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Technogenic Desertification of Some Polluted Steppe Soils: Assessment, Control and the Opportunity of the Rehabilitation

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Chernozems and soddy-carbonate soils in the vicinity of Kamenogorsk Pb-Cd plant, Cu melt plant, TEPS (Kazachskiy small hills) were under investigation. The fractionation of As species has been fulfilled according to schema that was proposed by authors. There was noticed exceeding of the background As content 20 times in the upper 10 cm of the most polluted soils. The dozen of the available species consists of near 15% from total. It shoud be under constant control. The most part of pollutant (50-70%) have been firmly fixed by Fe oxide, and that fact provide the sustainability of the investigated soils towards As. The washing of these compounds from the polluted soils can be used as one the method of the rehabilitation As polluted soils.

On a etai etudie les soles de tchernozem et rendzine polluter par l’arrachment de combinat metallurgique plombique-nikel et de production de cuivre en Ust- Kamenogorsk. La teneur general de As a determine par la method original d’auteurs. On a etablir le depassement de concentration abituelle par d’element en 20 fois. La part de compose labile atteindre 15% de volume total et doi controlee.La part general d’As (50-70% de total teneur), associe durablement avec d'oxyde ferrique, garantie la securite ecologique des soles pollute d'element. La possibilite de render meilleur du zone pollute c' est debourber le sole par les solvent qui peut reagir avec d’ As en form labile et pour extraction total — avec les reagents dissolve leur d’oxyde ferrique.

Introduction. The technogenic degradation of environment is a real evidence of the ecological crisis on the Earth. Anthropogenic degradation of soils is considered as the irreversible change of the structure and functioning of soils under the human activity, that exceeds the natural sustainability of soils to technogenic load. As a result, it leads to the impossibility of soils to carry out their ecological functions. The desertification is often defined as strong degradation of soils predominantly under drying up. But the climate change as well as severe human activity can lead to the analogical ecological danger. When climate is regulated by nature, people, on the contrary, control technogenic processes.

Water and wind erosion, chemical pollution and physical destruction prevail among different types of soil degradation. Technogenic deserts, provided by severe chemical pollution, occupy 12-15 % of the degraded lands on the planet. Anthropogenic deserts are not attached to the separate climatic zones. Their formation depends on the level of technical development of industry, energy plants and transport of the region. Their wastes are highly enriched with heavy metals, organic substances, and oxides of C, N and S. At first they form the local sports of polluted landscapes but later are included in global transmission. Chemical desertification is the most dangerous among others types of degradation, because of the spread of pollutants along food chains and influence on the health of population, and genetic consequences of this phenomenon are not well known. So chemical degradation occupies one of the leading places among different types of soil desertification.

Chemically degraded soils, as usual, take place in the vicinity of mining, metallurgical, fuel and energy plants. Their wastes consist of many nonorganic substances: Cu, Ni, Zn, Cr, As and others. Arsenic belongs to the elements of the first class of ecological danger (1). We consider the results of the investigations of As state in the polluted soils as an example of the working out the approaches to the assessment, control and rehabilitation of the polluted soils.

Anthropogenic deserts are not attached to the separate climatic zones, but the level of its danger is more sufficient in the regions where the natural conditions are mare favorable for climatic desertification.

Materials of investigation. The landscapes of Kazachskiy small hills (1000-1100 м under see level) were under investigation. The climate of the territory is dry (coefficient of humidity <0,5). The steppe vegetation is spread there. The products of weathering of effusive and sedimentary rocks, granites and shale's present parent rocks. Ancient alluvial carbonate deposits can be met there. The investigated soils are presented with two types of soils of the natural and technogenic landscapes: chernozems and soddy- carbonate soils. They both have relatively short profile and are developed on the ancient alluvial carbonate deposits.

The polluted technogenic chernozems take place in 700 m from the Cu melting plant (CMP) and thermoelectric power station (TEPS). CMP puts into atmosphere 160-375 tons of As annually. Arsenic supply in the upper 0,8 m were is accounted by 280-300 kg/hectare. The soil samples from the unpolluted low part of soil profile have been served as a control for the assessment of anthropogenic changes in the investigated soils. The polluted technogenic soddy- carbonate soils take place on the distance 400-500 m from Pb-Zn melting plant, metallurgical plant and TEPS.

The wastes of these plants consist of many nonorganic substances. The annual input of the wastes in this region consists of near 3500 tons. As, Sb, Zn, Cu, Pb, Cd, Se, Ag, Fe are notices in the composition of wastes. The most concentration has Zn, Pb (10-20 % from the total mass of the wastes). Arsenic does not dominate among them, but it is one of most dangerous. The annual As- input of the melting plants into atmosphere consists of 70-175 tons, and 0,2-0,5 tons – in wastes of TEPS. The upper 0.8 m soil layer consists of near 150 As kg/hectare. The analogical background soils are spread on the distance more than 50 km form the technogenic territory.

Methods of investigation. Total As content in soils was determined by the atomic-adsorption method with electro thermal dissociation after the smelting with NaOH.

The determination of As species in soils has been fulfilled. After some methodological investigation the authors suggested the following schema of the fractionating of As species (tabl.1):

Table1. Schema of successive extraction of As species from soil
(№ of the species from 1-st to 6-th)

Reagent	As species	Conditions
1% $(NH_4)_2SO_4$+ 0,25% $(NH_4)_2MoO_4$, pH 5,5-6,0	Sorbed nonspecifically, soluble salts	soil: solution = 1:50, 4 ч shaking 10 min, centrifugation
1 M $NH_4H_2PO_4$, pH 5,5-6,0	Sorbed specifically	soil: solution = 1:50, 4 h shaking 10 min, centrifugation
0,5 M $Na_3C_6H_5O_7$ + 1 M	Species, connected with	soil: solution = 1:50, 15 min

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$NaHCO_3$ + 0,13 M $Na_2S_2O_4*2H_2O$	oxides-hydro-oxides Fe, Al и Mn	(85^{o}C), centrifugation
0,1н. NaOH	Species, connected with organic matter	soil: solution = 1:50, 2 h shaking, staying 20 h, centrifugation, water washing
1 н. HNO_3	Species, connected with carbonates, organic matter with hardly soluble salts	soil: solution = 1:50, 1 h shaking, centrifugation, water washing
$HF+H_2SO_4$ (or melting with NaOH)	Species, connected with soil minerals	Treatment under 85^o C, dilution with 1n. HNO_3

Results and discussion. The technogenic soils occupy the territory near 2000 km^2 in the region of investigation. Some morphological signs have been noticed in the upper horizons of the two types of the polluted soils. The structure of the upper 10 cm become worse, soil aggregates have destroyed in comparison of the initial state of soils. The investigated soils are characterized by the following properties: pH 6.1-7,7 in chernozem, 6,7-8,3 =in soddy-carbonate soils, C org content- 2,4-3,4%.

Under the pollution the total content of As in upper soil horizons increased 3-20 times. The critical level of As content consists of 20 mg/kg (2). But it is not enough to know the total content of the pollutants in the soil for the assessment their ecological state. Only the information about the species of the chemical elements in the polluted soils can serve as the base of such assessment. The content of available species of chemical elements in soils (including As) serve as the parameters of the actual as well the potential danger of the pollutants in the landscapes. The available As species content in the investigated polluted soils raised 10-60 times in comparison with background territory. This parameter should be under regular ecological control.

It was estimated that iron oxides are the most active in fixation of technogenic As (table 2). It provides the ecological sustainability of the soils in this region towards As pollution.

Table 2. As species content (mg/kg (% from total content) in the polluted soils (1- soddy-carbonate soil, 2- chernozem) (№ of the species according table 1)

Soil, Horizon	As total, mg/kg	As avail. mg/kg	As species (mg/kg/ % from total content)					
			I	II	III	IV	V	VI
1- A_d	80	22	17 (22%)	11 (14%)	20 (24%)	26 (32%)	1 (2%)	6 (7%)
1- A_1	17	2	2 (10%)	1 (8)	10 (57%)	3 (16%)	1 (5%)	1 (4%)
1- B	17	2	1 (7%)	2 (9%)	10 (61%)	2 (12%)	1 (7%)	1 (5%)
1- C	17	3	2 (10%)	2 (9%)	10 (61%)	1 (8%)	1 (8%)	1 (4%)
2- A_1 (0-9 cm)	357	34	54 (15%)	43 (12 %)	183 (51%)	31 (9%)	30 (8%)	16 (5%)
2- A_1 (9-20cm)	49	8	6 (12%)	1 (2%)	30 (61%)	9 (17%)	1 (2)	3 (5%)

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2- A_1 (20-30cm)	17	2	1 (6%)	0,3 (2%)	13 (78%)	1 (8%)	1 (2%)	3 (4%)
2- AB	22	2	1 (4%)	0,3 (1%)	16 (63%)	2 (10%)	1 (2%)	2 (10%)
2- B_1	18	2	1 (5%)	0,3 (2%)	14 (75%)	2 (8%)	1 (49%)	1 (6%)
2- B_2	18	2	1 (7%)	0,2 (1%)	13 (72%)	1 (6%)	1 (6%)	2 (8%)
2- C	17	1	1 (7%)	0,1 (1%)	13 (78%)	0,2 (1%)	2 (1)	1 (4%)

Ecological danger of As polluted soils can be decreased by their washing by the salt solutions, that can extract the available As species (exchangeable and adsorbed forms). For the more full cleaning of the polluted soils from technogenic As can be recommend their washing by the reagent that are able to dissolve the iron oxide of the polluted soils and to release the As, connected with them.

Conclusion. Soil is the main component of ecosystem because all flows of substance, which connect atmosphere, hydrosphere, lithosphere, cross throw the soil. The sustainability (or vulnerability, or stress-bearing capacity) of biosphere to pollution has soil- chemical base. The properties of soil components ensure the quantity of pollutants (heavy metals and nonmetals) retained by soils, and the strength of their fixation. The sustainability to pollution is a property inherent in soil as provided by the system organization of numerous soil compounds of chemical elements. It is equally the true for the substances, which have as natural, so technogenic origin.

Two obligatory main groups of soil chemical components are important from ecological point of view: inert and elastic. The compounds of the first group bond the pollutants tightly; mobile substances present the compounds of the second group. There is the dynamic equilibrium between the named groups of soil components and it provides the sustainability to pollution of the soil and biosphere as a whole.

The parameters of the species of chemical elements in the polluted soils are informative for the assessment and for the control of the ecological state of degraded soils and can be active used in the choosing of the methods for the cleaning of polluted soils.

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