# TECHNOGENESIS OF GEOECOLOGICAL SYSTEMS OF NORTHEN KAZAKHSTAN: PROGRESS, DEVELOPMENT AND EVOLUTION

**[1]Kulchichan Dzhanaleyeva, [1]Gulnur Mazhitova, [1]Altyn Zhanguzhina, [1]Zharas Berdenov, [2]Tursynkul Bazarbayeva, [3]Emin Atasoy**
*[1]L.N. Gumilyov Eurasian National University (Kazakhstan)*
*[2]Al-Farabi Kazakh National University (Kazakhstan)*
*[3]Uludag University (Turkey)*

**Abstract.** The article is about landscape-geochemical research on techno-agricultural systems of Northern Kazakhstan. The following four techno-agricultural geoecosystems of Northern Kazakhstan are displayed hereunder: Tobyl-Kostanay, Yesil, Yertis-Pavlodar and Central Yesil. Travel and spread of pollution and heavy metals in soil layers play critical part during such researches. The result of this work is a map model of techno-agricultural geoecosystems of Northern Kazakhstan.

*Keywords:* techno-agricultural geoecosystems; geosystems; pollution; technogenic factors

## Introduction

The study of changes in consistent patterns of landscape formations of Northern Kazakhstan within a market economy is one of the least observed problems of nowadays geography. This can be explained by the lack of any comprehensive efforts in geographical research of one of the biggest regions of Kazakhstan. The last studies that were made in this field refer to the years of virgin land clearing, except for the research works on agricultural production, tourism and local problems of technogenesis in Kostanay and Pavlodar regions.

The aim is to study and highlight the peculiarities of techno and agrogenic pollution of the environment of Northern Kazakhstan.

Influence of human industrial activity increased over the last years of the 20$^{th}$ century, when the quantity of descendants of pollution matters reached the level of irreversible changes. The vivid example of such natural and anthropogenious process is the territory of Northern Kazakhstan including Kostanay, North Kazakhstan, Akmola and Pavlodar regions. High level of agricultural industry, increase of efficiency of agriculturally used lands in the 60-es of the last century, abrupt enhancement of mining industry, agricultural machinery, mechanic, instrument and electrical engineering, as well as increase and development of infrastructure in the beginning of the twenty first century resulted in the loss of essential natural potential of the region.

At the present moment discovering and exploration of the four techno-agricultural geoecosystems of Northern Kazakhstan (Tobyl-Kostanay, Yesil-Petropavlovsk, Yertis-Pavlodar and Central Yesil systems) are of current interest taking into account the dinamics of powerful process of agro-tecnogenesis.

According to the extent and level of exposure of anthropogenic activity on geosystems, the anthropogenic factors can be devided into agrogenic and technogenic factors. Most of the factors that influence over environment are of agricultural origin (dryland farming, animal and poultry breeding etc.).

Following the decision of the February and March Plenum of Central Committee of the Communist Party of the Soviet Union (dated 1954) named "About furthermost increase of grain production in the country and about clearing of virgin and fallow lands", 19 million hectares of land were ploughed and developed in Northern Kazakhstan. As a result, plough land coverage increased by four times, including grain crop lands which increased by 7.2 times.

Comparing to the pre-war period, the amount of industrial production in Northern Kazakhstan increased by 18 times. Those years cheap thermal coals (Ekibastuz, Kushmurun coal basins) and magnetite iron ores (Sokolovo-Sarbayskiy Mining and Processing Industrial Complex) were highly developed. There was built the giant iron-ore Lisakovskiy Integrated Plant. It was the time of rapid development of bauxite production (Turgayskiy Mining Plant), agricultural and chemical machinery, instrument engineering, production of different construction materials, spare parts and frameworks. The overall railway length in 1963 reached the number of four thousand kilometers. Population of the region grew through this year up to 1.6 million people.

Against the background of these positive changes and economic growth, the 1980-es showed the reduction of grain yields due to the loss of humus matter in top soil layers (up to 7 – 10 dt/ha); the increase of wind erosion caused impoverishment of natural pastures (up to 1.5dt/ha); the quality of surface waters and their volume decreased alongside with water-salt exchange deterioration and groundwater reduction. Plowing and overall involvement of vast areas of virgin lands for agricultural purpose resulted in a sharp reduction of hayfield meadows and pasture grounds in Northern Kazakhstan and triggered off a long crisis in one of the traditional branches of agriculture in the Republic – animal breeding.

Though possessing significant natural resource potential, by the year 2000 Northern Kazakhstan was typical to have semi-desert, cryophyte lands and hills with summer-spring and autumn pastures that had lost their value, and depleted grasslands in the flood plains of many rivers and lakes.

Almost all geosystems in Northern Kazakhstan transformed from natural into anthropogenically disturbed or indirectly altered by anthropogenic activities. Direction, intensityand scale of changes are determined by existing in every geoecosystem natural-anthropogenic processes, internal structural changes and disturbances. Together, they determine the geo-ecological quality of modern geoecosystem and become an essential element of integrated landscape research. The evaluation of geoecological detailsof modern geoecosystems is made for the study of landscape-geoecological conditions that were formed in new conditions of economic management and reinforcementof anthropogenic factors.

**Object of research**

The objects of research are techno-agrogeoecosystemsof Northern Kazakhstan. Techno-agro-geo-ecological system is a complex area that was formed under the influence of anthropogenic factors which determine the overall technological transformation in the conditions of intensive impact of agricultural production. Evaluation of geo-ecological detailsof modern geoecosystems has its aim to study landscape-geoecological conditions generated under the new economic circumstances and enhancement of technogenic factors.

Basing on the analysis and synthesis of the results of previously performed studies, we have compiled maps for summer field works (June – September, 2015 – 2016), sampled different soils, collected rich herbarium in geobotanical transects. There were 24 investigated index plots in the basins of three rivers of Northern Kazakhstan. The map of index plots is shown in Fig. 1.

**Materials and methods**

The research was carried out by conventional methods of geoecology, landscape science and landscape geochemistry.

Geophysical properties of landscapes were studied using methods proposed (Beruchashvili, 1990). Geochemical studies were carried out based on the methodology developed (Kasimov, 1988; Avessalomova, 1992; Glazovskaya, 1983). Evaluation of aerogenic pollution sources was carried out upon the scale (Saet, 1990) and scales of ecological regulation of heavy metals in soils (Zyrin, Obukhov, 1983). In landscape-ecological research in the region used the approaches proposed in the works (Geldyeva, 2008; Trapeznikova, 2002; Turner, Gardner, O'Neill, 2001; Chang, Lee, Bai, Lin; 2006; Bastian, Steinhardt, 2002; Buyantuyev, Wu, 2007). Landscape-typological map was made up as is created on the methodology of Solntsev (1949, 2001), Mamai (1972, 2005), and Isachenko (1991), Sochava (1978, 2005).

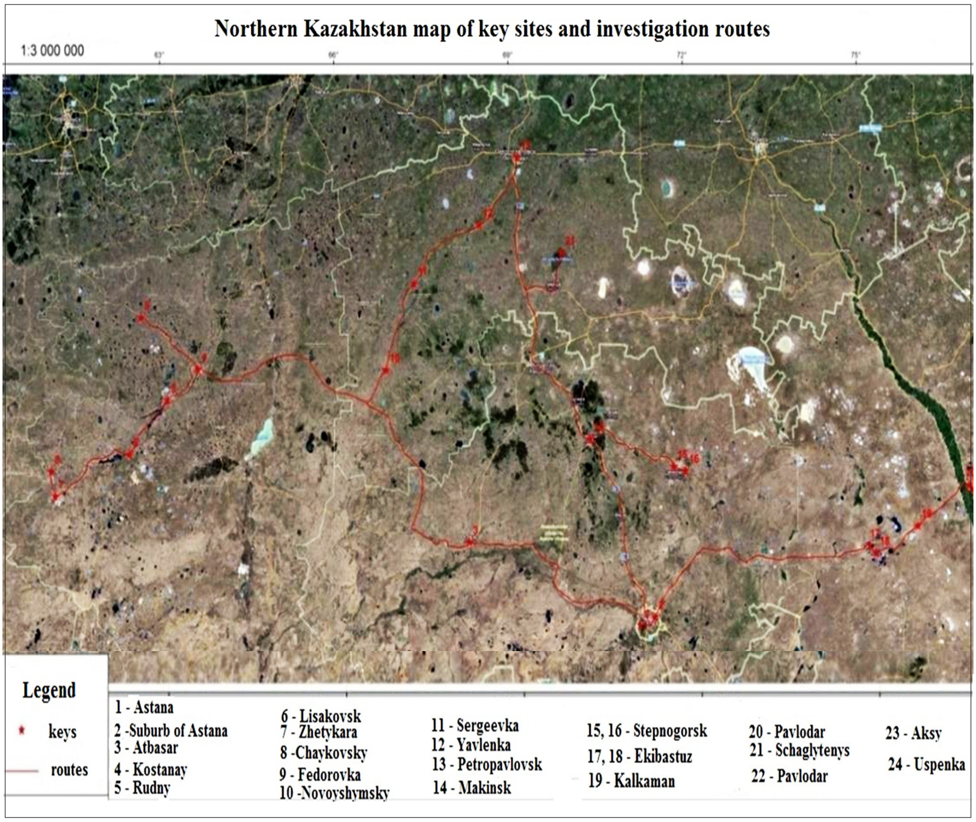


**Figure 1.** Northern Kazakhstan map of key sites and investigation routes

Particular emphasis should be put on the comprehensive nature of the research, using the latest research techniques (GIS, satellite image interpretation, etc.). The main feature of the studies were field investigations and observations made during expeditions along the routes determined on the basis of our landscape-geoecological maps and other maps of different assignment and science branches.

Climate and hydrological indicators were derived from the data represented in "Instructions of Kazgidromet service" as well as from annual bulletins of Kazhydromet in the last 10 years. Kazgidromet data also served as a source of information on hydro chemical indicators. Determination of pollution level of technogenic and anthropogenic origin was conducted when sampling and analysing samples of soil and water.. In this connection we used the indicators of main pollutants - heavy metals, sulfates, nitrites.

***Theoretical background to the study of geosystems of river basin territories***

Theoretical and methodological basis of the research was the concept of geo-system approach developed in the writings of (Sochava, 1978), the notion of basin (Koritny, 2001) and the geosistem-basin approach to study geosystems (Dzhanaleyeva, 2008).

The contents of the physical-geographical laws in the landscape studies are fully applicable to the two main theoretical and methodological approaches defined by F.N. Milkov (1954, 1977) and N.A. Solntsev (1949) in the last century and named in the literature typological and regional. For many years, landscape mapping was carried out on the basis of these two approaches. At present these approaches (regional and typological) do not solve complex scientific problems in landscape science and physical geography, the solution of which is important for the growing economy of our country. A regional approach is simply outdated and obsolete. The use of typological approach in physical geography does not solve geo-environmental problems. The increasing influence of anthropogenic factors on the natural environment creates different background of reverse reactions of landscapes in the processes of self-regulation. In this respect the "typification" of geoecological situations on a landscape basis will lead to more unreliability of scientific research.

The most suitable approach for solution of applied land-improving and other tasks is geosystem-basin approach where the researcher-geographer provides control over the condition of environment and natural resources of the basin, and conducts a full range of research activities from description to management. The basic geosystem-basin approach is a physical law - the law of conservation of matter and energy, balance method. After tracing down the possible ways of input and output of matter and energy in the fluvial geosystem and measuring the flows, we can judge by the difference about the ways accumulation in the geosystem or destruction of the considered variables occurred.

Geosystem-basin approach takes priority while studying space-temporal relationships between geosystems. When traditional landscape studies space and time are treated separately, a landscape map as a model of physical-geographical features considers only the spatial relationships of geosystems. Space-temporal relationships of real geosystems of river basin are characterized by continuity (Dzhanaleyeva, 2008).

**The research materials**

The climate of the region is characterized by hot summer, relatively cold winter and little amount of precipitations. Cloud cover is relatively small. The annual number of sunshine hours reaches 2500 KJ and is about 70% of possible sunshine goes for summer months. Daily number of solar radiation in the North of the region in June equals to 550 and in the South to 600 cal/cm$^2$. Rainfall in the Northern part of the region may be considered close to normal, i.e. precipitation, with the exception of certain years, covers evaporation, and it's quantity is significantly more in summer than in winter. The southern part has less rainfall, especially in summer months, while evaporation increases and natural hydration becomes insufficient. This is especially noticeable on the plains – in the Torgay valley and on the left bank of the Yertis.

Climate changes in the region are relatively small and depend mainly on topography. Torgay and Pavlodar plains have a little colder winter, summer is hotter and drier than in the elevated part of the region. Most hot and dry parts of the region are semi-desert South-Western areas.

The season of frost lasts averagely for about 5.5 months from the end of October to mid-April. The coldest winter month is January, average temperature here reaches -27°C and varies little across the territory; the least cold (-37°C) is elevated central part of the region. The largest capacity of snow cover can be seen in the second half of March and is about 30 cm in Torgay and Pavlodar plains and 40 – 50 cm in the central regions of Northern Kazakhstan.

Winds cause frequent blizzards and affect the distribution of snow cover in the fields. In spring average daily temperature, except for some days, is above zero, but some frost is possible in nighttime, especially during the so-called "cold spell".

The average temperature in the geosystems of the Northern outskirts in July (the warmest month) is around +19°C and +23°C, +24°C in the South.

In conditions of steppe and semidesert landscapes of Northern Kazakhstan waters are alkaline and neutral. The humus layer of soils possesses little nutrient accumulation (R=1,3 – 1,5) and sorption of mobile forms. The landscapes of calcium class have weak lateral migration of technogenic substances of some heavy metals. In the landscapes of meadow-marsh and sodic soil their mobility increases and they are actively involved in biological cycle. Copper and other heavy metals are mostly concentrated in surface water and soil, and in wormwood and goosefoot plants. The coefficient of lateral differentiation of heavy metals decay products reaches 5-8 and moving differentiation is up to 8 – 15 in the soda-alkaline landscapes of the middle part of the Northern Kazakhstan. These substances reduce the biological productivity of landscapes.

Soils and riverine sediments concentrate pollutants both in gross and mobile forms. In sediments of surface waters and upper soil layers, the surface atmospheric layer of urban landscapes there are being formed technogenic flows of scattering. Such anomalies are typical for the urban agglomeration of Kostanay and Pavlodar and Stepnogorsk industrial sites.

Active migration of the compounds of $Ni[(Ni(OH)_3)]$ indicates that it is being accumulated in certain types of alkali soils. According to various evaluations, Clark degree of one of the rarest elements – mercury – is 3 – 9*10 – 6%. Saukov (1975) suggested that annual halos of vapor appear over the territory with high mercury concentration. The stated gas halos, such as in Pavlodar, may also appear in different areas of the landscapes with sulfide or chloride compounds.

Oxidizing and alkaline environment prevents the accumulation and migration of Mn. Black and chestnut soils of Northern Kazakhstan generally contain more manganese.

**Results and discussion**

The research work has been conducted on the basis of geosystems-basin approach, developed (Dzhanaleyeva, 2008).

Main means for the classification of geosystemswithin river basins were satellite images and maps of component analysis. During the research wehave allocated Obsk-Tobol, Obsk-Yesil and Obsk-Yertismezo geosystems consisting of a number ofsubgeosystems.

We divided the territory of Northern Kazakhstan into the following four techno-agro-geoecosystems which in turn include a number of subsystems (the schematic map of techno-agro-ecosystems is shown in Fig. 2): (1) Tobyl-Kostanay techno-agrogeoecosystem: A) North-Tobylagrogenic system; B) Sokolovo-Rudny industrial system; C) Zhitikarinskytechnogenic-nuclear system; (2) Central Yesiltechno-agrogeoecosystem: A) Kokshetauagrogenic system; B) Stepnogorsktechnogenic system; C) Astana residential-industrial system; (3) Yesil-Petropavlovsk residential-agrogenicgeoecosystem; (4) Yertis-Pavlodar techno-agrogeoecosystem: A) North-Pavlodar agrogenic system; B) Pavlodar-Aksu techno-nuclear system; C) Ekibastuz anthropogenic system.

***TobylKostanaytechno-agrogeoecosystem***

This techno-agrogeosystemsis formed along the valley of the Tobolriver.The strategic enterprises of the area are of mining industry. It keeps up to 45.4% of all the industrial production of this area. In addition, 32 companies in other industries are the sources of pollution.Overall production has recently increased from 36.2% to 69.5% (LLP “KarasuYet”, “Kazogneupor Plant”, “Kostanay minerals”, Dairy unit, etc.). In connection with the observed increase of production the negative impact on the natural environment has amplified.

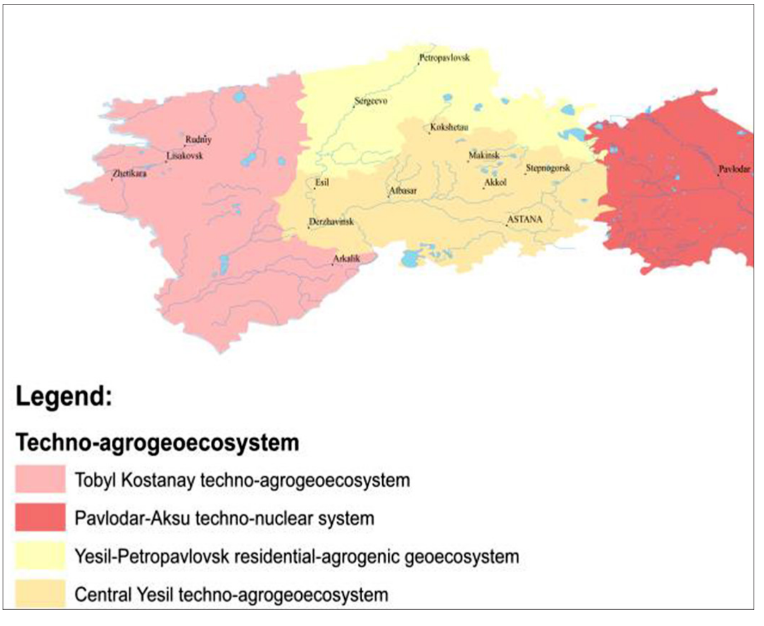


**Figure 2.** The map-scheme of Northern Kazakhstan`s techno-agrogeosystems

In 2015 we have defined the following index plots within this techno-agrogeosystem:

***The index plot No. 4*** was defined at 6500 m away from the water's edge of Tobol, on the first terrace above the flood.

As a result of economic activities, many sidestreams and the Tobol itself is being regulated by numerous ponds. The river is fed mainly by snow while rainfall and groundwater play a minor role. Strong variability of the annual runoff is typical for the river when the annual average water consumption exceeds the long-term average by several times.

The site is an area with a mosaic facies, soils and vegetation which are greatly oppressed. The depression of the vegetation cover can be explained by intensive water erosion. The efficiency not the elevated areas equals 3,8 – 6,2 dt/ha. Vegetation species composition is mostly represented by a high degree of weeds. Anthropogenic wastelands (with the size of 10 x 40 m) that appeared due to overgrazing are typical for the area. There are small lakes of the river valley fully overgrown with reeds (17 – 22 kg/ha) are found in great amounts here. Water in the lakes is dirty and cannot be used for human consumption.

In the territory of index plot No. 5 there was found a marsh-ridden plot of land that was caused by unscheduled release of water from industrial production. We stated vegetation clearing-off and the loss of the natural capacity of soils in the site. Small anthropogenic landforms produced through economic activityincrease the ruggedness of the terrain, which causes mineral, organo-mineral and bacteriological pollution of surface and groundwaters.

We have taken samples from four boreholes along the water line of the river to its watershed. Strong contamination by decay products of heavy metals is typical for the epicenter of the anomalies of this system. Contamination along the floodplain is zonal and is dominated by Zn and Pb.

The landscape of large areas of the Western outskirts of Kostanay region is polluted by decay products of ferrous compounds. Due to high Clarke degree (4.65%) and its chemical properties, Fe plays a crucial part in technogenic landscapes. There are more than 300 Fe minerals – oxides, sulphides, silicates, carbonates, phosphates. The ratio of dissolved and suspended forms of Fe in surface waters depends on the terrain, the alkaline-acid and redox conditions, presence of organic matters and other factors. Due to the high Clarke the iron accumulates in colloid, organic and truly-soluble forms in this landscapes.

There is also manganese entering the water and soil in the Tobol-Kostanaytechno-agrogeoecosystem. However, it does not form contrast technogenic anomalies and enters the landscape during development of ores, agricultural use and with waste waters. Aluminum salts are amphoteric elements and dissolve only in strongly acidic and strongly alkaline solutions, so in the acidic environment aluminum forms a soluble anionic-charged fulvate complexes, which have little effect on the processes of landscape forming. These and other pollutants in their different forms and compounds affect the functioning of geosystems of Northern Kazakhstan.

***Yesil-Petropavlovsk residential-agrogenicgeoecosystem***

This techno-agrogenic system is the most prosperous in agricultural terms. Sufficient rainfall, lack of large enterprises and zonal conditions create optimal conditions for the development of agriculture.

***The index plot No. 13*** was definedin the floodplain of the Yesilriver within 8 km from the South-Eastern suburbs of Petropavlovsk. This is an elevated ground plain with grass-forb meadow steppes on black soils interlaced with groves of birch. The area was laid out on the border of loamy old-lake lowland plains in complex with meadow-steppe alkali soil. The index plot has traces of grazing. The topsoil contains only 1.2% of humus. The content of nutrients (Na, K, P) is drastically reduced.

The signs of accumulation and transformation of sediments and traces of dumping of solid waste are clearly seen. Such natural complexes with stand repeated increase of substances of anthropogenic origin during their transeluvial accumulation. The observed area is a transit environment, directly receiving the emissions of the Petropavlovsk enterprises.

Anthropogenic products accumulated in water and soils negatively affect the quality of surface runoff and the biota. The central part of the investigated area performs oppressed vegetation communities (white wormwood, feather grass and geese foot). Not a single plant had a flower or earing during flowering time. Plant communities have negative influence of technogenic anomalies of Petropavlovsk, the soil of which has the concentration of zinc, lead and nickel increased by 3 – 10%. Emissions mainly consist of paedogeochemically-active substances that alter the acid-alkaline and oxidation-reduction conditions of soils. In general, slightly toxic elements with high Clarkes – Fe, Mg, Ca and alkaline elements that increase the pollution of Petropavlovsk and have a negative effect on tree and shrub formations and their productivity. When observing woods in the index plot, technogenic accumulation obscures the background eluvial-illuvial differentiation of the soil.

***Central Yesil techno-agrogeoecosystem***

***The index plot No. 14*** lies in 50 km South-East from Kokshetau. Anthropogenically transformed area of the plot is the nucleus of the anthropogenic influence. There are many industrial landfills near the town. Large areas and absence of large industrial complexes create favorable conditions for the development of agricultural production. Index of productivity of plant communities is 7 – 8 dt/ha.

Kokshetau is one of the cleanest cities in Kazakhstan because of good ventilation. All polluting ingredients found in the index plot are in the range from 0.02 to 7.9 MAC, copper – 9.3 MAC, cadmium – 1.5 MAC, zinc – from 0,04to 1.8 MAC. The most polluted area is the area of the North-West, where the lead concentration was 7.9 MAC, copper – 6.3 MAC, zinc-1.1 MAC. But while within the city the polluting ingredients are in the range of 7 – 9 MAC (for copper, cadmium, lead and other heavy metals), the territories of dryland farming 1.5 km away from the index plot have evident influence of the decay products of many heavy metals. The productivity of vegetation here has dramatically reduced to 1.8 dt/ha.

***Stepnogorsk technogenic system***

***The index plots No. 15 and 16*** are situated in 2.5 km from the town of Stepnogorsk. The content of heavy metals in the soil of Stepnogorsk according to the Central research laboratory (2013) are represented in Table 1.

**Table 1**. The content of heavy metals in Stepnogorsk technobiogeom soils

| Element | MAC, % | City | Sanitary zone | Technogenesis zone |
|---|---|---|---|---|
| Arsenic, % | 0,001 | 0,0 | 0,0 | 0,0 |
| Cobalt, % | 0,015 | 0,0032 | 0,012 | 0,0152 |
| Lead, % | 0,005 | 0,0025 | 0,0017 | 0,0064 |
| Nickel, % | 0,015 | 0,0133 | 0,004 | 0,008 |
| Zink, % | 0,05 | 0,0166 | 0,0112 | 0,208 |
| Cadmium, % | 0,005 | 0,0004 | 0,0 | 0,0005 |
| U, % | 0,002 | 0,0 | 0,0 | 0,0001 |

The content of cobalt, lead and nickel are within the permissible limits. Though the geochemical anomality of the city territory is relatively low, there is an industrial ring (7 km from the city of Stepnogorsk) where a lot of ash-slag deposits and dumps are allocated which cannot be evaluated under the cover of snow and soils. Here can be found contrast anomalous zones adjacent to technogenic sources. Activation of isotopes of uranium is rather weak in Stepnogorsk industrial complex. Decay products of this substance actively migrate in the water and concentrate on multiple barriers.

***The index plot No. 19***was defined on the dividing surfaces of the left bank of the Yesilriver, along 26 km of a dirt road in the direction of downstream. Loessial deposits cover bedding rocks, which lie close to the surface, as a mantle. Non-contrast radial differentiation of the trace elements and particle size distribution downwards from the top of the hill to the foot is typical for the plot. Autonomous downslope position of the plot retains maximum accumulation of heavy metal salts. Soil and vegetation has transformed into meadows. Soil isslightly humic (up 2.5%). Vegetation is sparse, weed grass prevails. Salinity is fragmentary. There are no conditions for the formation of contrasting geochemical anomalies. The area is heavily littered; there are a lot of visible signs of excessive cattle grazing.

***Pavlodar-Aksu techno-nuclear system***

Landscapes of industrial sites are mostly contaminated with the results of technogenic activities. Pavlodar city is a diversified industrial center, there are 87 industrial enterprises in the city. The largest of them are: aluminum (Pavlodar Aluminum Plant) machine, cardboard roofing, chemical (Pavlodar Chemical Plant), petrochemical (Pavlodar Petrochemical Plant), shipbuilding and ship-repairing, tool, tractor (Pavlodar Tractor Plant), rubber plants, steel and electrical plants. In addition, there are 3 CHPs, more than 20 boilers and 5751 units of private housing in the territory of the city, which annually burn a total of more than 3.5 million tons of coal. Enterprises' emissions of pollutants into the atmosphere of Pavlodar in 2013 amounted to 134.5 thousand tons, in 2015 – 109,778 thousand tonnes (Table 2). Additionally, 13.1 thousand tons of pollutants enter the atmosphere with the exhaust gases of vehicles (42231 units).

**Table 2.** The chemical composition of ash and dust in the territory of technobiogeom of Pavlodar-Aksy techno-nuclear system in 2015

| Ingredients, mg/kg | Pavlodar CHP | Aluminium Plant |
|---|---|---|
| Lead, water-soluble | 0,21 | 5,2 |
| Cadmium, water-soluble | 0,07 | 0,6 |
| Mercury, gross | 4,62 | 4,55 |
| Fluoride, water-soluble | 10,0 | 25,5 |

Pavlodar-Aksu techno-nuclear system has major anomalies of toxicants, which are dominated by metals of1$^{st}$and 2$^{nd}$ classes of toxicity (lead, cadmium, mercury, nickel, etc.) Parameters and the degree of contamination are amplified in winter because snow accumulates all the pollutants, which are lately infiltrated into soil and water.

The territory of the dividing surfaces of the North-Western outskirts and South-Eastern part of the region were mostly polluted.

***The index plot No. 20*** was set in the floodplain of the Yertisriveron alluvial plains. The processes of soils dehumification can be traced on the plot. Alluvial accumulation arerapidly eroded, and hydrofine-grass vegetation is replaced by xerophytic shrubs and spiraea-willow communities. Surface runoff is very dirty. According to Kazgidrometthe violation of maximum permissible concentration has been identified among four different factors: – fluorides – 11.2 MPC sulfates – 10.0 MPC, magnesium - 8.1 MPC, chlorides – 5.5 MPC. This increased activation of technogenesiscan be explained by increased production volumes at petrochemical and pipe-casting plants.

***The index plot No. 22*** is situated 400 m away from the edge of the Yertisriver. The plot is within steppe landscape. The level of self-organization and sustainability of steppe landscapes is inferior to the forest one. They have the closed cycle. When technogenesis takes place in steppe geoecosystems, the initial natural state is easily disturbed and difficult to recover. In the natural steppegeoecosystems cereals contain more Si, Ca, Na and other elements, that is why in the steppes of Northern Kazakhstan aridonit species were formed movable and actively absorb aniongenic elements.

In the index plots No. 20 and 22 total biomass of vegetation cover is reduced to 10 dt/ha. Reserves of humus in the soil are 150 – 170 dt/ha, its content in upper levels decreases to

3 – 4,5% alongside with increase of fulvic acid. According to the analysis of balance of migration-capable forms of trace elements in typical black soils it varies from humus to illuvial carbonate level. The upper layer of the soil is mostly dominated by Co, Mn, Pb and Cd, while thin and more inert, adsorbed forms are of subordinate importance. Under the influence of technogenesis the lateral migration of trace elements is more intensive in higher areas of watershed-draw-gully catenas of typical black soils. Hydrogenic accumulation of the researched area is poorly traced.

***The index plot No. 24***was seton the watershed of the North-Eastern outskirts of Bayanaulmountains. This plot is presented by interchanged ridges and depressions with the outputs of the parent rocks. There are processes of salinization and desalinization being observed on the plot. Selected soil samples showed interchange between alkaline black soils with alkali and soda saline soils. Anthropogenic products affect their soda-sulfate salinization, increasing them.Vegetation is mostly represented by meadow communities. In some places there were evidences of waterlogging, as part of the terrace was once a flood plain. The processes of soil salinization and soil alkalinity form alkali meadows here. The lowering of the base level caused of began desalinization, which led to the intensification of humification. Modern depressions and slopes of the plot show us traces of metals. Water here is calcium-bicarbonate. The productivity of plant communities is low and equals 6 – 7.5 dt/ha.

Geoecosystems of Northern Kazakhstan in damp years show higher productivity of vegetable communities, but at the same time the number of protein and nitrogen in plants seeds decreases. If the territories' plants are mostly representatives of composite family, then the ashes type generally is mainly calcic and calcium-sodium (content reaches 10%). According to the obtained data there were made the following ranks of a general biogenesity of macrocells: Cl, S, P, K, Ca, Mn, Si, Al, Fe.

Lately the total reserves of humus were measured in geoecosystems of meadow steppes. This figure showed 600 dt/ha, and that means its decrease in recent years (in 1960, the number of humus on 1 ha amounted to 900 MT). Repeated intensification of desertification and xerophytization leadsto predominance ofhumic acids over fulvic acids (HA/FA=1.5 to 2.0).

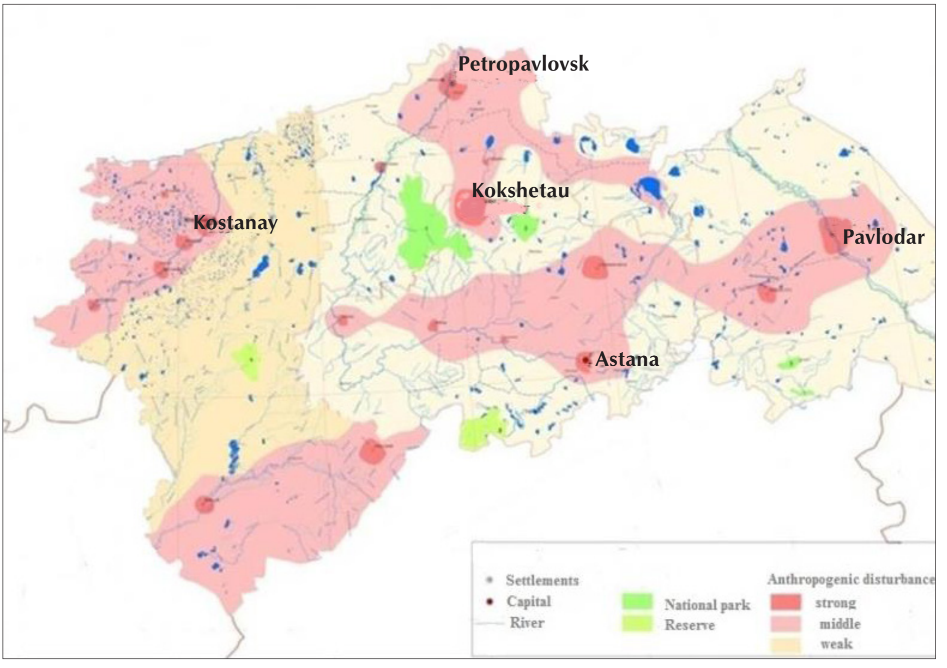


**Figure 3.** Fragment of the map-scheme of anthropogenic impact on the environment of Northern Kazakhstan

On investigating black soils on different index plots of Kostanai, Kokshetau and Pavlodar regions we can state the following: mildly alkaline environment intensifies and solubility of humic acids weakens along with high absorption capacity and abundance of organic colloids. Non-leaching water regime of the soil being intensified by the lack of precipitation in summer of 2015 defined low migration of many chemical elements. In this connection we can see increase aridonit plants in the area.

We have created a set of index-maps basing on geoenvironmental indicators of quality of geosystems. Basing on the data from index plots recorded in July 2015 we created a set of index-maps of mezo- and subgeosystems ofLysakovsk, Zhetikarinsk, Stepnogorsk, Ekibastuz, Pavlodar-Aksu units (Figs. 3 – 6).

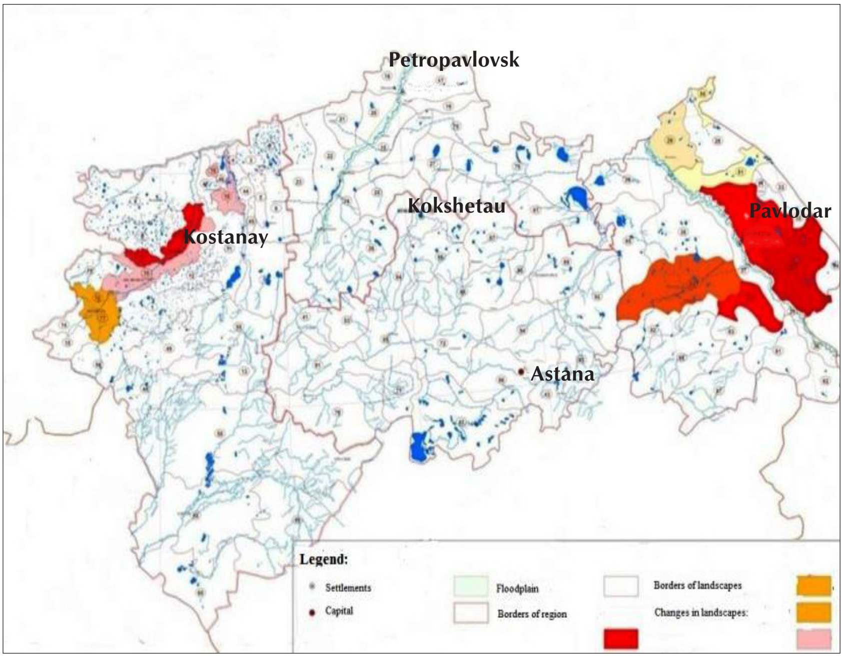


**Figure 4.** Fragment of the map-scheme of technogenic changes in the geosystems of Northern Kazakhstan

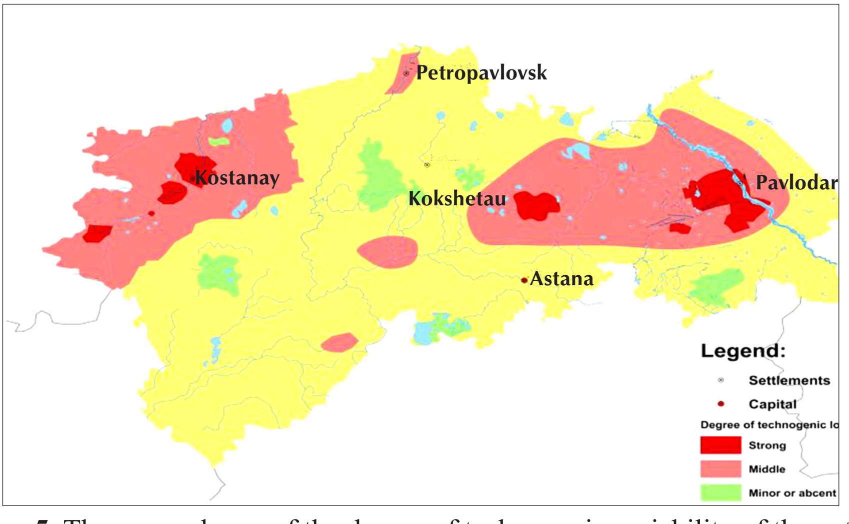


**Figure 5.** The map-scheme of the degree of technogenic variability of the natural resource potential of Northern Kazakhstan

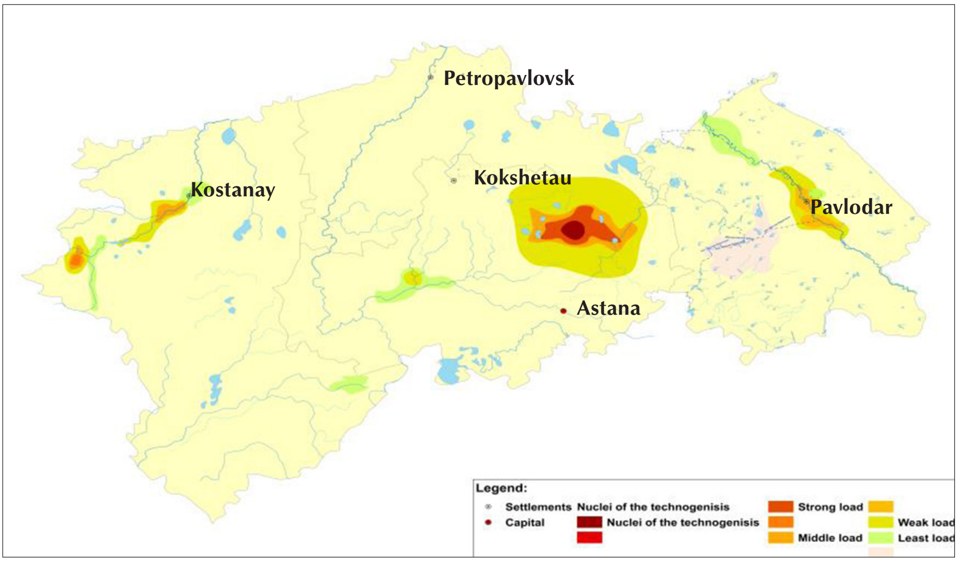


**Figure 6.** The map-scheme of the nuclei of the technogenic load on the environment of Northern Kazakhstan

An important step of the research was the assessment of geo-environmental quality of techno-agrogenicgeoecosystems on the basis of their qualitative and quantitative factors. By way of example, geoecological assessment of the quality of Tobol-Kostanaytechno-agrogeoecosystemis shown in Table 3. Geosystem-basin qualitative numbers of Tobol-Kostanaytechno-agrogeoecosystem, on the basis of which the assessment was performed, are shown in Table 3.

**Table 3.** The evaluation of geoecological quality of geosystems of the Tobyl-Kostanay techno-agrogeoecosystems

| № | Geosystem | Economic development | Structural changes in the landscape | Natural-Anthropogenic Processes | Quality of the techno-agrogenic system |
|---|---|---|---|---|---|
| 10 | Natural-animal-agrogenic | Pastures, fields of rainfed farming, recreational areas. | 80% - pastures, 10% - arable land, 10% -mudflow | Intensive processes of flat flushing, weak erosion, altered water erosion processes | Midle, stable, suffusive |

| | | | | | |
|---|---|---|---|---|---|
| 76, 77 | Natural-techno-anthropogenic | Pastures, rainfed lands, anthropogenic wasteland. | 10%- transport lands, 10% - fields 10% - Pastures | Processes of flat flushing, deflation, suffosion | Unstable, poorly eroded, erosion-deflationary |
| 73, 74 | Natural-technogenic-residential | Industrial dumps, wastelands of developed areas. | 60%-miningindustry | Weak erosion, altered by water erosion processes, deflationary | Wasteland-man-made, -slagheap-basin -ridge-like |

In addition, basing on the obtained data we analyzed geosystems qualityfor intensity of natural and anthropogenic processes. The results of such analysis of geosystemsquality for intensity of natural and anthropogenic processes of Tobyl-Kostanay techno-agrogeosystemare in Table 4.

**Table 4.** The quality of geosystems based on the intensity of natural-anthropogenic processes Tobyl-Kostanay techno-agrogeosystem

| № | Categories | Quality of the techno-agrogenic system | Intensity of development of natural-anthropogenic processes |
|---|---|---|---|
| 10 | Agricultural Geosystems | Intensively functioning | The strong, natural-anthropogenic processes depend on the degree of pasture degradation. |
| 73 | Mining Geosystems | Unstable, poorly functioning | Middle, some negative processes develop moderately, require intensive nature conservation measures. |
| 77 | Industrial-residential | Weak-resistant, middle-functioning | Strong industry-dependent factors of industrial production. |
| 74 | Transport-residential | Unstable, poorly functioning | Strong, slightly depends on the intensity of the functioning of transport and residential facilities. |

## Conclusions

Profound geo-ecological changes in the landscape of Northern Kazakhstan raise a number of new problems, the solution of which is important in the modern development of agricultural and industrial branches of the region and in powerful processes of agro-tecnogenesis. In our view, the prioritiesshould include a strategy of land use and land management, development of landscape-geoecological concept of the region, including environmental protection activities and monitoring of prospective solutions, creation of regional ecological plan on protection of desertification, development of scientific foundations of regional monitoring of industrial systems for sustainable development of the region (Ronov & Ermishkina, 1953).

The processes of anthropogenic desertification are clearly illustrated by landscape transformation in arid alluvial and lacustrine-alluvial plains. Unstable river water levels caused significant changes of hydromorphic geosystems. Hydromorphic landscapes experience different stages of changes under the influence of anthropogenic changes. On the background of desertification, different salts intensively consetrate. Under these conditions, salt complexes are formed in shallow groundwaters that results in their further semi-automorphic and automorphic development with the decrease of the groundwater level. Such a pattern can be seen in the landscapes of river valleys of Northern Kazakhstan where hydromorphic transformation of geosystems has been observed.

As a result of this work, we collected the information basis for the functioning of techno-agro geoecosystems of the region, starting with the period of development of virgin land to a modern state, developed the structural model of techno-agrogenic geoecosystems, created sets of maps reflecting the geoecological state of techno-agro geoecosystems of Northern Kazakhstan. Using the structural model of techno-agrogeoecosystem andcreated GIS database of the region, it is possible to perform the dynamics, development and evolution of the techno-agro geoecosystems of Northern Kazakhstan. We created a structural model that reflects internal structure of the techno-agrogeoecosystems of Northern Kazakhstan and relationships between its sub geosystems and sets.

Modern techno-agro geoecosystem is a natural-anthropogenic formation with a complex internal structure that performs specific functions and which provides the conditions of human life.

## REFERENCES

Avessalomova, I.A. (1992). *Ecological evaluation of landscapes*. Moscow: Moscow State University Press [In Russian].

Bastian, O. & Steinhardt, U. (2002). *Development and perspectives of landscape ecology*. Berlin: Springer.

Buyantuyev, A. & Wu, J. (2007). *Effects of thematic resolution on landscape pattern analysis. Landscape Ecology, 22*(1), 7 – 13.

Beruchashvili, N.L. (1990). *Geophysics of landscapes*. Moscow: Vysshaya shkola [In Russian].

Dzhanaleyeva, K.M. (2008). *Theoretical and methodological issues of geography*. Astana: L.N. Gumilyov University Press [In Russian].

Chang, C.-R., Lee, P.-F., Bai, M.-L. & Lin, T.-T. (2006). Identifying the scale thresholds for field-data extrapolation via spatial analysis of landscape gradients. *Ecosystems*, *9*. 200 – 214.

Geldyeva, G.V. (2008). Landshaftno-ekologicheskie issledovaniia dlia obespecheniia ustoichivogo razvitiia prirodno-khoziaistvennykh sistem Respubliki Kazakhstan. *Geografiia: nauka i obrazovanie*, pp. 31 – 35.

Glazovskaya, M.A. (1983). Principi klassifikatsii prirodnikh geosystem po ustojchivosti k tekhnogenezu i prognoznoe landshafto-geokhicheskoe rajonirovanie (pp. 61 – 78). In: Armand, A.D. & Dolgushin, I.Y. (Eds.). *Ustoychivost geosystem.* Moscow: Nauka.

Isachenko, A.G. (1991). *Landscape science and physico-geographical zoning*. Moscow: Vysshaya shkola [In Russian].

Kasimov, N.S. (1988). *Geochemistry of steppe and desert landscapes*. Moscow: Moscow State University Press [In Russian].

Koritny, L.M. (2001). *The basin concept in nature management: monograph*. Irkutsk: Institute of Geography SB RAS [In Russian].

Mamai, I.I. (1972). Metody landshaftnykh issledovanii i landshaftnyi printsip izucheniia prirody (pp. 29 – 41). In: Mamai, I.I. (Ed.). *Landshaftovedenie.* Moscow: Moscow State University Press.

Mamai, I.I. (2005). *Dynamics and functioning of landscapes*. Moscow: Moscow State University Press [In Russian].

Milkov, F.N. (1954). Tipy mestnosti i landshaftnye raiony TSentralnykh chernozemnykh oblastei k voprosu o vydelenii regionalnykh i tipologicheskikh edinits v landshaftnoi geografii. *Izvestiia Vsesoiuznogo geograficheskogo obshchestv*, *86*(4), 336 – 346.

Milkov, F.N. (1977). Genezis i geneticheskie riady landshaftnykh kompleksov. *Geography*, *12*, 5 – 11

Ronov, A.B. & Ermishkina, A.I. (1953). Methods of quantifying landscape-geochemical maps. *Doklady AN SSSR, 91*(5), 25 – 32 [In Russian].

Saet, Y.A., Revich, B.A., Yanin, E.P., Smirnova, R.S., Basharkevich, I.L., Onishchenko, T.L., Pavlova, L.N., Trefilova, N.A., Achkasov, A.I. & Sarkisian, S.S. (1990). *Geochemistry of the environment*. Moscow: Nedra [In Russian].

Saukov, A.A. (1975). *Geochemistry*. Moscow: Nauka [in Russian].

Solntsev, N.A. (1949). O morfologii prirodnogo geograficheskogo landshafta. *Voprosy geografii.* No. 16, 61 – 86.

Solntsev, N.A. (2001). *The doctrine of the landscape: selected works*. Moscow: Moscow State University [in Russian].

Sochava, V.B. (1978). *Introduction to the doctrine of geosystems.* Novosibirsк: Nauка [In Russian].

Sochava, V.B. (2005). *Theoretical and applied geography*. Novosibirsк: Nauка [In Russian].

Trapeznikova, O.Y. (2002). GIS and remote sensing techniques for space-time modeling of ecosystems of the east of Russian plain. *Proceedings 8th Annual Conference of International Association for Mathematical Geology*, pp.501 – 506.

Turner, M.G., Gardner, R.H., O'Neill, R.V. (2001). *Landscape ecology in theory and practice: pattern and process*. Berlin: Springer.

Zyrin, N.G., Obukhov, A.I. (1983). Printsipy i metody normirovaniia standartizatsii soderzhaniia tiazhelykh metallov pochve i sisteme pochva-rastenie-rastenie. *Biul Pochv in-ta im V.V. Dokuchaeva, 35,* 7 – 10.

✉ **Dr. Zharas Galimzhanovic Berdenov**
L.N.Gumilev Eurasian National University
5, Munaitpassova St.
010 000 Astana, Republic of Kazakhstan
E-mail: berdenov.87@mail.ru