INFLUENCE OF MINING AND CONCENTRATION WORKS ACTIVITY ON LAND RESOURCES

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Abstract. The research provides assessment of current and longer-term consequences of iron ore open pit mining for land resources of adjacent areas. There are applied methods of analysis of fund materials; comparison of topographic sheets and special maps, visual observation, soil testing, laboratory analyses and statistic processing of data obtained. It is revealed that facilities of iron ore mining and concentration waste accumulation (dumps and tailing ponds) are destructive factors for the local lithosphere, dust chemical contamination being the basic one. The steps aimed at reducing negative impacts of technogenic objects of the mining and raw material complex on the environment are under study.

Introduction. In terms of the environment, iron ore open pit mining is one of the most harmful and destructive. Consumptive use of Kryvyi Rih region's ecosystems and resources for the last 140 years has caused enormous destruction of the local landscape, litho- and hydrosphere. Extensive mining of Kryvyi Rih iron ore deposits through the Soviet times has escalated since the establishment of the market economy and private property reaching 5.5 bln t of raw iron ore [1]. Owners' irresponsibility for anti-environmental activities and low environmental abuse charges provide the basis for the region's continuous exploitation and reduce prospective investment of resource-saving technologies to be introduced here.

The research is aimed at determining consequences of mining and concentration works' (GOKs) activity affecting Kryvyi Rih region land resources. To achieve this aim, solution of the following tasks is envisaged:

- studying basic stages of formation of modern ideas concerning the role of the environment in Kryvyi Rih enterprises' economic activity in terms of iron ore mining;
- providing characteristics of primary factors and consequences of GOKs' activity affecting Kryvyi Rih region's landscape and environment;
- analyzing available data on GOKs' impacts on the environment;
- conducting field and laboratory investigations of the influence of waste accumulation areas of mining enterprises on land resources;
- developing recommendations on improving the environment of technologically disturbed and polluted lands.

Formation of modern ideas on the environment role in the region economic activity. As is known, there are two generalized models of the technogenic type of the economic development in terms of the environmental-economic policy - *frontal economy and the environmental protection concept*.

The frontal economy was widespread in the world and in Ukraine in particular in the 1980s. According to this concept, all lands and natural resources were considered unlimited and inexhaustible. Both in theory and practice, the economic growth was based on two factors only - labour and capital, without considering any natural resources, amounts of their consumption and potential restoration. This approach was justified by the low level of productive force development and great potential self-regulation in the biosphere that caused no global changes so far.

Consequences of this economic stage for Kryvyi Rih environment included significant destruction of the surface relief and withdrawal of hundreds of hectares of agricultural lands because of unsystematic creation of many iron ore open pits and underground mines and accumulation of millions of tons of rocks in overburden dumps of open pits and waste dumps of underground mining. The local rivers Salsahan and Inhulets, the regional underground hydrosystem and land resources were seriously damaged.

The first damages of Kryvyi Rih region landscape and environment were caused by the mining enterprises of Rakhmanovo-Kryvorizke, Almazne, Pivdenne and Novokryvorizke associations created at the end of the 19th century in 1885-1886. In the Soviet times, the same principles of the frontal economy were guiding in escalating rich iron ore mining accompanied by creation of the mine administration and several underground mines. In 1950s-1970s, there were built large-scale mining and concentration works (YuGOK in 1955, CGOK in 1956, SevGOK in 1958, NovoKryvokizkyi in 1959 and InGOK in 1965) oriented on "poor" low-grade iron ore mining and concentration to obtain marketable ore.

Newly established GOKs multiplied the destructive impact of mining on the regional landscape and environment, these changes becoming irrevocable. Huge open pits and dumps, landfill sites of concentration wastes (tailing ponds) and intensive dust-gas emissions turned hundreds of hectares of mining sites into dead zones and powerful sources of dust contamination for adjacent lands. The consumptive attitude to the environment on this stage of Kryvyi Rih region economic development did not provide any nature-saving and restoration steps at mining facilities as the increased iron ore output was the only top priority. The mentioned approach resulted in numerous destroyed and polluted areas and greatly affected the regional biogeocenose.

Awareness of exhaustibility of natural resources, escalating environmental instability in industrial regions and acknowledgement of hazards of further application of the frontal economy made many world countries change their attitude to the planet's environment at the end of the 1970s. In 1972, in Stockholm, the Declaration of the UN Conference on Environmental Issues was adopted declaring that maintenance and improvement of the environment is an essential problem affecting people's welfare and the economic development of all world countries [2].

Consideration of nature laws in solving economic problems have gradually encouraged the transition from the frontal economy to ***the concept of environmental protection*** that requires economic entities' taking account of environmental consequences of production. Since then, in many countries, including Ukraine, there have appeared state structures of nature protection and accelerated legal activity on the issues of regulating resource use standards and procedures. Active international cooperation on environmental issues has begun worldwide [3]. In Ukraine, the law "On Environmental Protection" has been valid since 1991 [4].

Under *the environmental protection concept*, Ukraine has reached some environmental stabilization, yet there has not been any qualitative improvement as **the general technogenic type ideology** of the environmental-economic development has not changed. Economic interests, industrial acceleration and application of scientific and technological achievements to increasing profits remain of primary importance.

The economic development of the technogenic type is characterized by ***the externality effect*** when some negative environmental and economic consequences of the economic activity occur and corresponding economic entities are not responsible for the damages [5]. An example of this is any occurrence of harmful emissions into the atmosphere and pollutant discharges into water reservoirs, their consequences being evident not only in places of discharges, but also along the whole dispersion front with the wind and water currents. Damages are normally not compensated to aggrieved parties.

In 1981, following the USSR initiative, the UN General Assembly approved the Resolution "On Historical Responsibility of States for the Preservation of Nature for Present and Future Generation". A year later, on October 28, 1982, 111 UN General Assembly Members adopted the World Charter for Nature [6] that fixed the dependency of human life on natural systems functioning.

Further evolution of the nature preservation concept resulted into that of ***sustainable social and economic development*** when the heads of 178 world states including Ukraine signed "**Agenda 21"** during the UN Conference on the Environment and Development (Rio de Janeiro, June 3-14, 1992) [7]. The indicated ideas were approved on the World Environmental Summit of 2002 in Johannesburg (South Africa) that formulated the modern definition of sustainable development comprising three components - economic efficiency, social equality and environmental sustainability. It is defined that **sustainable social and economic development** *is the one under which optimal satisfaction of people's needs is achieved under con-*

ditions of using all possible resources in the way that generations to come will be able to satisfy their needs accordingly [3]. Therefore, in the modern formula of industry, **nature** (the environment) should go first followed by **capital** (economy).

Certain intensification of Ukrainian state institutions, business and community activities aimed at introducing sustainability ideas started in 2010 when Euro-integration became a priority of the country's policy. The state declared **its full support of sustainable economic and social development** that was confirmed by the Law of Ukraine "On the Fundamental Principles (Strategies) of the State Environmental Policy of Ukraine for the Period until 2020" as of December 21, 2010 (№ 2818-VI) [8].

The Decree of the Cabinet of Ministers of Ukraine "The State Strategy of Regional Development for the Period until 2020" (August 6, 2014, № 385) also became a strategic document developed according to European standards [9].

After signing the Ukraine-EU Association Agreement, a new stage of Ukraine's economic development commenced as this document contained clear suggestions on implementing sustainable development principles in environmental, social and economic areas [10]. The Decree "On Strategy for Sustainable Development "Ukraine-2020" approved by President on January 12, 2015 (№ 5/2015) has become one of the steps aimed at introducing European living standards in Ukraine [11].

The Law of Ukraine "On Environmental Impact Assessment" of May 23, 2017 (№ 2059-УІІІ) is intended to encourage industrial greening [12].

Thus, the sustainable social and economic development concept has been adapted to Ukrainian conditions for over 10 years, yet permanent economic crises, absence of clear development strategy, recurrent changes of governments and their priorities could not enable proceeding from sustainability declaration to its implementation. Drafted legislative and regulatory documents on economy greening issues are neither efficiently implemented nor observed. The current low charges for natural resource use, harmful emissions/discharges and industrial waste disposal cannot compensate actual damages to the environment and people's health. They are also unable to provide industrial producers with required incentives to care about the environment to a greater degree than about their own profits.

The natural resource-intensive and destructive ***technogenic type of the economic development*** is still prevailing in Ukraine' economy, both in general and in that of Kryvyi Rih region in particular. This development type is characterized by large-scale and intensive use of nonrenewable resources (minerals) only, but also renewable ones (soils, water, etc.) with the rate exceeding their self-restoring capacity.

Privatization of mining enterprises has not resulted in increased investment in equipment and technology necessary for iron ore mining and concentration. The region's vital issues of concentration tailings re-treatment, application of oxidized ores, manufacturing of construction materials from waste rocks, introduction of internal dumping technologies and reduction of hazardous emissions into the atmosphere and water reservoirs. There is continuous intensive withdrawal of extra land for disposal of iron ore mining and concentration wastes. Operations on restoring mined and disturbed lands are not envisaged in deposit rent agreements and are usually underfinanced or financed randomly and slowly.

Characteristics of factors of mining and concentration enterprises' activity affecting Kryvyi Rih region landscape and environment. Kryvyi Rih landscape was damaged the most in the early 1960s because of introduced "poor" low-grade iron ore mining (ferruginous quartzite of 17-42 % iron content) by the open pit mining method accompanied by its subsequent concentration to produce a 65-67 % Fe concentrate. The five operating mining and concentration works (GOKs) of Kryvyi Rih are engaged in iron ore mining at nine open pits of over 300 m deep with the total area of about 6 thousand hectares. Mining and concentration of 1 ton of raw ore by current technologies results in 3-4 tons of wastes accumulating in enormous waste dumps and either multi-layered or flat tailing ponds (landfills) containing concentration wastes.

There are almost 4 bln m^3 of accumulated industrial wastes covering the area of almost 12 thousand hectares, 5 thousand hectares of which are occupied by waste dumps and over 7 thousand hectares - by tailing ponds. The total area of the city and suburban sites of disturbed after-mining lands makes about 34 thousand hectares, their restoration rates being extremely low (0.2-1.7 % per year) [1]. At the same time, waste dumps and tailing ponds are growing by 55-60 million m^3 of waste materials annually, tens of hectares being withdrawn additionally. Mining landscapes occupy almost 30% of the city area which is 431 m^2, this proportion constantly increasing. This figure should be supplemented by 70 % of adjacent lands including arable ones and suburban agricultural facilities disturbed under the action of dust and highly mineralized water filtrates from waste dumps and tailing ponds.

Thus, iron ore concentrate manufacturing at modern mining and concentration works of Kryvyi Rih results in formation of huge man-made formations of accumulated mining and concentration iron ore wastes.

Waste materials from dumps and tailing ponds contain high percentages of fine fraction components of the average particle diameter d_{av}= 0.089 mm [13], the latter becoming a source of intensive dusting. Besides, on mature surfaces of technogenic facilities, there are created *weathering crusts* of destroyed rocks with formed fine particles being an additional dusting sources. Under the action of wind, dust particles go up into the air and are transported as dust clouds over great distance and accumulated in topographic lows. Taking account of the fact that in Kryvyi Rih, northern, north-eastern and eastern winds (over 50 % of all river rhumbs) [14] prevail, it is evident that dust emissions of the mining and concentration works propagate along the wind plumes over the suburban villages and agricultural lands. Kryvyi Rih mining and concentration enterprises have been functioning for over 60 years, thus investigations into consequences of long-term dust impacts on the lands adjacent to the waste dumps and tailing ponds are of particular interest.

Consequences of long-term impacts of waste accumulation facilities of the mining and concentration works on land resources. Analysis of researches and publications on the issues of local GOKs affecting land resources reveals that investigations into dust and gas emissions of mining and concentration enterprises affecting the lithosphere indicate the greatest influence of the chemical composition of aerogenic pollutants on soil conditions. According to this, the majority of known works deal with the problem of accumulated heavy metals and the mechanism of their further translocation into plants and plant products [14-23].

The chemical composition of the dust on the GOK facilities is determined by the composition of rocks at waste accumulation places. According to V.D. Babushkin and his co-authors (1971), the primary pollutant substance of waste dumps and tailing ponds is dust containing from 20% to 70% of silicon dioxide [22]. The rest dust components are transitive and intransitive metals, some semimetals (metalloids) and non-metals. The charts of waste disposal sites of YuGOK and Novokryvorizkyi GOK indicate that a kilogram of tailings of "Voikovo" and "Obiednane I Karta" tailing ponds contains 112 g of Fe total, 15 g of magnetite quartzite (Fe_{mag}), 56 g of iron oxide (II) (FeO), 81 g of iron oxide (III) (Fe_2O_3), 614 g of silica dioxide (SiO_2), 39.8 g of magnesium oxide (MgO), 1.2 g of manganese oxide (MnO), 53.4 g of sodium and potassium oxide mixture (Na_2O+ K_2O), 1.02 g of sulfur (S), 1.71g of phosphorus oxide (P_2O_5) and 2.77 g of micro-components of nickel, copper, zinc, lead, cobalt, molybdenum, tungsten, chromium, mercury, thallium, etc. Rocks stored in waste dumps have almost the same chemical composition [13; 15; 17; 23-24]. It is determined that inside waste dumps and multilayered tailing ponds, under the action of atmospheric precipitation, seasonal temperature changes, highly mineralized waters, changeable alkalinity, etc. there occur some physical and chemical processes resulting in readily soluble salts (sulphate and chloride of K, Na, Ca, Mg, carbonate of alkaline and alkaline-earth metals). At the same time, there is hydrolysis of silicate and base leaching of KOH, NaOH, $Mg(OH)_2$, $Ca(OH)_2$, silica and $MnCO_3$ into moveable alkaline waters. The least soluble are compounds of Fe, Mn, P and heavy metals (Cr, Ni, Co, Cu, Zn, Pb, Ni, etc.) which are difficult to transport by water, yet they can migrate over large distances with dust [17; 21-22].

Concentration of admixtures of the mentioned metals and their compounds in dust samples from different facilities of certain GOKs can vary from traces to several milligrams, yet no element exceeds the current sanitary norms. At the same time, it is known that being deposited on the soil surface, dust components including heavy metals are capable of accumulating and due to the summing effect, local concentration of certain elements can considerably increase.

To determine the rate of escalation of chemical contamination of soils by certain dust components from waste dumps and tailing ponds and longer-term consequences of their influence on the whole range of agrochemical parameters of soils and the rate of their chemical contamination, special investigations into dynamics of agrochemical indicators of agricultural lands were conducted.

Research results and their discussion. The testing site is presented by a land lot of 10 thousand hectares in the northern part of Shyroke district of Dnipropetrovsk region. On its boundary, in the northern and north-eastern part, there are “Livoberezhni” (Left-Bank) dumps (in operation since 1969, 823 hectares, (from now on the area is given as of 2016)) and the multi-layer tailing dump “Voikovo” (in operation since 1977, 592 hectares) of the PJSC YuGOK. The multi-layer dump “Obiednane” (in operation since 1964, nearly 695 hectares) shared by the PJSC YuGOK and the mining and concentration works (GOK) of the Mining Division (MD) of ArcelorMittal Kryvyi Rih (AMKR) is in the east and dumps 2-3 of the MD AMKR (in operation since 1972, nearly 498 hectares) are in the west. So, technogenic facilities of two typical Kryvyi Rih GOKs functioning for over 60 years are in a semicircle around the chosen site.

The facilities situated to leeward are as high as the operation sites (dust formation sources) more than 140 m over the level of the surrounding landscape and continue growing.

The central and eastern parts of “Livoberezhni” dumps consist of oxidized ferruginous quartzite, the north-west part - of crystalline schist, non-metal and low-metal quartzite. Dumps 2-3 of the MD AMKR are made of overburden rocks (low levels) and at present oxidized ferruginous quartzite is being stockpiled there. The prevailing mineral of the tailings is quart (up to 65%), other minerals are magnetite, hematite, carbonate, clay silicate, calcium, ferric hydroxides, apatite, trace elements etc.

Results of agrochemical monitoring of soils were analyzed retrospectively on the basis of archives (1980-2003) of the state institution “Institute for Soil Protection of Ukraine”, Dnipropetrovsk branch.

To estimate the character and degree of agrochemical changes in the condition of land resources on the area under study, 115 samples of soil were analyzed. The samples were taken at substantiated points of the specially developed network of monitoring test sites the choice of which considered the character the technogenic pressure on the area under study. In most cases the size of monitoring sites made 500×500 m.

Each soil sample was further studied by laboratory methods (at laboratories of the state institution "Institute for Soil Protection of Ukraine", Dnipropetrovsk branch) for contents of productive moisture, labile phosphorus and potassium (by Chirkov method); nitrogen mineral and easily accessible for plants organic compounds; humus (by Tiurin method); metabolic calcium, sodium, magnesium compounds; total carbonates. Other measurements included: moisture absorption capacity of soils; acidity, solid residue of water extract; content of total and labile (resulted from ammonium-acetate extracting at pH=4.8) forms of iron, manganese, lead, cadmium, mercury, copper and zinc; remains of pesticides (DDT, hexachloran and 2.4-D) and density of radioactive contamination (cesium-137 and strontium-90).

The investigation resulted in the conclusion that the dominating soil of the area under study is southern chernozem (69% of the studied monitoring sites). Other types of soils are alkaline chernozem common for terrace plains, divide lowlands, low old terraces of the Inhulets river and diluvium tails. Saline areas among these soils are the result of saline chloride-sulphate ground water flooding.

Analysis of the archive data on agrochemical observations of the above territory soils in 1988-1990 shows that the productive moisture level during that period fluctuated within 144-237 mm in the 0-100 mm layer that is considered to be very good according to the current criteria. In 2004 the amount of the productive moisture in the soils decreased to the "good" level and remained the same in 2016. According to the data of 1988-1996, the pH level of the water extract fluctuated within 6.7 to 7.6, in 2004 – within 7.2-7.5, in 2016 - within 8.4 – 7.2), i.e. this indicator changed from subacid to subalkali. Considering the fact that pH 8-9 is already characteristic of saline and alkali soils, it can be concluded that for the last 10-12 years the soils have undergone certain salinization due to filtrates of highly mineralized waters of the nearby tailing ponds.

Analysis of the 30 years' observations of the humus content in agricultural soils of the area under study shows that the content is mostly mean (2.1-3.0 %) and elevated in some places (3.1-4.0 %). However, for the last 20 years (from1996 to 2016) the humus content has decreased by average 0.36% (in Ukraine for this period its content has decreased by average 0.22%, data as of 2014) resulting in corresponding land productivity decrease. The above mentioned is a negative phenomenon as restoring the humus content by 0.1 % in natural conditions requires 25-30 years [24]. Soil impoverishment may be caused by both the national-level trends of agricultural workers' violation of farming culture (commitment to exhaustive cropping, violation of crop rotation, insufficient mineral and organic fertilizer treatment) and technogenic factors (soil erosion and the above mentioned alkalization without plastering). As land productivity of the area under study has decreased by 0.14 % which is above the average national indices, this fact may be considered as the one caused by technogenic pressure.

In terms of nutrients, the soils under study are sufficiently supplied with nitrogen, phosphorus and potassium (as of 2016) and their agrochemical estimation is 100 points and more.

The conducted monitoring of contaminating and dangerous compounds accumulated in the soils under study (remains of pesticides and radiation contamination density) in the samples in 2016 and comparison of these data with the results of environmental and agrochemical examination of the area lands in 1996 and 2004 show that all arable lands do not contain pesticide remains (DDT and its metabolites, hexachloran and 2,4-D amine salt) and density of their radiation contamination with ^{137}Cs (cesium-137) and ^{90}Sr (strontium-90) is within the norm.

Estimation of contamination of the soils with chemical elements was conducted for the whole range of micro- and macrocomponents determining the total content and the content in labile compounds (ammonium-acetate extract from the soils). It is well-known that *the number of pollutants in labile forms* of compounds testifies to the extent to which corresponding chemical elements *are able to enter human trophic chains* through vegetable food and livestock products.

The results of monitoring in 2016 demonstrated excess of maximum allowable concentration (MAC) norms for labile forms of I and II hazard classes (lead, zinc and cadmium) on the area of nearly **188** hectares of the examined territory.

Soil of nearly 143.6 ha area are contaminated with labile forms of **zinc** (hazard class I element) compounds exceeding MAC 5.4-fold on average. The contaminated areas lie in the north-west of "Livoberezhni" dumps of YuGOK (about 83.5 hectares) and within 1 km distance to the south of the tailing pond "Obiednane I Karta" of YuGOK.

The labile forms of the element of the I hazard class **lead** exceeds MAC norms (6 mg/kg) on 4 monitoring sites: a 14.6 ha field in 0.9-1.1 km distance southwards from the tailing pond "Obiednane" (1.6-fold excess of MAC) and a 13.4 ha field 0.8 km southwards from the dumps "Livoberezhni". The contaminated 0.8-2km wide zone of 83.5 hectares with the detected level of labile forms of lead exceeding MAC 1.8-fold is located on the above mentioned site polluted with zinc in the south-western direction from the dumps "Livoberezhni". Another contaminated field of 16.3 hectares lies westwards from YuGOK tailing pond "Voikovo". In general, the area of agricultural lands with an excessive level of labile forms of lead makes over **127.8** hectares (as of 2016).

Analysis of detecting labile forms of heavy metals of the II hazard class, particularly cadmium, shows that this element contaminates 83.5 hectares (already mentioned as one of the sites contaminated with lead and zinc) and is 2.8 times as much as MAC (0.7 mg/kg).

Considerable (exceeding MAC, 1.5 mg/kg) contamination of soil with labile forms of **manganese** is observed on sites impacted by dust from "Livoberezhni" dumps.

Contamination with **copper** (MAC 3 mg/kg) is detected on a small area and registered in only one sample of soil near the dumps "Livoberezhni" of YuGOK.

The above norm content of **iron** (MAC 12 mg/kg) is detected about 1.5-2 km southwards from the complex of technogenic facilities (the dumps "Livoberezhni", tailing ponds "Obiednane" and "Voikovo"). The contaminated territory occupies the area of about 57 hectares.

Besides studying soluble forms of soil pollutants, contents of total of forms individual elements from dump and pond dust in soils under technogenic pressure have been analyzed. In this case, data of the background level of soil contamination with corresponding elements for Dnipropetrovsk region are taken as criteria of soil contamination occurrence [26].

Analysis of data on distribution of the content of *total forms* of **zinc** shows that the background level (30 mg/kg) on practically all the examined territory in Dnipropetrovsk region is exceeded. On 23 testing sites (20 % of the examined territories) the content of zinc is 2 and more times larger than the background level and makes 60.61 to 83.3 mg/kg. These areas are mostly located in the north-western part of the technogenically affected territories, i.e. they are in close neighborhood with the dumps and tailing ponds. The maximum level of zinc is registered in the south-western direction 0.8-2 km away from YuGOK dumps and makes 487.5 mg/kg, i.e. 16 times larger than the region background level.

Total forms of **lead** exceed the background level (10 mg/kg) in 50% of samples from the examined territory. These lands are mostly located in the south-western directions from dumps and ponds.

Analysis of the content of *total forms* of **cadmium** and **manganese** shows that their content on the examined territory exceeds the background level (1 mgr/kgr and 0.6 mg/kg respectively) on 6 monitoring sites whereas for **copper** it does not practically exceed the background level (20 mg/kg) in majority of studied samples. 3-fold excess of cadmium compounds and 10-32 % excess of manganese are detected on monitoring points of sampling westwards from the dumps “Livoberezhni” of YuGOK.

Iron compound content exceeds the background level (2-7 mg/kg) on 65 % of the territory under observation. On most sites, this excess makes 1.5-2 times but on the monitoring sites near the dumps “Livoberezhni” and on the south-western part of the observed territory impacted by the ponds it makes 7-10 times.

All the above data testify that due to accumulation, certain elements contained in dust create zones of above-norm concentration exceeding the current sanitary norms. Components of dust from dumps and tailing ponds of the operating GOKs, particularly the southern group of Kryvbas, enable accumulation of I (lead, zinc) and II (cadmium, manganese, copper and iron) hazard class (toxic) elements. Significant accumulations of chrome, strontium, mercury and nickel in soils are not detected.

The comparative analysis of the data on chemical contamination of the examined soil during 1996-2016 shows that soil contamination occurs in time and space with gradual acceleration. For instance, in

1996, content of manganese, copper and zinc in soils averaged 21, 0.44 and 0.21 mg/kg respectively, in 2004 - 23, 0.5 and 0.22 mg/kg respectively, in 2016 contamination reached on average 49.9, 1.37 and 4.91 mg/kg respectively (maximum for zinc – 89.17 mg/kg!), i.e. for the recent 12 years contamination has increased 2.5-fold, and for zinc - 22-fold. The dynamics of contamination accumulation like that testifies either to increased toxicity of dust or increased dust volumes.

Considering the location of contaminated soils relative to technogenic facilities, directions of prevailing winds and composition of dump and pond dust, *the following statement can be made*. Dump and pond dust spread with the wind (northern and north-eastern winds are known to prevail in the district under study) is the source of soil contamination with traces of heavy metals. This is a manifestation of the fact that *technogenic facilities are correlates of contamination*. Availability of land sites with exceeded MAC norms and regional background level for traces of **lead**, **zinc**, **cadmium** and **iron is manifestation** of, firstly, presence of these toxic elements in dust of the dumps and ponds that **increases significantly the hazard class** of the dust like that. Secondly, aerogenic contamination is happening gradually and accumulation of the dust compounds in soils happens with certain acceleration in 0-10 and 10-25 cm deep layers of soil.

The studies have determined that due to long-term (up to 60 years) aerogenic contamination of soils with dust emissions from GOK dumps and tailing ponds, the upper soil layer accumulates certain pollutants that are considered as traces in spot dust samples are not significantly concentrated. It has also been determined that in individual cases there are formed geochemical anomalies (centers) of heavy metals in the upper layer of zones of long-term contamination. In our investigation the center like that was formed in the zone of the direct impact of dust emissions from the dumps “Livoberezhni” of YuGOK under prevailing north-eastern winds, namely on the 83.5 ha site (2016) of agricultural lands. There, high (over MAC) simultaneous concentrations of zinc, lead, cadmium, manganese and partly copper are registered.

Considerable decrease of self-purification ability of soils is known to occur on sites with geochemical anomalies and physical and chemical conditions for migration of contaminating elements are radically limited.

Conclusions: On the basis of the given results of the investigation into soil conditions in the zone of aerogenic contamination with dust from GOK dumps and tailing ponds the following conclusions can be drawn:

1. Due to the effect of accumulation and summation, microelements of the GOK dump and pond dust create considerable over MAC norm concentrations of harmful substances on the soil surface.

2. The most harmful and capable of accumulating in soils of the adjacent to YuGOK and NKGOK territories dump and pond dust microcomponents are elements and compounds of zinc, lead, (I toxicity class), cadmium, manganese and iron (II toxicity class).

The class of environmental hazard of open pit mining and iron ore concentration wastes accumulated in dumps and tailing ponds of GOKs requires reconsideration as such components as heavy metals are able to migrate long distances (up to 3-5 km) with the wind and create zones of accumulation and over norm concentration in the upper layer of the soil.

4. Parameters of sanitary and protection zones (SPZ) around places of accumulation of potentially toxic wastes of iron ore mining and concentration require reconsideration. At present SPZ around mining and concentrating works are established according to "National Sanitary Rules for Planning and Development of Residential Areas" No. 173, June 19, 1996 and make only 300 m which is insufficient for multi-level technogenic facilities (dumps and tailing ponds) with dust-forming surfaces of over 100 m high.

5. To decrease pollution pressure on lands of territories next to dumps and tailing ponds, local and environmental control authorities should demand unconditioned observance of Point 5.13 of the Order of the Ministry of Health Care of Ukraine No. 173, June 19, 1996 "On Approval of National Rules for Planning and Development of Residential Areas" which provides landscaping of SPZ around all dumps and tailing ponds on the distance of not less than 60 % of their width.

6. Signs of chemical contamination of soils impacted by aerogenic pollution caused by dumps and tailing ponds start appearing 10-15 years after the beginning of such impact with further acceleration of

the effect. In 30-40 years it reaches the level of chemical degradation.

Recommendations. The current situation concerning prospects for implementation of the concept of sustainable social and economic development requires solving the following tasks:

1. On the national and legal level:

- considerable growth of financial responsibility of economic entities for violation of the environmental law of Ukraine and recommendations of international environmental programs;

- introduction of requirements concerning development of the chapter on landscape planning for all projects of building and reconstructing mining facilities into national building norms (NBN);

- making it obligatory to include not less than 10% of annual incomes of the designed production into cost estimates of any mining projects for land remediation and optimization of destroyed landscapes;

- cancellation of preferential taxation in the Tax Code of Ukraine for stockpiling each ton of mining wastes and raise of tax rates to the objective level of the III hazard class, which is conditioned by availability of highly toxic heavy metals in these wastes.

2. On the local authority level:

- development of a strategic plan of measures for optimizing the city's landscape structure in cooperation with design companies and enterprises;

- introduction of concrete measures on phase implementation of the strategic plan of enhancing the city's landscapes into Complex environmental programs and allocation of not less than 15% of the city's environmental fund for this purpose;

3. On the level of mining enterprises:

- considerable intensification of investing in development of measures for enhancement of iron ore concentrate production, namely in technologies: re-treatment of concentration tailings, oxidized ores, creation of inside dumps in dead zones of open pits etc.

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