GEOECOLOGICAL ANALYSIS OF INDUSTRIAL CITIES: ON THE EXAMPLE OF AKTOBE AGGLOMERATION

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Abstract. Landscape-geochemical assessment of the industrial areas is of particular interest to many researchers. This study describes the micro element composition of soils and hydrochemical composition of surface waters of the Aktobe region in Kazakhstan. A landscape-geochemical analysis was conducted in Aktobe agglomeration. Biogeochemical data is used to indicate the state of the degree of pollution. According to a study compiled agglomeration modern landscape map and identified anthropogenic impact on the total pollution index.

Keywords: geosystem; landscape; industry; technogenic anomalies

Introduction

Landscape geochemistry, describes the geochemistry of the environment. The basics of landscape geochemistry were first described more than 60 years ago (Polynov, 1956). Landscape geochemistry focuses attention on all aspects of the behavior of chemical entities in both living and non-living matter in landscapes of all kinds and interaction of the lithosphere with the hydrosphere, atmosphere and biosphere (Efe, 2010). The excessive content of heavy metals in the environment influences the biological properties of soils and groundwater, and causes pollution of the food chain (Kwasowski et al., 2016). There is relationship between sediment concentration and sediment adsorption of some chemical elements (Fuping et al., 2016). Water and soil pollution is a widespread environmental issue worldwide. There are different degrees of pollution of urban rivers in most countries and regions, in which the living environment of aquatic organisms has been destroyed, and the ecological function of such rivers has been severely affected (Perelman & Kasimov, 1999). Most surface rivers in Asia, Europe are polluted by untreated industrial wastewater and sewage. For these rivers, the dilution and purification function is lost and the ecological function seriously damaged (Li et al., 2014).

Data on the microelement composition of soil and water is important for the assessment of the pollution. Microelements in natural habitats have been studied by several authors (Kasimov et al. 2011; Dobrovolskii, 2011; Kabata Pendias & Pendias, 1989; Plekhanova & Obukho, 1992; Sawidis et al., 1995; Klumpp et al., 2002; Yu et al., 2014; Polynov, 1956).

Understanding the landscape requires geochemical mapping. The rocks and soils that are the foundation of our environment leave an imprint on the chemistry of our water and our lives. This chemical landscape reflects a combination of natural history and cumulative human impacts, and it influences biodiversity and human health. Geochemical mapping thus is needed to clarify elemental variations, and to support assessment of the natural and human-influenced factors that dictate these variations (Fortescue, 1992). The Minnesota Geological Survey (MGS) and the Minnesota Pollution Control Agency (MPCA), in cooperation with the United States Geological Survey (USGS), therefore have assembled three geochemical data sets for soil and water as a basis for an atlas that will provide an overview of geochemical patterns, and a reference that will place more thorough environmental geochemical surveys into a context. Data contributed to the project were derived from soil, soil parent material, and well water samples analyzed following USGS, Geological Survey of Canada, and Environmental Protection Agency protocols, respectively. The soil data include stream sediments largely in the western part of the state, and the soil parent material data are from sites underlain by till. The well water samples were from multiple aquifers utilized for drinking water, at greatly varying depth and geology (Lively & Thorleifson, 2009). The rocks and soils that are the main elements of our environment affect the chemistry of the water. Chemical landscape has an influence on biodiversity and human health. (Lively & Thorleifson, 2009).

Plants best absorb heavy metals by exchange. Most heavy metals get into plant roots and tubers from soil and into leaves from the atmosphere.

Aktobe region is one of the major industrial centers in western Kazakhstan. The region is a strong base of mining and metallurgy, chemical, petroleum industries and instrumentation. Over the past decades, supply of pollutants in the Aktobe region increased.

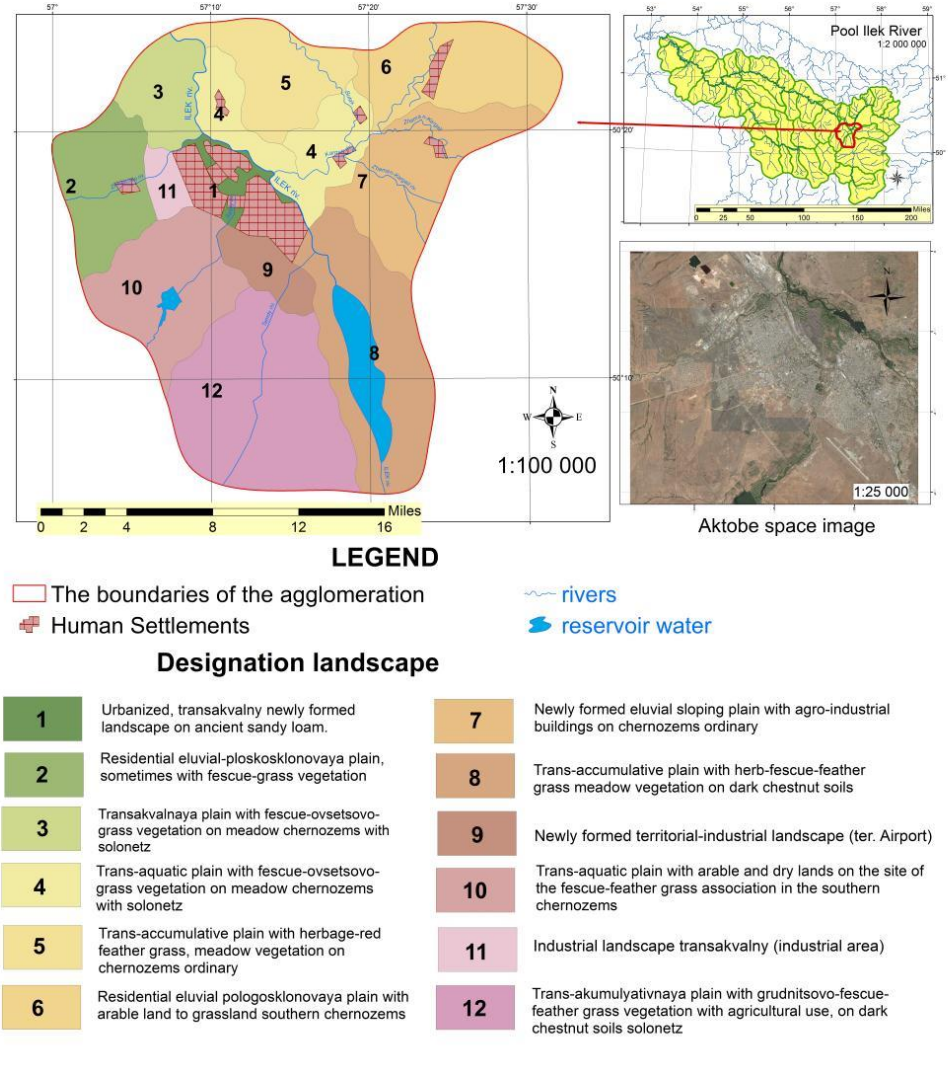

Figure 1. Landscape map of studied area

More than 900 companies are involved in in dustrial production (The National Atlas). The Aktobe region has a unique mineral resource base. Its territory has a concentration of about 10% of proven reserves and 30% of natural hydrocarbon resources in Kazakhstan (oil, gas and gas condensation), as well as all domestic reserves of chromium, 55% – nickel, Titan, 40%, 34% – phosphate, 4, -Zinc 7%, 3.6% -Media, -aluminum 2%, 1.4% is the rate of the total reserves of the CIS. The region ranks third in the world in reserves of chromite ore -. With more than 400 million tons; the second in Kazakhstan copper ores -. With 100 million tons, and industrial oil reserves – 900 million tons, the fourth largest in the country for gas reserves. Aktobe subsoil is rich in gold, silver, cobalt, potassium salts, asbestos, kaolin, glass and color stone raw materials, natural facing materials, oil bituminous rocks and many others. Chemical industry, ferrous and nonferrous metallurgy industries have developed on the basis of mining.[1)]

City of Aktobe and its surroundings is largest industrial center and it is described as the agglomeration (Bardenov et al., 2015). Single external circuit agglomeration boundaries are increasingly held in view of the impact of anthropogenic facilities, industrial complexes and architectural developments. In arid regions, the boundaries of urban systems are usually blurred. However, according to our research, the city limits were determined according to the procedure (Kasimov, 1995) and in accordance with the degree of anthropogenesis and technogenesis. The agglomeration includes 3 Geosystems (the theory geosystem-basin theory of the study area belongs to the basin of the river Ilek (Berdenov et al., 2015). It borders with the geosystems dynamic, changing in accordance with space-time relation. In the study of urban systems, there is the need for "dis", i.e. dividing them into components of the system (landscapes). According to many years of research, the environment of Aktobe agglomeration and interpretation of satellite images Landsat 8TM machine (using software ERDAS 9.3), landscape map the study area was drawn up (Fig. 1), which was a result of the typological groups, and then the structural-genetic classification, ordered in a hierarchical taxonomy.

Methodology

The basic method for estimating the state of the territory - landscape-geochemical, involves the synthesis of information about the components. Evaluation of the material composition of geosystems is of particular importance in the development of landscape-geochemical problems of industrial development of the regions (Perelman & Kasımov, 1999). The geochemical data provides a regional context for environmental management effort in the study area.

The objective study regarding the structure and dynamics of geosystems of the Aktobe agglomeration is particularly relevant in connection with the continued growth and expansion of the production of ferrous and nonferrous metallurgy, which determines the special significance of environmental risk assessment. Inevitably, with the growth of man-made impact, geosystems structure changes occur, including a change in their chemical parameters under the influence of mechanical disturbances and pollution. Therefore, knowledge of the landscape and geochemical characteristics and chemical composition of the components of geosystems, and their metabolism is necessary to support the effective implementation and environmental monitoring industrial regions (Perelman & Kasımov, 1999).

Analysis

Our study is vulgar in nature and affects virtually all geosystems of the Aktobe agglomeration. For a more detailed study of the Aktobe agglomeration, key areas were established around the perimeter of contact for sampling of surface water and the upper horizon of the soil cover. More study was conducted in the south-western part of the city of Aktobe, where the largest numbers of industrial enterprises were located, and the southern part, which was home to an increasing number of people. By the nature of the use of the city, zoning was carried out. According to our research results, five areas were highlighted: residential, industrial, agricultural, transport, green area. The final result is a functional zoning map scale of 1: 120 000 and 1:25 000 scale map (Fig. 2).

Environmental pollution in a large industrial city can be divided into three groups: Air emissions, waste water (effluents), solid and liquid waste (Kasimov, 1995) Emissions in turn lead to the contamination of air, soil, vegetation, surface waters.

Effluent (discharges) in streams containing pollutants, chemicals with industrial and municipal water sources come and mix into the water. During migration of contaminating substances in the water, they act as toxicants in food consumed by humans and animals, thus affecting the health and life activity of the latter. Solid and liquid wastes generated in public storage, in landfills, chrome dumps also affect the environment. By flushing tailings melt and rain waters pollute the soil and surface water streams. Aktobe has dissected topography characteristic of the urban area, slopes toward the river Ilek facilitating the discharge of water into the pool.

The source of water pollution is industrial enterprises and articles of household use. Large main industrial facilities are mainly located near water bodies, thereby causing water pollution due to the household waste (landfill in the flood plain of the river Zhinishke), animal and industrial waste, etc. The main polluters are: Aktobe plant of chromium compounds (APCHC), Aktobe Ferroalloys Plant, JSC "TNK Kazchrome", "Aktobe CHP", "Akbulak", JSC "Aktyubrentgen", JSC "Aktobe Oil Equipment Plant", the production of alcoholic beverages LLP "Geom", LLP "Omirbek", LLP "Bakhtiyar" and others such as small-scale food industry companies (Saharan et al., 2012).

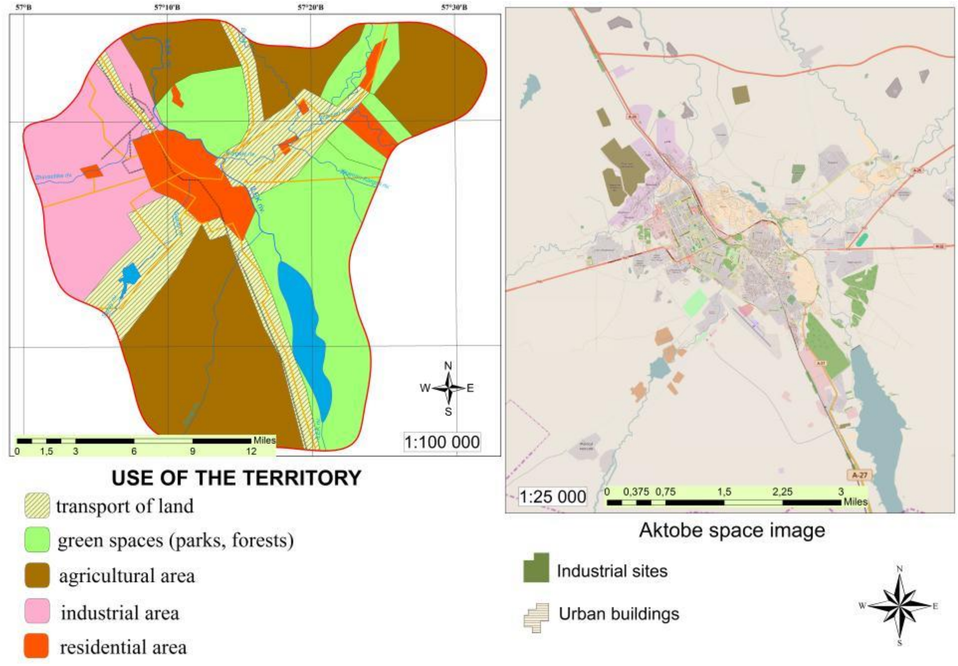

Figure 2. Map of the territory studies

When we studied the surface water in the area (Zhinishke, Sazdy, Kargaly rivers) a set of wide range of chemical elements were found in aquatic systems and the estimation of water pollution to sanitary protection zone. We also studied in detail questions of technogenic pollution of surface waters and Sazdy Zhenishke rivers salts, heavy metals and other pollutants to the confluence of the main channel of the river Ilek (Tables 1 and 2).

The main watercourses draining industrial and residential zone of the city are: river Ilek and its tributaries (river Sazdy, river Zhinishke, river Kargaly). Pools of these rivers have a high degree of human development. Microelement composition of water from surface water courses is diverse and reflects not so much the composition of water-bearing rocks as industrial and domestic waste water flowing into their beds. Migration trace elements in surface waters occur in two forms: a weighted and dissolved. Analysis of trace-element composition of surface waters shows that the concentration of heavy metals in them exceeds the background value several times.

Table 1. Results of chemical analyses (average for 2015)

Appellations Substances (mg / l)	District South East r. Zhinishke site territory №3 to the Industrial Zone	District Industrial Area r. Zhinishke №4 site territory after before.	District Industrial Zone Ilek river land area №6	Appellations acting norms of acts
1	2	3	4	6
Turbidity	0,1	2,4	1,42	GOST -26499.1
Colority	18,1	44	24	-
oxidability	3,2	3,2	3,7	-
pH	7,1	7,8	8,1	-
Alkalinity	3,1	4,1	4,0	-
polyphosphate	0,01	0,01	0,01	GOST -18309-72
Total hardness	4,1	5,1	5,5	GOST -4151-72
Ammonia	0,03	н/о	0,1	GOST -4192-48
Nitrate	38	43	46	GOST -18826-73
The chlorides	112	87	107	GOST -4245-72
Sulphates	130	189	141	GOST -4389-72
Iron	н/о	0,02	0,08	GOST -4011-72
Copper	0,09	0,22	0, 21	GOST -4388-72
Manganese	0,050-0,01	0,053-0,03	0,050-0,04	GOST -4974-72
Fluorine	0,011	0,1	0, 1	GOST -4386-72
Chromium	0,22	0,6	0,85	GOST31956-2012
Borum	н/о	0,15	0,29	GOST52109-2003

Sazdy and Zhenishke rivers have the highest degree of concentration in soluble form. In the waters of rivers, migration of elements with a high degree of concentration occurs both in soluble and suspended form. This is apparently due to the weather conditions in spring and autumn during observation periods. In the period of stabilization of the water regime of the rivers and the lack of strong surface flow changes in the composition of trace-element concentrations were observed. This suggests that the main factor influencing the change in concentrations of trace elements in the surface watercourses draining the industrial and residential zone is run off from anthropogenic areas (Kasimov et al., 1995). The analysis was made in view of the calculation of WPI surface Ilek river water before and after entering the Aktobe agglomeration (Table 3).

Calculation analysis showed a sharp increase in the WPI p. Ilek when leaving the metropolitan area, where the main sources were metallurgy, mining and processing industry and urbanization that belonged to the class of 6 contaminations.

Table 2. Results of chemical analyses (average for 2015)

ppellations	District Aviagorodok River Sazdy site territory №1	District Kirpichnyi River Kargaly №5 site territory	District 41 stations river Ilek after Aktobe storage reservoir №2	Appellations acting norms of acts
1	*2*	*3*	*4*	*6*
Turbidity	2,3	0,8	1,23	GOST-26499.1
Colority	39,5	17	27	-
oxidability	3,8	0,8	5,9	-
pH	7,8	7,1	8,2	-
Alkalinity	3,5	1,8	4,1	-
polyphosphate	0,02	-	0,03	GOST-18309-72
Total hardness	6	1,8	4,9	GOST -4151-72
Ammonia	0,04	н/о	0,2	GOST -4192-48
Nitrate	38	35	35	GOST -18826-73
The chlorides	125	95	110	GOST -4245-72
Sulphates	175	195	144	GOST -4389-72
Iron	н/о	0,02	н/о	GOST -4011-72
Copper	0,34	0, 4	0,24	GOST -4388-72
Manganese	0,050-0,04	0,053-0,05	0,050-0,04	GOST 4974-72
Fluorine	0,15	0,1	0,2	GOST -4386-72
Chromium	0,07	0,04	0,1	GOST 31956-2012
Borum	-	0,05	0,5	GOST 52109-2003

Profound changes occurred in the territory of the soil in the area. The main feature of these changes is the change in soil-forming processes, soil functioning, and the accumulation of humus. The process of forming a natural pedomass in the city changed to 70-80%, no mortmass, reduced the additional application of nutrients, thus reducing the percentage of longitudinal substances. Under the influence of technogenic soils in Aktobe, the bulk density of the natural soil decreased, and the structure of the soil horizons changed; increase in the amount of fine particles was their intensive removal of the soil profile, altered redox, acid-alkaline conditions and formed new geochemical barriers, not typical for zonal soil properties. A soil horizon disappeared recently, which was introduced by the Coating soil. Natural zonal soil-geochemical environment changed. Therefore, soils in the southwestern outskirts of the city of Aktobe changed and the percentage of nutrients increased the decay products of chromium, boron and iron. It is associated with these processes decreasing productivity in suburban agricultural products.

Table 3. Hydrochemical indicators of surface waters in River Ilek

№ class site territory	Appellations site territory along Ilek River	Water pollution index	Ingredients and water quality	Average concentration mg / l	The multiplicity the maximum permissible concentrate
1	R. Ilek, until city of Aktobe, 2 km below Aktobe storage reservoir.	4,49	BOD5	2,52	0,84
			Oxygen	11,32	0,53
			Copper	0,011	11,00
			Phenols	0,002	2,00
			The ammonium ions	1,144	2,29
			Borum	0,482	24,1
			Chromium	0,04	2
4	R. Ilek, downstream on the 3 km after the confluence of the River Zhinishke	8,26	BOD5	2,01	0,67
			Oxygen	9,92	0,60
			Phenols	0,002	2,00
			Copper	0,031	31,00
			The ammonium ions	1,375	2,75
			Borum	0,213	12,53
			Chromium	0,1	10

The question of car exhaust emissions at the roadside has an important role in environmental pollution. Along the perimeter of the agglomeration, 4 key areas for sampling from the upper soil horizon were laid.

Samples of soil, regarding the analysis of the components, were taken from a maximum distance – (50 – 150 m) of the road – and were grouped according to the depth of the selection as follows: 0 – 10 cm and 10 – 20 cm. The roadside of highways intensively accumulated lead, zinc, copper, chromium and fluoride. The content of lead, copper and chromium decreased in the samples with increasing distance from the edge of the road, but at a distance of 50 m or more to 150 m content remains unchanged. Vehicles polluted the soil with lead the most. The content of the first lead at a distance of 10 m exceeded 2.5 times background, then it fell to 125 and m was 2 backgrounds.

The lead content increased (up to 1.5 mg / kg) in the soil samples collected directly from the road sides. In general, a roadside strip of bypass tracks contaminated with lead was much stronger than in the central areas of the city.

Table 4. The upper horizon of the soil research on the content of heavy metals

Key areas of the territory	The average for 2015									
	cadmium		plumbum		Copper		Chromium		Zinc	
	mg / kg	QMC	mg / kg	QMPC	mg / kg	QMPC	mg / kg	QMPC	mg / kg	QMPC
The main motorway key №7	0,25	0,45	25,45	0,8	10,10	0,3	2,25	0,5	18,01	0,91
City center №8 city center city center city center	0,07	0,1	12,01	0,4	9,72	0,3	3,31	0,5	11,20	0,3
Aviagorodok №1	0,10	0,3	95,1	2,5	7,87	0,2	1,60	0,3	4,83	0,21
Bypass route №9	0,09	0,2	11,65	0,5	10,75	0,35	2,05	0,3	8,10	0,30
District Factory AFP, APCC №10	0,09	0,2	30,55	1,1	70,67	2,0	10,39	2,0	29,40	1,54

Note: Q - rate of excess by MPC

In the area of roads Industrial Zone (312 str. Devizii Avenue), surrounding the city of Aktobe has the highest degree of contamination of roadside strips of lead, as well as significantly higher concentration of chromium, iron, and zinc ions; obviously, this is due to the close proximity of the micropollutants emission sources (APCHC, AFP, Aktyub Rentgen plant). As a result of the detailed soil analysis in key areas in the city of Aktobe, we identified the maximum permissible concentration of cadmium, lead, copper, zinc and chromium on the borders of sanitary protection zones of large industrial enterprises in the areas of major highways (Table 4).

The dangerous toxic properties are non-naturally occurring compounds such as chemical elements as zinc, copper, arsenic, chromium, nickel and others. Almost all of them were found in the city. The highest concentration in the south-western part of the city was home to industrial enterprises' development and dense residential areas, as well as intense vehicular traffic. All chemical elements according to the degree of hazard and carcinogenic properties of the impact on the environment were divided into 4 classes.

When the territorial characteristics of heavy metals anomalies were conducted, a multi-element anomaly detection of heavy metals, determination of the concentration on the hazard classes and the total pollution of soils were identified; chemical elements were also identified in the area of total pollution index (SDR).

Square SDR values of the content of chemical elements were divided into weakly contaminated, heavily soiled and extremely polluted landscapes. On the basis of the functional zoning maps were produced illustrating the landscape-geochemical map of 1:10 000 scale (Fig. 3).

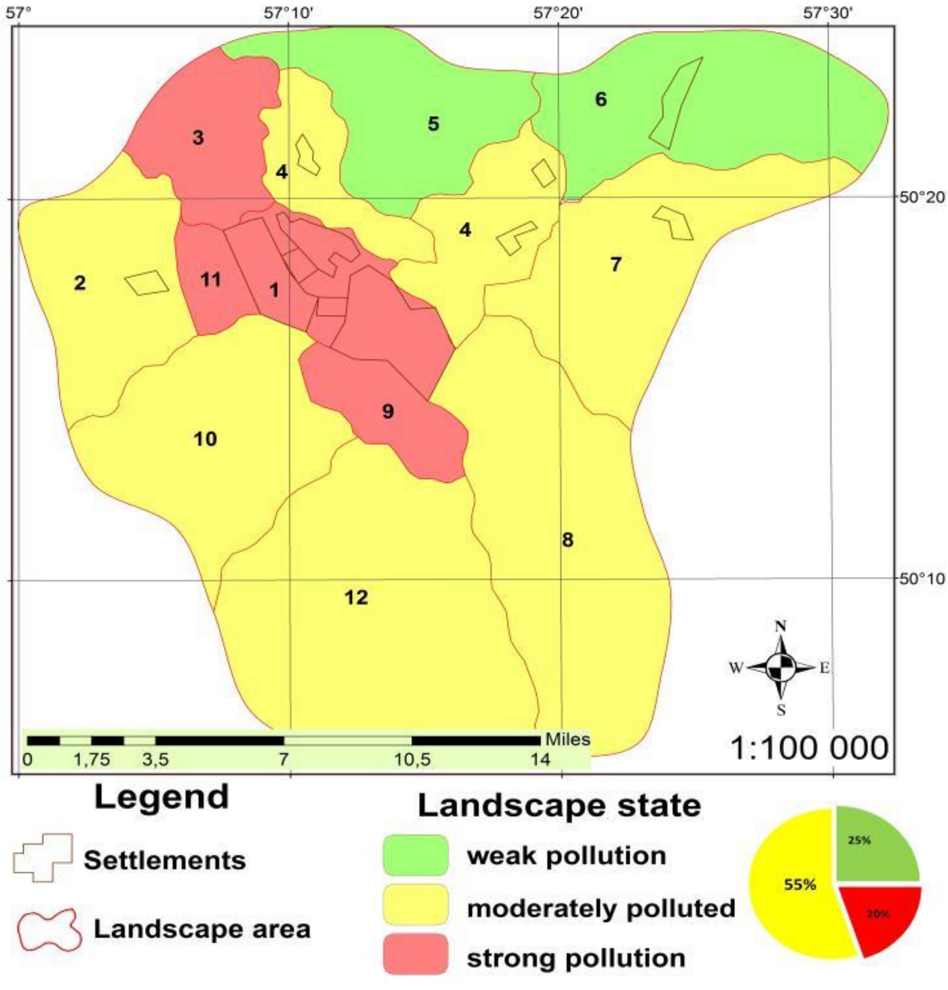

Figure 3. Landscape geochemical map

Conclusion

In fact, environmental conditions were disturbed in each agglomeration zone around Aktobe. Therefore, a residential area of construction disabled the organization of green areas, recreation areas, and placement of sports fields.

Spatial differentiating role of technological components during the technogenesis in Aktobe are related to their interspecies variations created by the difference between the real and the background (optimal) parameters technogenesis in its various parts. The urban system is located in the middle reaches of the river Ilek; technogenic-transformed differentiation will be formed depending on the nature of the leading technological processes (technogenic nucleus) and the degree of intensity of these factors (i.e. technogenesis products). Patterns of spatial boundaries technogenic factors correspond to the intensity of the impact of man-made cores.

NOTES

1. https://ingeo.kz/?p=3643&lang=en

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