine land with particular reference to the metaliferous mine wasteland in China: a review of research and practice. Science of the Total Environment 357:38 – 53**.**
3. Maciak F., 1996. The Protection and Restoration of the Environment. Szkoła Główna Gospodarstwa Wiejskiego, Warszawa, Poland.
4. Puziewicz J., Zainoun K., Bril H., 2007. Primary phases in pyrometallurgical slags from a zinc – smelting waste dump _Swie˛tochłowice, Upper Silesia, Poland. Can. Mineral. 45, 1189 – 1200.
5. World Bank Group, 1999. Pollution Prevention and Abatement Handbook Toward Cleaner Production. The International Bank for Reconstruction and Development / The World Bank, Washington, USA.
6. Backor M., Fahselt D., 2004. Physiological attributes of the lichen Cladonia pleurota in heavy metal – rich and control sites near Sudbury (Ontario Canada). Environ. Exp. Bot. 52, 149 – 159.
7. Mirzayev G.G., Ivanov B.A., Shcherbakov V.M., Proskuriakov N.M. Ecology of mining // Textbook for universities. – M .: Nedra. 1991. – 320 p.
8. Mining and technical characteristics of the enterprise Kokdzhon (Materials of Kazphosphate, 2008).
9. Dubinin A.A. Justification of potential possibility of development of the site Kesik Tobe in Kokdzhon field // Proceedings of the International scientific and practical conference «Assurance of ecological safety – the way to sustainable development of Kazakhstan. February 23 – 24, 2010». – Taraz «Senim». 2010. – S. 232 – 235.
10. Arinushkina E.V., 1961. Handbook on the Chemical Analysis of Soils. Mosk. Gos.Univ., Moscow.
11. Kaczynski N.A. Mechanical and micro – aggregate soil structure, methods of its study. M. 1958. 188 – p.
12. Zatula E.D. and Prozhorina T.I., Methods for the determination of total carbonates in soils. In Chemical analysis, 2008 U.D.C.02.2 (301.7), pp. 23 – 28.
13. Radov A.S., Pustovoy I.V., and Korol'kov A.B., Methods for the determination of total potassium in soils, in Practicum on agrochemicals, 1965 U.D.C. 631.8.(075. 8), pp.177 – 178.
14. Shein E.V., Goncharov V. M., Agrophysics. 2006.UDK 631 (075.8) 15 – 52.
15. Gilyarov M.S. Zoological method of soil diagnostics, 1969. 277 – p.
16. Mishustin E.N., Emtsev V.T., Microbiology. M., «Kolos».
17. Beadle K.L. Analysis of plant growth / K.L. Biddle // Photosynthesis and biological productivity: methods and definitions: articles. – M .: Agropromizdat, 1989. – P. 53 – 61.
18. Toktar M., Papa G.Lo., Kozybayeva F.E., Dazzi C. Soils and plants in an anthropogenic dump of the kokdzhon phosphorite mine (kazakhstan) EQA – Environmental quality / Qualité de l'Environnement / Qualità ambientale, 26 (2017) 13 – 22.
19. Androkhanov V.A., Kulyapin E.D., Kurachev V.M. The soils of technogenic landscapes: genesis and evolution. – Novosibirsk. 2004. – 149 p.
20. Androkhanov V.A., Kurachev V.M. Soil – ecological condition of technogenic terrains: dynamics and evaluation. Novosibirsk: Publishing House of SB RAS. 2010. – 224 p.
21. Kurachev V.M., Androkhanov V.A. Soil classification in technogenic terrains. – SEZH. N. 2, 2002. – p. 255 – 261.

22. Gorlov V.D., Lozanovskaya I.N. Biological and environmental remediation criteria.
23. Kozybayeva F.E., Beiseyeva G.B., Azhikina N.J., Abdresheva M.B., Toktar M. Processes of soil formation on dumps of phosphorite deposit «Kokdzhon» in Zhambyl region // IX Russian scientific conference with international participation «Biological remediation and monitoring of disturbed land» – Yekaterinburg, 20 – 25 August 2012. – P. 125 – 127.
24. Androkhanov V.A., Ovsyannikov S.V., Kurachev V. M. Tehnosoils: propertis, regimes functioning. – Novosibirsk: Nauka.2000. – 200 p.
25. Polokhin O.V. Size distribution of different aged embryosoils of technogenic terrains KATEK // Soils – national treasure of Russia: Materials of 4th Congress of Dokuchaev Society of Soil Scientists. – Novosibirsk. 2004. – 569p.
26. Androkhanov V.A., Ovsyannikov S.V., Kurachev V. M. Tehnosoils: propertis, regimes functioning. – Novosibirsk: Nauka.2000. – 200 p.
27. Fatkulin F.A. Energy of humus accumulation in technogenic terrains of Kuzbass // Soil formation in technogenic terrains. – Novosibirsk. Nauka. 1979. – P. 203 – 212.
28. Trofimov S.S., Naplekova N.N. and others. Humus formation in technogenic ecosystems. – Novosibirsk. Nauka. 1986 – 126 p.
29. Makhonina G.I. Environmental aspects of soil formation in technogenic ecosystems in the Urals. – Ekaterinburg. 2003. – 356 p.
30. Trofimov S.S., Fatkulin F.A. The composition of humus in young soils in moldboard – mining terrains of Central and Southern Kuzbass // Restoration of technogenic terrains of Siberia. – Novosibirsk: Nauka. 1977. – P. 113 – 119.
31. Naumov A.V., Naumova E.N . Decay of plant root mass in «young» soils in KATEK // Soil science. – 1993. – № 5. – P. 47 – 55.
32. Toktar M., Papa G. Lo., Kozybayeva F.E., Dazzi C. Ecological restoration in contaminated soils of Kokzhon phosphate mining area (Zhambyl region, Kazakhstan) // 2016. – c. 1 – 3.
33. Kozybayeva F.E., Toktar M., Abdresheva M., Molzhigitova A. Soil formation and evaluation of soil and environmental functions in technogenic terrains // International Scientific Conference. 15 Dokuchaev youth readings dedicated to 150th anniversary of R.V. Rizpolozhenskiy «Soil as a natural biogeomembrane» St. Petersburg. March 1 – 3, 2012. – St. Petersburg. 2012. – P.284 – 286.
34. Lavelle P., Bignell D., Lepage M. Soil function in a changing world: the role of invertebrate ecosystem engineers // European Journal of soil biology. – 1997. – Vol. 33. – P. 159 – 193.
35. Gilyarov M.S. Zoological method of soil diagnosis. – M .: Nauka. 1965. – 275 p.
36. Zhukov A.V., Zhukova V.V. Ecomorphic spectrum of earthworms complexes in zoological soil diagnostics // Herald Dnepropetrovsk Univ. Biology and Ecology. – 1997 – Vol. 3. – P. 216 – 221.
37. Bellegarde A.L. Forest vegetation of the southeast of Ukraine. – K .: Publishing House of Kiev State. Univ. 1950. – 294 p.
38. Zhukov A.V. Products and diversity of *soil* fauna complexes ... soil in steppe Dnieper area: Author. Dis. Cand. Biol. Sciences. D.: 1996. – 22 p.
39. Gilyarov M.S., Striganova B.R. Quantitative methods in soil zoology. – M .: Nauka. 1987. – 288 p.
40. Gilyarov M.S. Zoological method of soil diagnosis. – M .: Nauka. 1965. – 275 p.
41. Gilyarov M.S., Striganova B.R. Quantitative methods in soil zoology. – M .: Nauka. 1987. – 288 p.
42. Sukachev V.N. Biogeocoenosis as expression of interaction of living and inanimate nature on surface of the Earth: correlation between the concepts «biogeocoenosis», «ecosystem», «geographical landscape» and «phase» // Basics of forest biogeocenology / ed. V.N. Sukachev, N.V. Dylis. – M .: Nauka. 1964. – P. 5 – 49.