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RECLAMATION OF TECHNOGENICALLY DISTURBED LAND TO RESTORE AGRICULTURAL LANDSCAPES (ON EXAMPLE OF PHOSPHORITE DEPOSIT KOKZHON)

Abstract. The total area of disturbed lands more than 1000 hectares, including on the field "Kokzhon" is 278 hectares. Onstony - gravelly surface of the dump the layout and layering backfilling of dump by loamy breed were carried out. Loam breed layer thickness was 30 cm. As biochar improver was used, obtained from rice hulls by pyrolysis at 450C^0. The use of biochar in innovative technologies can provide carbon sequestration in the atmosphere for thousands of years, while reducing the level of degradation of the local soil, which is subject to 84 per cent of arable land worldwide. Restoration through planting shrubs or herbaceous planting crops is an effective means of restoring the land of pastures. In experiments biochar and nitrogen fertilizer were used as meliorant. 600 shrubs were planted 31 trees and shrubs established. In the first year 31 trees and shrubs established. Herbaceous plants sprouted well. And in versions introduced with biocar, they were characterized by low density and moisture retention in the soil.

Key words: Reclamation, dump, disturbed land, soil moisture and density, biochar, soil.

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].

Opencast mining operations involve removal of huge quantities of overburden, dumping and backclling of the excavated area. Substantial increase in rate of accumulation of waste materials in recent years has resulted in greater height of dumps to minimize ground cover area. Consequently, this has given rise to the danger of dump failures, gully erosion and various associated environmental problems [3].

Land is one of the most important resources on which human beings depend. The mining disrupts the aesthetics of the landscape and soil components such as soil horizons and structure, soil microbe populations, and nutrient cycles which are otherwise crucial for sustaining a healthy ecosystem [4]. The effects of mine wastes can be multiple, such as soil erosion, air and water pollution, toxicity, geo-environmental disasters, loss of biodiversity, and ultimately loss of economic wealth [5-6].

Reclamation of mine dumps and abandoned mine lands (AML) is a complex multi-step process. The first step in transforming the mine contaminated lands into productive agricultural lands is restoring its ecological integrity [7-8]. Reclamation strategies must address soil structure, soil fertility, microbe populations, topsoil management and nutrient cycling in order to return the land as closely as possible to its pristine condition and continue as a self-sustaining ecosystem [9]. Conservation and reclamation efforts to ensure continued beneficial use of land resources are essential. Reclamation is the process by which derelict or highly degraded lands are returned to productivity, and by which some measures of biotic function and productivity is restored. Long term mine spoil reclamation requires the establishment of stable nutrient cycles from plant growth and microbial processes [10-11].

Industrial dumps formed during open-pit mining of fossils represent special technogenic territories. Thus, the industrial deserts are formed that are initially almost totally free of seed germs, very strongly stony, with high content of microelements (including heavy metals). Technogenically disturbed areas are lifeless, and it will require a long time period for their self restoration, especially in conditions of semi-deserts. Vegetation of surrounding undisturbed landscapes is sparse desert, and plants from outside practically don't grow on dumps. On industrial waste dumps which have been worked out 25 years ago, there are some isolated plants or small clumps. Abandoned developed mine fields are often the center of erosion processes, and then land plots adjacent to the mine become waste lands. Destroying the environment – land surface and pit massif, open pit also changes the terrains. We should particularly note the destructive effect of open pits in desert and semi-desert areas with severe natural-climatic conditions. Vast areas of disturbed lands, devoid of vegetation are the main area of carbon emission into the atmosphere, which results in increasing global changes in biosphere. The above material shows that the development of theoretical foundations of remediation of technogenically disturbed lands is a relevant issue. The obtained results of theoretical approach will serve as a basis for practical use in conducting remediation measures aimed at environmental conservation, sequestering of carbon emission into the atmosphere, full functioning of biosphere and ecological balance in industrial towns.

Materials and methods. The research object includes technologically-disturbed lands at phosphorus deposit "Kokdzhon". Major disturbance of soil surface occur in development of phosphorus deposit. At the same time 50-70 m high multi-layer industrial dumps are formed on the surface. In the open method of extraction of agro-ore, career hollows 1,6-2,98 km long, 360-430 m wide and 90-95 m deep are formed. There are dumps with sloping surface with incline 7-10° [15].

In exploring the field "Kokdzhon" the following methods were used: expedition- field, experimental-field and laboratory analytical. The study of the basic properties of soil grounds is carried out by conventional methods used in soil science and agricultural chemistry (reconnaissance tour, choice of key points for conducting field experiments with sampling soil-ground samples (loamy rock) on physical, physical-chemical, chemical properties and nutrient regime. The following mining-technical remediation methods were used: cutting and layout of dump surface, delivering and putting of loamy rock on dump surface. The total volume of human transported material (HTM) used was 700 tons. After mining-technical remediation with phyto-meliorants, the biological remediation was conducted.

In experimental section, 150 g of biochar was used as a meliorant in each hole [12-14]. Urea was applied as mineral fertilizer at the rate of 70 g per each hole. Size of planting holes was 1600 cm^2. 750 shrubs were planted, 150 of them - seedlings of black Saxaul, 150 -Androsov Elm, 150 - Salt Cedar, 150 - Russian Olive. On one of these dumps, a site of 110x115 m was chosen for experimental- field remediation works. Also herbaceouswere planted- Smooth brome, Russian wildrye, Tall oat-grass, Perennial ryegrass, Meadow fescue, Cock's-foot, Alfalfa, Common sainfoin. Twice a week, seedlings were irrigated, agro technical treatment and phenological observation of plants growth and development has been conducted.

Phytomeliorants have been selected Russian Olive, black Saxaul, Russian Salt Tree, Salt Cedar, Androsov Elm) with regard to their biological and ecological characteristics.

Table 1 – Main features of the tree species used for the ecological restoration of the test site

Tree species	(Latin name)	Main characteristics
Russian Olive	Elaeagnus AngustifoliaL.	This is a tree that grows rapidly, especially at a young age and develops a deep root system. Drought-resistant, it almost does not suffer from hot dry winds in the south-eastern steppe regions. It is unpretentious to soils. Due to the presence of nodules on the roots with nitrogen-fixing bacteria, this is a tree that improve the soil nutrient regime.
Black Saxaul	Haloxylon Aphyllum (Minkw.) Iljin	This is a tree that can grow in desert areas. It is able to tolerate extremely severe drought, unbearable heat, and soil salinity.
Androsov Elm	Ulmusminor Mill.	This is a tree that shows a dense spherical crown, which gives a deep shadow. The root system - with many lateral surface roots – allows for a good anti-erosion function.
Salt Cedar	TamarixgracilisWilld.	This is a tree that usually grows on saline soils. It is fire-adapted, and have long tap roots that allow it to intercept deep water tables.

Table 2 – Main features of the herbaceous species used for the ecological restoration of the area

Herbaceous species	Latin name	Main characteristics
Smooth brome	Bromus InermisLeyss.	Perennial grass, drought-resistant crops. Grows in aerated loamy and sandy soils. Crops of this herb is used to improve natural hayfields and pastures, as well as turfing sloping lands.
Russian wildrye	Elymus junceusFisch.	The long-term loosely bush grass, drought-resistant, not demanding to soil, grows well in saline soils and solonetz.
Tall oat-grass	Arrhenatherum ElatiusP. Beauv. ex J. Presl& C. Presl	Loosely bush grass, drought-resistant plant, growing on moderately moist loam and sandy loam.
Perennial ryegrass	Lolium PerenneL.	Loosely bush grass - valuable for forage and pasture use. It grows in sandy loam and sandy loam, not too acidic soils.
Meadow fescue	Festuca PratensisHuds.	Loosely bushy herb is widely used in mixtures with the creation of hayfields and pastures durable on different types of soils (except sand). It grows well in loamy, clay, soil.
Cock's-foot	Dactylis glomerataL.	Loosely bushy perennial grass, quite drought-resistant. Grows well on sandy loam and clay soils, responsive to high doses of nitrogen and irrigation. In mixtures can hold up to 8-10 years.
Alfalfa	Medicago sativaL.	Herbaceous perennial. The root system is very powerful. It is cultivated as an important forage crop in many countries around the world.
Common sainfoin	Onobrychis ViciifoliaScop.	Herbaceous perennial. The root system of sainfoin well absorbed nutrients, especially phosphorus from the soil. Serve as a good means to contrast erosion.

Results and discussion. Reclamation effort making use of engineering techniques may facilitate the vegetation development on the derelict land [16]. However, few studies have investigated the long-term effects of site treatment on plant community development by natural processes in mining areas [17-18]. The concept of adaptive management and the notion that a restored site be regarded as a long-term experiment is a sensible perspective. In practice, however, the lack of post-restoration monitoring and research has meant few opportunities to improve the theory and practice of ecological restoration in mining areas.

In the field experiment site of the dump, where remediation works were carried out the phonological studies have been conducted. Only 4.1 % of the planted trees survived. The most suitable were Androsov Elm (10 plants with minimum and maximum height ranging from 58 to 150 cm); Salt Cedar (10 plants with minimum and maximum height ranging from 30 to 95 cm); and Black Saxaul (9 plants with minimum and maximum height ranging from 55 to 90 cm). However, it should be noted that next year some varieties will germinate as near-root and root systems haven't died and is at rest condition [19-21]. Among herbaceous plants germinatedSmooth brome, Russian wildrye, Tall oat-grass, Perennial ryegrass, Meadow fescue, Cock's-foot, Alfalfa, Common sainfoin.

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 (Donahue, R.L., Miller, R.W., and Shickluna, J.C. 1990).

In spring soil moisture biochar + urea under plantings in 0-10sm layer was 6.03%, in 10 - 20 cm layer 6.99%, in between the rows in 0-10 cm layer was 4.5%, in 10 - 20 cm layer 7.9%, in control layer 0-10 cm was 4.33%, in 10-20 cm layer was 4.7%. In the autumn soil moisture on the option biochar + urea under plantings in 0-10 cm layer was 3.2%, in 10 - 20 cm layer was 6.4%, in 0-10 cm layer of loam was 0.78%, in 10-20cm layer 1, 34%, in the 0-10 cm control layer is 0.78%, 10-20 cm layer is 1.34% (table 3). Biochar absorbs and retains water.

Bulk weight of loamy rocks in artificial layer has the same parameters in 0-10 cm layer was 1.34 g/cm^3, in 10 - 20 cm layer 1.4%, in between rows in 0-10 cm layer was 1.38 g/cm^3, in 10-20 cm layer was 1.45 g/cm^3. In the fall the bulk mass in the option biochar+ urea under plantings in 0-10 cm layer was 1.43 g / cm^3, in 10 - 20 cm layer was 1.46 g /cm^3, in between the rows in 0-10 cm layer was 1.45 g / cm^3, in 10-20 cm layer was 1.46 g / cm^3, in 0-10 cm in control layer was 1.45 g / cm^3, in 10-20 cm layer was 1.46 g / cm^3 (table 4).

Table 3 – Soil moisture after reclamation in the topsoil (0-10 cm, 10-20cm) of the test area (N=20) springtime

Options	Depth, cm	Values (%)			Δ	Standard Deviation
		mean	min	max	max-min	
Springtime 2014						
Biochar + urea under plantings	0-10	6,03	3,2	12,5	9,3	2,47
	10-20	6,99	2,98	11,6	8,62	2,13
Between the rows	0-10	4,5	0,81	8,2	7,39	1,8
	10-20	7,9	2,5	12,6	10,1	2,5
Control	0-10	4,33	1,1	7,2	3,1	1,74
	10-20	4,7	1,4	7,9	6,5	1,75
Autumntime 2014						
Biochar + urea under plantings	0-10	3,2	0,4	8,2	7,8	2,5
	10-20	6,4	3	9,7	6,7	2,1
Between the rows	0-10	2,8	1,1	5,1	4	1,21
	10-20	5,1	1,4	6,3	4,9	1,1
Control	0-10	0,78	0,4	1,13	0,73	0,24
	10-20	1,34	1	1,7	0,7	0,25

Table 4 – Volume weight after remediation in the topsoil (0-10 cm, 10-20cm) of the test area (N=20) springtime

Options	depth cm	Values (g/cm^3)			Δ	Standard Deviation
		mean	min	max	max-min	
Springtime 2014						
Biochar + urea under plantings	0-10	1,34	1,1	1,6	0,5	0,11
	10-20	1,4	1,05	1,65	0,6	0,14
Between the rows	0-10	1,38	1,19	1,5	0,31	0,09
	10-20	1,45	1,31	1,64	0,33	0,1
Control	0-10	1,40	1,15	1,62	0,47	0,11
	10-20	1,46	1,27	1,65	0,38	0,1
Autumntime 2014						
Biochar + urea under plantings	0-10	1,43	1,28	1,59	0,31	0,1
	10-20	1,46	1,27	1,66	0,39	0,12
Between the rows	0-10	1,44	1,25	1,66	0,41	0,11
	10-20	1,45	1,27	1,68	0,41	0,11
Control	0-10	1,45	1,41	1,51	0,1	0,04
	10-20	1,46	1,41	1,52	0,11	0,05

Data in spring in comparison with fall data showed that due to very hot months in summer in layer 0-10 cm was observed a slight compaction. High density is mainly due to strong drying during the summer period of the mound layer of loam and lack of vegetation on the surface. Strong drying of loam leads to cracking of the surface and appearance of polygonal fractures that only enhances drying of mound layer. At the same time, high density and grouting of loam surface reduces removal of fine particles from the surface, so we can hope that mound horizon will be not removedby wind, as it is often observed in the application of light loam or topsoil in arid areas.

Conclusions. After mine technical reclamation the biological remediation phase was conducted. Loamy rocks contain a small amount of field moisture. In the spring, moisture is 2 times higher than in the autumn. Volume weight is 1.4 g / cm^3. For the vegetation season, within the reclamation works, the plants as Salt Cedar, Black Saxaul, Androsov Elm and Russian Olivewere more resistant to the extreme conditions of industrial dumps. But it should be noted that next year some trees and shrubs will be grow because their root system is alive and it is at rest. The grass kinds as Smooth brome, Russian wildrye, Tall oat-grass, Perennial ryegrass, Meadow fescue, Cock's-foot, Alfalfa, and Common sainfoin sprouted. Grass and tree roots play a very crucial role in the stabilization of coal mine overburden dumps.

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АУЫЛШАРУАШЫЛЫҚ ЛАНДШАФТАРДЫ ҚАЛЫНА КЕЛТІРУ ҮШІН ТЕХНОГЕНДІ БҮЛІНГЕН ЖЕРЛЕРДҢ РЕКУЛЬТИВАЦИЯЛАУ («КӨКЖОН» ФОСФОРИТ КЕН ОРНЫ МЫСАЛЫНДА)

Аннотация. Жерді ұтымсыз пайдалану барысында республикамызда пайдалы қазбаларды ашық әдіспен игеру мен өндіру кезінде кен орындарының аумағы деградацияға ұшырайды. 30 жылдық кезеңнен кейін жүргізілген бақылау жұмыстарының нәтижелері жерасты тау жыныстары мен жасанды түрде жасалынған субстраттардағы топырақ түзілуінің бастапқы процестерін, олардың биологиялық рекультивация кезіндегі жылдамдығы мен бағытын көрсетті, агроландшафтық жайылымдық жерлердің агроэкологиялық функцияларын қалыптастыруда аталған зерттеу нысынында шөл және шөлейтті аймақтың рекультивациялық зерттеу негіздері қалыптасты.

Шөл және жартылай шөлді аймақтардың бүлінген жерлерінде сол аймақтарға төзімді өсімдік қауымдастығының жойылып кетуінің нәтижесінде экожүйенің қалпына келуі ұзақ уақыттыалады және стратегиялық басқаруда қиындықтар тудырады.

Жаңатас елді мекенінің фосфорит кен орындарының бүлінген жалпы аумағы 1000 га-дан асады, оның ішінде Көкжон фосфорит кен орнында бүлінген жер 278 га. Құрайды. үйіндідің беткі қабаты қиыршық-тасты бөліктерін тегістеп, құм-балшықты топырақгрунттары төгіліп техникалық рекультивация жүргізілді. Құм-балшықтың қалыңдығы 30 см құрады. Күріш қабығынан 450C^0 температурада дайындалған пиролиз жолымен алынған биокөмір қолданылды. Биокөмір инновациялық технологияларда қолдану әлемде егістік жерлердің 84 пайызына жататын жерғілікті топырақтың деградация деңгейін төмендету арқылы мыңдаған жылдар бойы атмосферада көміртек секрециясын қамтамасыз етеді. 600 түп ағаш-бұталылар және шөптесін өсімдіктер егілді. Ал шөптесін өсімдіктер жайылым жерлерін қалпына келтірудің тиімді құралы болып табылады. Тәжірибелерде биокөмір және азот тыңайтқыштары мелиорант ретінде пайдаланылды. 600 түп ағаш-бұталы фитомелиоранттардан 31 түп өсіп шықты, шөптесін өсімдіктердің өнімділігі жақсы. Биокөмір енгізілген нұсқаларда топырақтың төмен тығыздылығы мен ылғалды сақталуымен сипатталды.

Түйін сөздер: Рекультивация, үйінді, бүлінген жер, топырақ ылғалдылығы мен тығыздылығы, биокөмір, топырақ.

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РЕКУЛЬТИВАЦИЯ ТЕХНОГЕННЫХ НАРУШЕННЫХ ЗЕМЛИ ДЛЯ ВОССТАНОВЛЕНИЯ СЕЛЬСКОХОЗЯЙСТВЕННЫХ ЛАНДШАФТОВ (НА ПРИМЕРЕ ФОСФОРИТНОГО МЕСТОРОЖДЕНИЕ «КОКЖОН»)

Аннотация. В ходе нерациональной деятельности по использованию земель в республике территории рудных месторождений при разработке и добыче полезных ископаемых открытым способом подвержены деградации. По истечении 30-летнего периода результаты мониторинговых исследований показали начальные процессы почвообразования на искусственно созданных субстратах, их скорость и направление при биологической рекультивации отвалов.

В результате исчезновения растительных сообществ, устойчивых к данным зонам, в местах разрушений пустынных и полупустынных зон, восстановление экосистем идет длительное время и вызывает трудности в стратегическом управлении.

Площадь нарушенных земель составляет более 1000 га, в том числе на месторождении "Кокжон" - 278 га. На каменисто-щебнистой поверхности отвала образовалась планировка и послойная засыпка отвала суглинистой породой. Глинистые породы толщиной слоя 30 см. Биоуголь был использован как улучшитель, получаемый из рисовой шелухи, методом пиролиза в 450С^0. Использование биоугля в инновационных технологиях может обеспечить связывание углерода в атмосфере на протяжении тысячелетий, одновременно снижая уровень деградации местной почвы, которой подвержено 84 процента пахотных земель во всем мире. Восстановление путем посадки кустарников или травянистых посадочных культур является эффективным средством восстановления земель пастбищ. В опытах в качестве мелиоранта использовали биоуголь и азотное удобрение. Было высажено 600 кустарников. В первый год было установлено 31 кустарник. Этому способствуют природно-климатические условия региона и отрицательное воздействие антропогенных техногенных факторов. Хорошо проросли травянистые растения. А в вариантах, введенных с биоуглем, они характеризовались низкой плотностью и удержанием влаги в почве.

Ключевые слова: рекультивация, отвал, нарушенная земля, влажность и плотность почвы, биоуголь, почва.

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