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TECHNOGENIC IMPACT OF MINING INDUSTRY ON ENVIRONMENT IN KARAGANDA REGION OF REPUBLIC OF KAZAKHSTAN

Abstract. This paper is devoted to evaluation of a technogenic impact of the mining industry on the environment in effecting of a gold deposit in soils. This study determined a content of 27 chemical elements in slime of the tailings and sampling materials of overburden; the analysis of structure of emissions in the atmosphere from the organized sources. It was noted that tailing dump contents barium, boron, ferrum, manganese, strontium, phosphorus, zirconia, and overburden rock has titanium. The emissions are such as sulfur oxides, nitrogen oxides, carbon oxide, ferrous oxide and the inorganic fines.

Based on the received results a total soil pollution index (P_t=20.34) was calculated that it characterizes an ecological soil conditions as hazard. In order to evaluate the soil conditions in the sanitary protection zone (SPZ) the analysis of a soil pollution level in eight cardinal directions on the SPZ border of an enterprise was performed with the six-year research results. It was found that the minimal pollution indexes (P_t) are characteristic for soils in southwest (12.53), east (13.13), northern (13.36) and the northwest (13.58) directions from the productive facilities. The high contribution to indexes is made with the gross arsenic contents (6.90, 6.93, 5.38 and 6.75) within maximum permissible concentration (MPC), respectively. The high soil pollution indexes (P_t = 32.97 and 26.06), corresponding to a critical pollution level, were determined in soils of the southeast and western borders in the sanitary protection zone. In addition, this paper demonstrates an analysis of the flora and fauna condition in a studied area and impact of the analyzing industrial facility on it. The research result can be applied to develop the maps for the estimating potential inertial landscape stability to different types of pollution and erosive hazard.

Keywords: geosystem, soils, mining industry, Karaganda region.

Introduction. The purpose of this paper is to explore the impact of the mining industry on the environment, stability of geosystems to the technogenic activity of mining industry and to estimate a capability of self-recovery of the disrupted areas in mineral deposit territories in the Karaganda region.

The research objectives is to study the existing technogenic landscapes or natural complexes in the Karaganda region and their geoecological conditions, to estimate impact of mining industry on them over time; to evaluate the possibilities of self-recovery of these landscapes.

The impact of mining industry on environment for long time is a basic issue in ecology. The Karaganda region of Kazakhstan is a center for mining and processing industry. The territory of the Karaganda region makes 428 thsnd. km^2. It is 15.7% of total area of the Kazakhstan territory. Deposits of various minerals are in the Karaganda region, from them 100% of manganese reserves in the republic, 36% of copper, 80% of tungsten, 64% of molybdenum, 54% of lead, over 40% of coal (including 100% of crozzling coal reserves). Subsoil of area is rich with rare and rare-earth metals: bismuth, argentum, antimony, titanium, nickel, cobalt, asteria, arsenic and others [1].

Impact of mining operations begins with mineral investigation and continues to completion of field exploitation that it takes decades. In addition it is important to appreciate a level of impact on environment prior to conduct of operations in the deposit and in a complex to study the geosystem of the field.

Researches of an anthropogenic impact on the environment are relevant. Thus, the paper [2] analyzed the samples of deposits from some chosen points in river heads to measure a concentration of heavy metals. Results demonstrated that concentrations of heavy metals in environ of mines and cities were higher than concentration in other areas. Pollution growth with heavy metals in the mining process should be predicted in the formation process of the regional strategies in the environment management.

A state estimation of soils is performed in the agricultural areas [3]. It was found that generally pollution was received from the anthropogenic sources, especially local industrial facilities.

The paper [4] studied the impact of the technogenic mineral formations on the environment with using the analysis and synthesis of literary data. The high mercury content was found in the area of the spent alluvial gold deposits.

For all that underground coal mining is reduced impact for the nature, but effect of rock dumps on the environment components is not excluded from researches [5]. However an underground mining method is technologically very complicated and demands some new approaches to its using [6].

Impact on landscapes does not stop after liquidation of mining enterprises that is subject to further researches [7]. The impact principles of rock dumps in coal mines are studied, and the procedure of a complex ecological evaluation of impact is improving [8]. In order to evaluate an impact of coal rock dumps on environment the materials of space survey are applied [9].

An ecological approach is used for hydrocarbon production on Arctic shelf [10]. Oil products may enter reservoirs in development process of oil deposits. Application of the correlation, factorial and cluster Pearson analysis indicates that pollution with heavy metals in soils comes from an industrial activity [10]. The analysis of references and materials of environmental impact evaluation is able to formulate the basic principles of typification of impact on the environment at the mining operations, to study a point of view on impact of mining industry on all environment components [11, 12].

The paper [13] studied the interrelation between quality of natural surface water and finding of air pollutants in the atmospheric air. It is of special interest for ecosystems and capability to use waste water for soil treatment in irrigated fields that can be as an environmental action [14].

Thus, despite the extensive literature about impact of mining facilities on environment, there is an information deficiency on long-term pollution of ecosystems and a possibility of their recovery.

As a rule, geosystems are as social-ecological and economical systems - landscapes in which connections between its components are observed. Diagnostics determinates the ecological landscape evaluation and analyzes the current state of the studied facility in the certain directions including a condition of fauna, flora, and soil, a hydrological mode, climatic conditions, etc.

Components of geosystems such as location, climatic conditions, hydrological mode, water content, deposits of underground resources, vegetation and fauna can be its strong supporting factors and vice versa. Thus all components of the landscape need to be considered to define its ecological evaluation, as a result to know a risk of environmental consequences. To determine the ecological landscape evaluation one of its major characteristics as stability is used, which can be characterized as opposition to external, negative factors of the natural and technogenic environment without losing features of geosystem.

Referring to a paper [15] the environment changes may be defined as a catastrophic ecological situation and a crisis ecological situation, which are close or it is able to become as catastrophic. The critical ecological situation and excess of permissible technogenic pressure lead to a fast increase of risk in natural resource losses. The observance of the natural conservation measures prevents the intense and conflict ecological situations. But at that point the balance in an ecological capacity of the ecosystem has to be observed.

Such areas are formed under the impact of the technogenic factors and they are called industrial landscapes. Their landscape complexes are modified under the technological features of the industry [16].

Different types of industrial landscapes are such as the ore mining, mining and processing, energy production. Depending on production types a morphological structure and spatial organization of the initial natural and economic landscapes respectively are able to change in the process of their development

and functioning. Changes in the environment and image of areas are good shown in industrial landscapes of the appropriating type, for instance, with open-pit and dump geocomplexes of mining productions. Thus, a morpholitogenic basis (relief and geological structure) of the landscape and its related properties has been changing radically.

Methods. In order to solve the objectives, the Karaganda region with its underground resource deposits was chosen and mining was started. However fields including their temporary characteristics were chosen to valuate a geosystem prior to conducting operations and its change in processing.

This paper performs the geoecological researches containing a preparatory period (collecting, analysis and material generalization in area of the deposit) and analyses the field, laboratory and analytical monitoring data. The ecological-geochemical indexes, characterizing pollution of various environment components of maximum permissible concentrations (MPC) and background values of the area of the field, were determined.

The Karaganda region on the landscape characteristics is very different and interest of researches. Steppe zones are generally characteristic for this area (figure 1, a), but in the east of the area the Karkaralinsky district called as "the forest oasis" is located, in the south– desert Balkhash district.

a *b*

Figure 1 – Wilderness steppe zone:
a – route in the Topar reservoir; b – route in Temirtau (authors' photo)

The big area is occupied with the technogenic landscapes formed as a result of mining activity (figure 2).

a *b*

Figure 2 – Technogenic landscape:
a – old spent tailing dump near Zhezkzagan; b – dump near Satpayev (authors' photo)

The substantial natural areas include the protected natural territories unaffected with the technogenic activity (table 1).

Thus, the substantial natural areas (232893 ha) of the Karaganda region makes only 0.54% of all land fund of region.

Table 1 – The substantial natural areas of the Karaganda region

No.	Name	Location area	Area, ha
1	Karkaraly National State Natural Park	Karkaralinsky district	90 323
2	Zhezkazgan Botanical Garden	Zhezkazgan city	62
	State natural wildlife areas:		
3	Belodymovsky (zoological)	Osakarovsky district	3 000
4	Belagashsky (zoological)	Bukhar-Zhyrau district	1 500
5	Kuvsky (zoological)	Karkaralinsky district	33 500
6	Bektauatinsky (zoological)	Aktogay district	500
7	Karaagashsky (zoological)	Zhanaarkinsky district	15 000
8	Kyzylaraisky (zoological)	Aktogay district	18 200
9	Ulytausky (zoological)	Ulytausky district	19 300
10	Turangovy (botanical)	Aktogay district	48
11	Kogashinsky (botanical)	Zhanaarkinsky district	6 800

For more detailed analysis the stated purpose and objectives of this paper studied the gold-ore deposit of the Karaganda region. Now the sources of impact on the environment are located in the area of the deposit: overburden dump of rock refuse, open-pit mining of deposit, dump leaching.

The geosystem integrity of the studied area, its internal unity and independence of the environment shows that the initial level before the conducting mining operations includes a steppe zone without especially expressed borders and with its interconnected components. But after the beginning of the conducting mining operations the integrity is broken with the new relief forms: mining pit, dumps of dead rock, complex of heap leaching and steppe access roads.

The applied procedure in paper [17] of the ecological and geochemical investigations permits to obtain some representative data on environmental pollution of the area, to determine the environment pollution level and to evaluate the technogenic impact of earlier functioning industrial facilities on the environment.

Results and discussion. The climatic conditions of the Karaganda region differ in a big variety that caused by large territory, length from North to South and the biggest length from West to East and rugged relief.

The climate in the studied area is extremely continental and dry, shown in big annual and daily temperature amplitudes and in instability of climatic indexes in time (every year) [18]. The natural and climatic zones are presented with steppe, semidesert and desert landscapes of a temperate zone.

In general the dry climate of the area is characteristic for the Karaganda region that caused by existence of desert and steppe vegetation. The big semi-desert areas are occupied with the weakly compacted and hilly sands where can be observed *Artemisia arenaria*, *Agropyron fragile*, *Elymus giganteus*, *Calligonum* bushes and other beach grasses.

The area of the deposit includes the following facilities: overburden dumps, open-pit mining, dumps of heap leaching, gold recovery plant with tailings dump and water pipeline, and also auxiliary industrial facilities.

The initial research level found the possible pollution facilities:

1. soils (subsoils) in the area neighboring to technogenic facilities entering borders of the Sanitary Protection Zone (SPZ);
2. the atmospheric air in a zone of active pollution and the SPZ border;
3. underground waters (productive underground reservoir), underground waters in zone of impact of the area of heap leaching (ground waters) and a surface water of Lake Balkhash.

This paper will study impact of the gold-ore deposit on soils.

The areas, impacting on a condition of the landscape, are open-pit mining, tailings dump, overburden dumps.

The analysis results of slime from the tailings dump demonstrate that slime content has 27 chemical elements such as barium, boron, ferrum, manganese, strontium, phosphorus, zirconia, i.e. as well as in content of the mill tailings (figure 3). However, the overburden rock has titanium in difference from sampling materials of the tailings dump (figure 4).

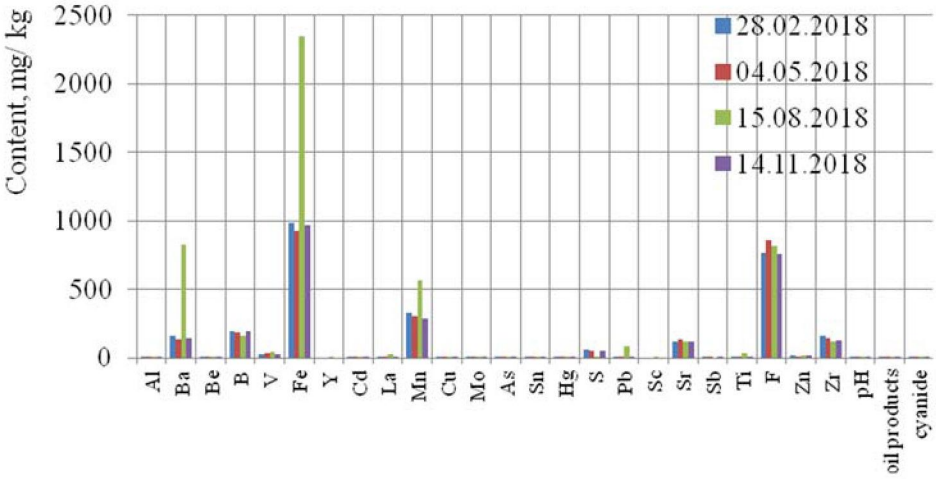

Figure 3 – The analysis results of slime from the tailings dump (observation point 0101)

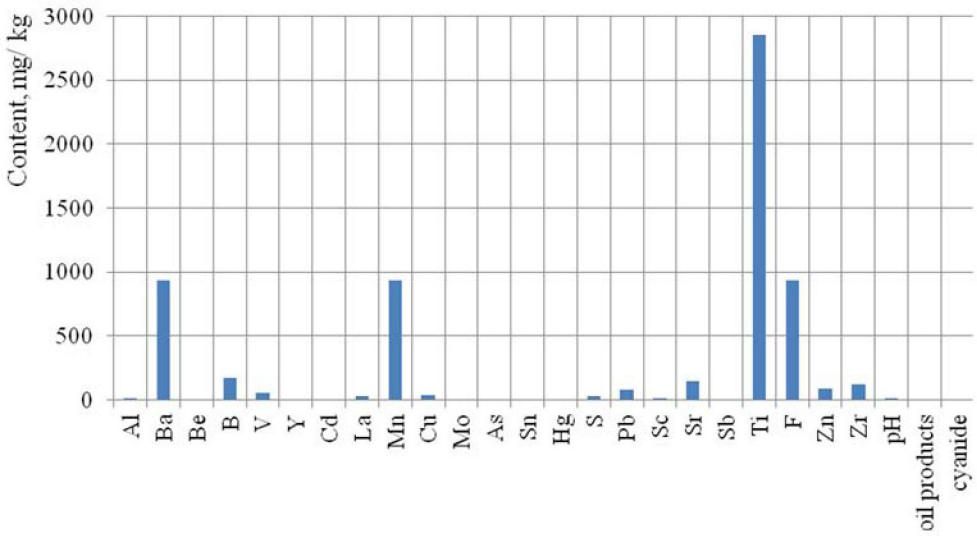

Figure 4 – The analysis results of overburden rocks

Analyzing the structure of emissions in the atmosphere from organized sources (figure 5), it is noted that the main contribution includes sulfur oxides, nitrogen oxides, carbon oxide, ferrous oxide and the inorganic fines. The insignificant emissions of acetone, from sources of chemical plant, chlorine hydride and hydrocianic acid are observed.

The approximate structure of associations of air pollutants at the gold-containing ores mining is presented with the following elements [19]:

- lead, arsenic, zinc - elements of 1st hazard class;
- manganese, copper, antimony – elements of 2nd hazard class;
- sulphide sulphur - element of 4th hazard class;

On the basis of a studied structure and content of the ecologically hazard chemical elements in solid wastes and raw materials of the deposit, including the discovery of these elements in soils (subsoils) of the area, the following association of air pollutants (heavy metals and toxic elements) was accepted:

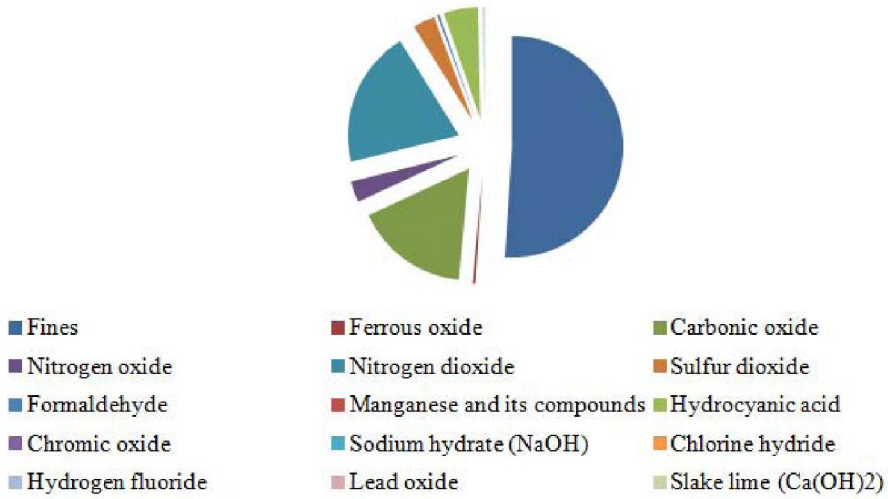

Figure 5 – Structure of emissions in atmosphere from organized sources

- mercury, benzpyrene, lead, beryllium, cadmium, zinc – 1st hazard class;
- copper, molybdenum, cobalt – 2nd hazard class;
- manganese, titanium, barium, vanadium, strontium –3rd hazard class;
- gold, phosphorus, cyanides, sulfur, amount of polycyclic aromatic hydrocarbons (PAHs) – 4th hazard class.

This association of air pollutants was a basis to evaluate the pollution of soils including a local natural and natural-technogenic background, it was also considered to estimate pollution of atmospheric air and underground waters [17, 20-22].

Concentration values of air pollutants in an approbation point on border of the project sanitary protection zone (SPZ) at distance of 3.1 km to the east from the mining site, and at 3.2 km to the south of the heap leaching site were taken for a geochemical background. The choice of this point is motivated with a short distance from an ore complex that it considers a natural ecological-geochemical background of this area and enough distance from sources of an anthropogenic impact on this area during the investigation and opening of the deposit.

Average results of content of air pollutants in the soils selected on the SPZ border for 2012-2018 (figure 6) are illustrated below.

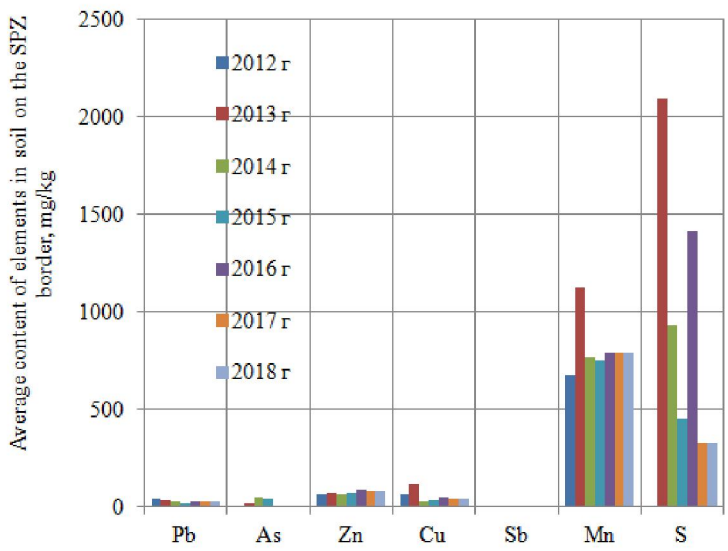

Figure 6 – Average content of air pollutants of associations in the soil on the SPZ border for 2012–2018

Soils of the sanitary protection zone of the deposit on the gross content of heavy metals in maximum permissible concentration shares by four-year research results are characterized by the following geochemical row:

$$As(11.7) > S(5.78) > Zn(3.20) > Cu(2.40) > Sb(1.52) > Pb(0.98) > Mn(0.54).$$

Table 2 – Evaluative criteria of soil conditions [19]

Name of parameters	Ecological state of environment			
	Accepted (relatively satisfactory)	Hazard	Critical (extraordinary)	Catastrophic (disastrous)
Total pollution index (P_t)	Less 16	16-32	32-128	Over 128

Calculating an average total pollution index (P_t) of soils of the sanitary protection zone for seven substances entering into association of air pollutants, established for the studied area, the value 20.34 was received that characterizes an ecological condition of soils as hazard.

In order to evaluate a condition of soils of the sanitary protection zone the analysis of soil pollution level in eight cardinal directions on the SPZ border of the enterprise was performed using the six-year research results.

Results of the analysis of soil samples on border of sanitary protection zone on 8 points are presented in figure 7.

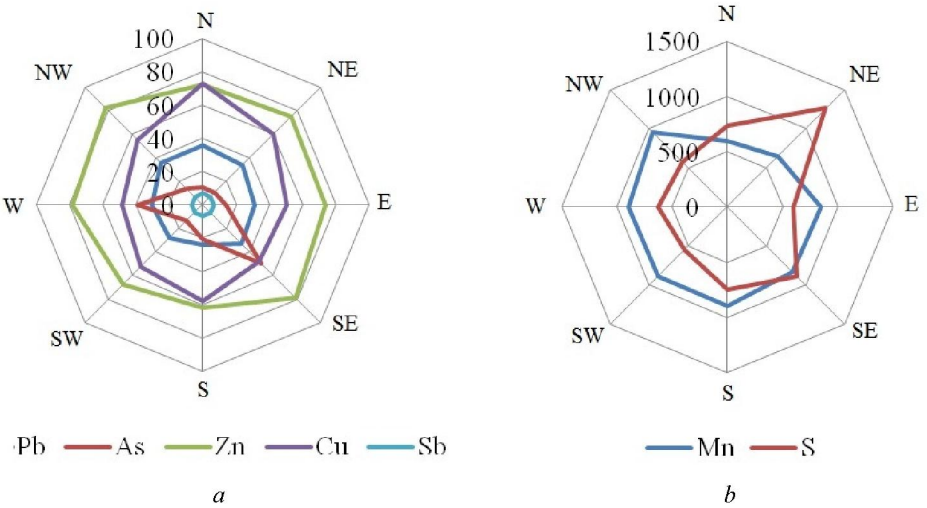

Figure 7 – Average content of air pollutants in soil on the SPZ border for 2012–2018 on 8 points: a – lead, arsenic, zinc, copper, antimony; b – manganese, sulfur.

Comparing of the calculated total soil pollution indexes of the sanitary protection zone it was found that minimal pollution indexes (P_t) are characteristic for soils in southwest (12.53), east (13.13), northern (13.36) and northwest (13.58) directions from the industrial facilities. The large contribution to a value of indexes is made with the gross arsenic contents (6.90, 6.93, 5.38 and 6.75 respectively) within MPC (maximum permissible concentration).

Sulfur content makes 3.47 MPC (SW), 3.72 MPC (E), 4.59 (N) and 3.63 MPC (NE).

Copper content equals 2.30 MPC (SW), 2.20 MPC (E), 3.16 (N) and 2.42 MPC (NE).

Zinc content is 2.95 MPC (SW), 3.21 MPC (E), 3.15 (N) and 3.57 MPC (NE).

Antimony content equals 1.43 MPC (SW), 1.53 MPC (E), 1.55 (N) and 1.48 MPC (NE).

Lead content makes 0.89 MPC (SW), 0.98 MPC (E), 1.12 (N) and 1.11 MPC (NE).

Manganese content is 0.59 MPC (SW), 0.56 MPC (E), 0.40 (N) and 0.64 MPC (NE).

The received results confirmed the theory that including the prevailing winds in this area the minimal concentrations of air pollutants, which characteristic for gold deposits, shall be observed.

Thus, these results may conditionally be considered as indexes of a natural geochemical background of the studied area.

Under value of total pollution index calculated on a gross content of minerals, the ecological condition of soils in the northern and northwest directions is characterized as accepted, and in northeast as hazard but close to an accepted value.

The large pollution soil indexes (32.97 and 26.06) corresponding to the critical pollution level were determined respectively in soils of southeast and western borders of the sanitary protection zone.

Sulfur content is 5.58 MPC (SE) and 3.92 MPC (W), i.e. it is not significant above than a conditioned background.

Copper content equals 2.07 MPC (SE) and 2.10 MPC (W), i.e. it is approximately twice less than the conditional background.

Zinc content makes 3.44 MPC (SE) and 3.40 MPC (W), i.e. it is at a level of the conditional background.

Antimony content equals 1.50 MPC (SE) and 1.49 MPC (W), i.e. it is at a level of the conditional background.

Lead content is 1.02 MPC (SE) and 0.96 MPC (W), i.e. it is at a level of the conditional background.

Manganese content makes 0.55 MPC (SE) and 0.60 MPC (W), i.e. it is at a level of the conditional background.

Under value of total pollution index calculated on a gross content of minerals, the ecological condition of soils in the southeast and western directions is characterized as a critical (extraordinary) value.

Thus the increased arsenic and sulfur concentrations on the western SPZ border are observed near open-pit mining that is an ore geological body, it can be a natural geological reason of high contents of elements.

In other directions values of total pollution soil indexes within 15.98-17.27 were received.

It may be noted that the lead and copper contents in soils of the SPZ in all directions is at one level within 0.75-1.12 MPC and 2.07-3.16 MPC respectively.

Zinc content (2.69-3.57 MPC) and sulphur content (3.47-5.58 MPC) are practically recorded at one level, (except for NE direction). Antimony content within 4 years has never recorded in soils of the southeast, southwest and northwest directions. In other directions the antimony content is in limits of 1.43-1.55 MPC.

In reference to the contents of water soluble arsenic and mercury in soils on the SPZ border, they are at a level below than a range of definition in the testing laboratories and make: arsenic - <005 at 2.0 mg/kg MPC, mercury - <006 at 2.1 mg/kg MPC. Concentrations of water-soluble zinc in all selected soil samples are approximately at one level and balance within 0.0495-0.0825 mg/kg.

MPC (maximum permissible concentration) for water-soluble zinc in soils were not determined. Thus, from the above, it can be concluded that soils of the sanitary protection zone of the enterprise are characterized as a facility with low migration and water properties.

Initial year can be chosen 2012 when the geosystem was not yet exposed. In 2014 some industrial facilities were constructed such as tailings dump, building of washing plant, field camp, polygon of household waste, warehouses, etc.

However, it is important to note that the pollutants getting to ambient air in the process of operations from the organized high-level sources and unorganized low sources in process of dispersion settle on soil near the industrial facilities and in the sanitary protection zone (1000 m). The representatives of flora and fauna are potentially affected.

In the analyzed area the following ecological groups of plants were found: halophytes, ephemers and ephemeroids. A basis of vegetable communities in September in the arid salted area was made with *Chenopodiaceae* plants which were at a stage of blossoming and fructification.

In 2 years (2015) by the monitoring results in this area of the deposit 51 species of plant relating to 20 families were found.

As a result of the monitoring sites were recorded in the studied area:

- without vegetation – area of open-pit mining, dumps, tailings dump;
- subject to a considerable road digression – enterprise territory, polygons of household waste;

- almost not changed specific species composition and structure of communities – sanitary protection zone;

- with change of vegetable communities including ruderal, mesoxerophytic species and the cultivated plant species which were absent in this area before – sites near tailings dams and residential zone of the enterprise.

If to research fauna of the studied area then it is possible to note as follows:

- the constant load on fauna by reason of presence of humans and machines as this area is exposed to a continuous technogenic impact;

- the animal habitats are taken away, especially considerably affects mammals and birds.

The activity of the studied industrial facility was resulted by the anthropogenic modifications of landscapes.

Flora and fauna of the industrial facility for the reporting period were analyzed:

- 105 plant species and 79 animal species;

- every year of the analyzed period 4 plant species were recorded (3.8 %) (*Salsola arbusculaeformis* Drob; *Lasiagrostis splendens* (Trin.) Kunth; *Rheum tataricum* L.; *Limonium suffruticosum* (L.) Kuntze) and 3 animal species (3.8 %) (*Aquilla nepalensis*; *Falco tinnunculus*; *Corvus corone*);

- in 2014 and 2016, 12 plant species (11.4%) and 15 animal species (19%) repeated;

- in 2013 and 2015, 26 plant species (24.8%) repeated;

- in 2013 – 2015, 4 animal species (5%) repeated.

Conclusion. After restoration of the areas broken with mining industry the restored landscapes are observed. It is possible to call their as post-industrial landscapes. However it is considered that the economic modified landscapes can be more productive and substantial in comparison with natural as they are better adapted to the anthropogenic impacts.

The pollution of soil cover, flora and fauna in the territory of the most industrial facility and its sanitary protection zone were estimated.

The direct research purpose of soil cover in the area of the deposit is to evaluate indexes of subsoil conditions in sites which will be under a technogenic impact during the perspective mining and ore processing form and to control indexes of subsoil conditions in the polluted area during functioning of the deposit [17]. Comparison of substance concentrations in soils of the deposit is made with the set up MPC (maximum permissible concentration).

But it is important to note that the increased content of some chemical elements in the soil are not always pollution indexes. It is necessary to consider that elements can be mineral deposits.

Data of theoretical papers were analyzed and they demonstrate that some chemical elements, containing in soils of the deposit, were initially as the associated components.

Thus the high arsenic content has natural character as arsenic is an element associating to gold-bearing formations – a gold indicator. Abnormal arsenic concentration is characteristic for the soils which formed over deposits of polymetals. Ore samples contain sulfur more twice higher than contents in rock refuse. Waste practically does not differ on the content of zinc, antimony, copper, lead and manganese.

The received data confirm the association of air pollutants for the enterprises on gold ore mining which was offered in a regulatory document on the valuation level of environmental pollution [19]. By results of sample analysis on other substances with set up MPC values the high concentration were not observed.

This risk factor especially impacts on settlement of small mammals. Organization of construction projects, roads leads to the artificial differentiation of habitats. It results to a direct reducing habitats and isolation of the separate groups of the small mammals.

The monitoring found the sites without vegetation such as an area of open-pit mining, dumps and tailings dump.

The areas are subject to a considerable road digression – enterprise territory and polygons of household waste;

The areas are almost not changed specific species composition and structure of communities – a sanitary protection zone;

The result of this paper can be the maps for the estimating potential inertial landscape stability to different types of pollution and erosive hazard.

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ҚАЗАҚСТАН РЕСПУБЛИКАСЫ ҚАРАҒАНДЫ ОБЛЫСЫНЫҢ МЫСАЛЫНДА ТАУ-КЕН ӨНЕРКӘСІБІНІҢ ҚОРШАҒАН ОРТАҒА ТЕХНОГЕНДІК ӘСЕРІ

Аннотация. Алтын кен орнының топыраққа әсер ету мысалында өнеркәсіптің қоршаған ортаға техногендік әсерін бағалауға арналған жұмыс. Бұл жұмыс қалдық қоймасының шламда және үстіңгі қабаттың үлгілерінде 27 химиялық элементтерінің құрамын анықтауға; ұйымдастырылған көздерден атмосфераға шығарындылардың құрамын талдауға арналған. Қалдық қоймаларында – барийдің, бордың, темірдің, марганецтің, стронцийдің, фосфордың, цирконийдің, ал үстіңгі қабаттағы жыныстарда – титанның құрамдары бейім болғаны белгіленген. Шығарылындарда негізгі үлесті күкірт оксидтері, азот оксидтері, көміртегі тотығы, темір тотығы, бейорганикалық шаңы құрайды. Алынған нәтижелер негізінде топырақтың ластануының жалпы көрсеткіші (Зс = 20.34) есептелген, бұл топырақтың экологиялық жағдайын қауіпті ретінде сипаттайды. Санитарлық-қорғаныш аймағының (СҚА) топырағының жағдайын егжей-тегжейлі бағалау мақсатында кәсіпорынның СҚА шекарасында жарықтың сегіз бағытында топырақтың ластану деңгейіне алты жылдық зерттеу нәтижелерін пайдалана отырып талдау жүргізілді. Ең төменгі ластану көрсеткіштері өнеркәсіптік нысандардан (Зс) оңтүстік-батыс (12.53), шығыс (13.13), солтүстік (13.36) және солтүстік-батыс (13.58) бағыттарында орналасқан топырақтарына тән. Көрсеткіштердің шамасына ең үлкен үлесті мышьяктың жалпы құрамы 6,90, 6,93, 5,38 және 6,75 ШРК тиісінше қосады. Топырақтардың ластануының ең жоғарғы көрсеткіштері (Зс = 32.97 және 26.06) критикалық ластану деңгейне сәйкес келетін санитарлық қорғау аймағының оңтүстік-шығыс және батыс шекараларында орналасқан топырақтарында орын алған. Бұдан басқа, мақалада зерттелетін аймақтың флорасы мен фаунасының жай-күйі және қаралатын өнеркәсіп объектісінің әсері талданады. Зерттеу нәтижелерінің қортындысы ластаудың және эрозиялық қауіптің түрлеріне ландшафттардың әлеуетті инерциялық тұрақтылығын бағалау карталарын әзірлеу үшін пайдаланылуы мүмкін.

Түйін сөздер: геосистема, топырақ, тау-кен өнеркәсібі, Қарағанды облысы.

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ТЕХНОГЕННОЕ ВЛИЯНИЕ ГОРНОЙ ПРОМЫШЛЕННОСТИ НА ОКРУЖАЮЩУЮ СРЕДУ НА ПРИМЕРЕ КАРАГАНДИНСКОЙ ОБЛАСТИ РЕСПУБЛИКИ КАЗАХСТАН

Аннотация. Работа посвящена оценке техногенного влияния горной промышленности на окружающую среду на примере воздействия золотоносного месторождения на почвы. Данная работа заключалась в определении содержания 27 химических элементов в шламе хвостохранилища и пробах вскрыши; анализе состава выбросов в атмосферу от организованных источников. Отмечается, что в хвостохранилище преобладает содержание бария, бора, железа, марганца, стронция, фосфора, циркония, а в породах вскрыши – титана. В выбросах основной вклад приходится на оксиды серы, оксиды азота, оксид углерода, оксид железа, пыль неорганическую. На основе полученных результатов рассчитан суммарный показатель загрязнения почв (Зс=20.34), что характеризует экологическое состояние почв как опасное. В целях детальной оценки состояния почв санитарно-защитной зоны был произведен анализ уровня загрязнения почв по восьми направлении сторон света на границе СЗЗ предприятия, используя результаты шестилетних исследований. Установлено, что наименьшие показатели загрязнения (Зс) характерны для почв в юго-западном (12.53), восточном (13.13), северном (13.36) и северо-западном (13.58) направлениях от производственных объектов. Наибольший вклад в величину показателей вносят валовые содержания мышьяка 6.90, 6.93, 5.38 и 6.75 ПДК соответственно. Наибольшие показатели загрязнения почв (Зс = 32.97 и 26.06), соответствующие критическому уровню загрязнения, были установлены соответственно в почвах юго-восточной и западной границы санитарно-защитной зоны. Кроме того, в статье проведен анализ состояния флоры и фауны исследуемого региона и влияние на него рассматриваемого промышленного объекта. Результатом исследования могут использоваться для разработки карт оценки потенциальной инерционной устойчивости ландшафтов к разным видам загрязнений и эрозионной опасности.

Ключевые слова: геосистема, почвы, горная промышленность, Карагандинская область.

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