



Research article

The economic situation and ways to solve the environmental problems in the city of Ust-Kut

Tatyana P. Kalikhman*

Environmental Biotechnology Laboratory, A. E. Favorsky Irkutsk Institute of Chemistry SB RAS, 1 Favorsky St., Irkutsk, Russia 664033

* **Correspondence:** Email: kalikhman@irigs.irk.ru; Tel: +79041208101.

Abstract: The Ust-Kutsky district and its center, the Ust-Kut city, have become the fastest growing in the Irkutsk region of Russia in the last decade. Ust-Kut is a very important settlement for the economic development of the northern territories of the Irkutsk region and the southern territories of the Republic of Sakha (Yakutia). The city is a key transport hub, where various types of transport routes converge: railway, aviation, automobile, river, and product pipeline. There are deposits of various minerals near Ust-Kut. The timber mining and timber-processing industries are represented here as much as possible. On the other hand, Ust-Kut is one of the ten most air-polluted cities in the Irkutsk region. Most of the air pollution consists of substances formed as a result of fuel combustion. The unfavorable air regime of the city is influenced by climatic conditions: relatively weak winds and temperature inversions in winter. The oil and gas deposits located nearby may help solve the problem of air pollution by gasification of Ust-Kut. In addition, water and soil pollution have been noted in the city due to technological problems of wastewater disposal, garbage collection, and recycling, as well as certain types of industrial waste processing. Therefore, the main task of the sustainable development of the city is to solve its environmental problems. Ust-Kut's environmental problems are solved at the expense of financial resources from government programs, which are not sufficient. But the tax on mining is completely federal, as these funds do not remain in the territory. Through this research, we have searched for ways to achieve a balance between economic development and environmental well-being in Ust-Kut. Specifically, we have explored additional types of economic activities that are safe for nature and public health. For Ust-Kut, located in the north of Eastern Siberia, it is important to increase the area of green spaces within the central part of the city. The development of a system of parks and squares involves their improvement and the formation of a connection into a single natural framework through linear landscaping objects and

connections with urban forest sites. The use of sanitary protection zones around enterprises that emit into the environment will contribute to the formation of a comfortable environment and expand landscaping opportunities.

Keywords: Ust-Kut city; environmental pollution; ecological framework; protected natural areas; landscaping

1. Introduction

The city of Ust-Kut and the Ust-Kut district are among the fastest growing in the Irkutsk region of Russia, called territories of advanced development or support territories. The city-forming basis of the city and the district is the transport complex and industry. The traditional forestry and timber-processing industries have now been joined by the oil industry represented by LLC Irkutsk Oil Company (IOC) and its subsidiary JSC Ust-Kutneftegaz. The pace of economic development is influenced by physical, geographical, social, and environmental factors. Ust-Kut is located in the upper reaches of the Lena River at the confluence of the left tributary of the Kuta River. The city stretches along these rivers from west to east in a straight line for 28 km. Historically, Lena was the first transport artery, to which the railway and the highway were added, and there is also an air connection. Since the construction of the Baikal-Amur Mainline (BAM), Ust-Kut has been a transshipment point connecting the railway and the Eastern Siberia–Pacific Ocean oil pipeline. There are sections of product pipelines operating here:

- from the Verkhnechonskoye oil mineral deposits in the neighboring Katanga district of the Irkutsk region;
- from the Danilovsky oil and gas condensate mineral deposits located next to the previous one;
- from the Yaraktinskoye oil and gas condensate mineral deposits located on the border of Ust-Kutsky and Katanga districts;
- from the Verkhnemarkovsky oil and gas condensate mineral deposits located on the border of Ust-Kutsky and Katanga districts near the village of Verkhnemarkovo in Ust-Kutsky district.

For the first time, this article consistently analyzes the main factors of pollution of the urban environment of Ust-Kut along with existing environmental problems, and provides justification for the most acceptable ways to solve them. The work was carried out between 2023–2024. The materials of the Mayor's office, statistical information, and the results of interviewing residents of Ust-Kut were used.

2. The main pollutants of the city's environment

2.1. Air pollution factors

Weather conditions significantly affect the intensity of atmospheric air pollution. The dominant wind directions throughout the year in Ust-Kut are westerly and southwesterly. The quality of atmospheric air is associated with the peculiarities of local conditions, including the relief structure, wind regime with low speeds, low winter temperatures, and, in addition, with the type of heating of

residential and industrial premises (coal, firewood, and wood chips are used as fuel in a fairly extensive private sector along with 15 city boiler houses of various accessories, giving a significant volume of solid particles of aero pollutants—soot and other aerosols). Also, due to the considerable length of the city, the purity of the air is affected by a significant amount of exhaust gases from vehicles in winter, while stagnant phenomena are noted, leading to the accumulation of air pollution in the lower layers of atmospheric air. The situation is attributed to dangerous meteorological phenomena including the temperature inversion of the air (see Figure 1). The maximum single concentration of suspended solids in winter are often significantly higher than the MPC and are felt even organoleptically. In the photo, it is noticeable that, in such conditions, smog cannot rise above a certain height and creeps along the surface of the earth.



Figure 1. Smoke in the atmosphere of Ust-Kut in winter, a view of the city in the western direction from the side of the automobile bridge on the right bank of the Lena River (photo by the author, 02/04/2024).

The second most important factor in air pollution is considered to be fires that occur due to natural and anthropogenic causes. The latest examples of emergency situations in Ust-Kut are: in 2015, the months-long smoldering of sawdust deposits on the territory of the Trans-Siberian Forest Company enterprise; in 2019, due to the northeasterly wind, the strongest smoke of Ust-Kut was established in the territory of the Kirensky district, where 22 fires occurred; on December 19, 2022, a large fire broke out on Verkhnemarkovsky gas mineral deposits due to the ignition of a complex natural gas treatment plant; since November 2023, prolonged flare burning at the IOC mineral deposits has led to an unpleasant chemical odor due to complex testing of equipment. In addition, burning gas was located in the Verkhnemarkovsky gas mineral deposits.

2.2. *Pollution of water bodies*

The main sources of pollution in Ust-Kut are river fleet vessels, ports, oil depots, the fleet maintenance base (FMB), shipyards, sewers (conditionally treated wastewater), and industrial and household wastewater that has not been treated. Among the pollutants, petroleum products, phenols, and copper compounds predominate. In spring, melted snow flows into rivers along with slag,

garbage, and deicing reagents. The water in Lena is estimated from “conditionally clean” and “polluted” in the western part of the city to “dirty” in some areas in the eastern part downstream [1].

Of the enterprises of housing and communal services in the Lena River in the city of Ust-Kut, only LLC Management Company Vodokanal-Service has permission to discharge wastewater (conditionally treated). The solution to the problem of cleaning the city’s territory from liquid household waste (LHW) is being handled by the Customer Service for Housing and Communal Services of the Ust-Kut Municipal Formation (urban settlement), which has implemented a program working toward “reducing the cost of transporting liquid household waste (septic tanks, cesspools) from residential buildings in Ust-Kut for 2012–2019.”

2.3. Solid municipal waste

In accordance with the order of the Ministry of Natural Resources and Ecology of the Irkutsk Region “On Amendments to the Order of the Ministry of Natural Resources and Ecology of the Irkutsk Region No. 43-mpr dated December 29, 2017” (No. 66-51/1-mpr dated 10/06/2023), the Ust-Kut administration provided information on the location of an existing landfill of solid household waste (SHW) with annual actual volumes of solid municipal waste removal of 90–140 thousand m³. To date, the register of SHW accumulation sites of the city includes 142 objects, of which 68 sites are on a concrete impermeable base, 19 are without designation, and the rest are on the ground.

Sawdust is the waste of wood-processing industries, the long-term accumulation of which often turns the sites of Ust-Kut forestry enterprises into peculiar “relief forms”. With a short storage period, these wastes have almost no dangerous properties, and storage for more than 11 months or burial in unauthorized places leads to environmental pollution, posing a significant threat to the ecological situation of the city, namely:

(1) High fire hazard with spontaneous heating of the inner layers with the highest temperature for 4–6 months of storage. A special type of burning is smoldering, which often leads to large-scale fires and significant air pollution.

(2) Release of toxic substances including wood dust carried through the air (leads to allergic respiratory diseases, inflammation of the mucous membranes, cancer). The main released toxicants are phenols, which, even at low concentrations, sharply worsen the quality of water and soil, and when chlorinating water containing phenols, stable chlorophenols are formed. The soil accumulates such pollutants, which leads to a slowdown in plant development even in insignificant concentrations [2,3]. It has been shown that the toxic effect of phenolic acids correlates with their concentration and completely disappears at a content below 0.01% [4].

(3) Lignocellulose raw materials have a high ability to absorb minerals from the soil, impoverishing it.

(4) Sawdust accumulations can be a reservoir for tree pathogens.

3. Approaches to solving environmental problems

The air pollution of the city is directly associated with the use of coal and wood as fuel in different versions. Gasification has been called the main means of solving the problem of air emissions for many years. Within the framework of the Irkutsk region program “Development of housing and communal services and energy efficiency improvement in the Irkutsk region” for 2024–2030,

it is planned to build a 70 MW gas boiler house in Ust-Kut with a cost distribution over the years totaling 2,613,963.99 thousand rubles from the finances of the regional budget. Taking into account the proximity (100 km) of the Verkhne-markovskiy oil and gas mineral deposits from Ust-Kut, as well as the passage of other pipelines in the city area, gasification here could be one of the first among similar ones in the region.

Shifting the costs associated with gasification from the federal to the regional budget seems devoid of the logic of territorial development. For the Ust-Kut city and similar neighboring districts, there is no interaction with companies extracting minerals within the boundaries of the administrative district, sometimes called a “social contract”, which ensures the mandatory deduction of part of the extraction tax to local budgets. This principle, for example, applies in Alaska (USA), in the provinces of Canada. The problem is related to the establishment, in 2002 in Russia, of a direct federal tax on mineral extraction (FTME), which was explained by state ownership of the subsoil. The most significant revenues to the consolidated budget of the Russian Federation, ahead of VAT, income tax, and personal income tax, are FTME. But municipal budgets, in whose territories mineral resources subject to FTME are mined, and whose natural land plots are irreversibly violated, do not receive any rental funds [5]. In addition, given JSC Gazprom’s monopoly on laying pipelines and the company’s interest only in exporting gas abroad, there is a long-term lack of gasification opportunities in the Irkutsk region, a region in which significant gas fields and oil fields with associated petroleum gas are located.

In accordance with the State Program of the Irkutsk region “Environmental Protection”, in the section on the complex of measures of the long-term development plan of the Ust-Kutsky municipal district, it is planned to build a new SHW landfill in the Ust-Kutsky district based on 25,000 tons/year with a commissioning date at the end of 2027. It is clear that, for a modern city, this is not a full-fledged solution for the issue. In the future, an enterprise should be created and, accordingly, new jobs for activities aimed at reducing the volume, sorting, and processing of municipal solid waste. For the organization of waste accumulation sites in accordance with the State Program of the Russian Federation “Environmental Protection” until 2025, 9,888,88 thousand rubles are planned for the arrangement of temporary SHW accumulation sites in Ust-Kut, of which 8,504.44 from the federal budget and 384.44 from the local budget will bring 18 SHW small-sites into a normative, safe, sanitary condition.

In addition to household waste, solutions for the elimination and processing of industrial waste, primarily wood-processing enterprises, may be relevant. The A. E. Favorsky Irkutsk Institute of Chemistry SB RAS has developed a nature-like technology for accelerated composting of sawdust using a specially selected composition of wood-destroying mushrooms, which gives bio humus as a finished product. The resulting fertilizer contains the necessary nitrogen, phosphorus, and potassium in a form easily absorbed by plants and in a well-balanced form [6]. Such a technology can be based on well-known approaches to the stimulating role of “green” production factors of companies [7].

In general, in Russian legislation, industrial waste in the form of sawdust should be classified as a secondary resource.

Effective sanitation can be provided by the following measures: in the territory not covered by the centralized sewerage system, collection of household wastewater from autonomous septic tanks; elimination of leakage of collection tanks and pollution of aquifers; reconstruction of centralized wastewater disposal (wear is 63%) on the territory of Ust-Kut (especially in the village of Angara-Lena Geophysical Expedition (ALGE), microdistrict “Northern geological exploration expedition”,

and in other areas most remote from the city center); in the Turuka village, which is part of the Ust-Kut urban formation, the arrangement of the missing centralized wastewater disposal system and the exclusion of the discharge of untreated wastewater to the relief; modernization of methods and automation of treatment of complex wastewater treatment plants; arrangement of storm sewers; obtaining a license to discharge wastewater into a reservoir by enterprises and individuals who are still carrying out unlicensed discharge of inadequate quality water into Lena. Funding for these events is still missing or extremely insufficient.

4. Formation of an ecological framework

The term “ecological framework of the city” adopted in scientific research is based on a number of terms used in regulatory documents, in particular “green areas”, “green spaces”, “specially protected natural areas” (PA). At the same time, the ecological framework refers to the systematic organization of undeveloped areas and areas not covered with artificial materials with vegetation.

The main thing in the formation of the ecological framework of Ust-Kut is the structure of landscaping of residential and industrial areas of the city. The satisfactory ratio of green areas to the city area is a consequence of the contribution of natural suburban forests included in the boundaries of Ust-Kut. Such an assessment, however, has little to do with individual neighborhoods of the city. In the Code of Rules “Landscaping” [8], landscaping standards are determined not by the peculiarities of preserving urban green landscapes of the “natural framework”, but by the number of the urban population. Ust-Kut has a population of 40 thousand people. According to the classification of cities in the Rulebook [9], small towns are indicated by 8 m² per person, and residential areas do not have an indicator provided at all, unlike large and medium-sized cities (indicated by 6 m²/person). These regulatory documents poorly reflect the intensity of air emissions, the number of vehicles, the area of green zones, as well as their density, location, and interconnection.

The process of forming an ecological framework includes:

- creation of green “cores” (specially protected natural areas, urban forests, parks, squares, etc.);
- linear green objects (boulevards, alleys, embankments, sanitary protection zones around industrial facilities, protective forest belts along transport and other linear engineering structures, water protection zones around and along surface water bodies and drinking water intakes), connecting the cores and natural forests around the city into a single structure.

4.1. Specially protected natural areas

In accordance with the “State Cadastre of PAs of regional significance of the Irkutsk region”, on the Ust-Kut municipality (urban settlement) territory, they are missing. Nevertheless, the nature monument of regional significance “Skala Mir” almost touches the border of the city. Also, directly within the borders of Ust-Kut, there is a natural monument of regional significance “Ust-Kutsky source”. The site of this PA belongs to the lands of settlements, located within the sanatorium “Ust-Kutsky”. Both protected areas were included in the approved regional list of PAs (Order of the Ministry of Natural Resources and Ecology of the Irkutsk Region “On approval of the list of specially protected natural areas of regional and local significance of the Irkutsk Region as of 05/01/2020” No. 26-mpr dated 06/18/2020, replaced later by a similar Order No. 66-42-mpr

dated 08/11/2022) [10]. The reserved areas for the purpose of creating new PAs and recreational areas in Ust-Kut include the following: nature park “Ust-Kutsky”; natural monument “Hen harrier nests”; mineral spring “Turuksky”; and the promising recreational area of local significance “Eiseira Sanatorium”.

4.2. Water protection zones

The width of water protection zones, which are linear structural elements of the frame, on which a special regime for carrying out economic and other activities is established in order to prevent pollution, clogging, siltation of water bodies, and depletion of waters and preserve the habitat of aquatic biological resources and other objects of the animal and plant world, is established based on the length of the watercourse. In Ust-Kut, water protection zones are not defined on the ground and are not publicly registered in the Unified State Register of Real Estate of Russia (USRRE). The width of the water protection zones is indicated below (Table 1).

Table 1. Width of water protection zones of rivers and streams in Ust-Kut.

No.	Name of the water object	Length, km	Standard, m
1	Lena River	44,000	200
2	Kuta River	408	200
3	Yakurim River	73	200
4	Bermyakina River	22	100
5	Panikha River	5	50
6	Polovinnaya River	93	200
7	Turuka River	240	200
8	Streams	–	50

4.3. Coastal protective strip

Coastal protective strips have not been installed on the territory of Ust-Kut and are not on the state cadastral register in the USRRE.

4.4. Area of sanitary (mining and sanitary) protection of health-improving areas, resorts, and natural healing resources

Within Ust-Kut, there is a licensed sanatorium of the 1st category—CJSC Sanatorium Ust-Kut. It should be noted that the Ust-Kut resort was registered in the first state register in our country No. 1272p dated 07/26/1993. No one has canceled this resolution, and the established boundaries of the sanitary protection zones remain.

4.5. Sanitary protection zones for drinking and household water supply sources

By order of the Ministry of Natural Resources and Ecology of the Irkutsk Region No. 66-55 dated 10/14/2022 “On the establishment of a sanitary protection zone for the Lena water intake (Ust-Kut)”, a description of the boundary of the first sanitary protection belt of this intake was approved.

For the remaining 57 water intakes of the city, according to the administration, sanitary protection zones are not established.

4.6. Protected forests

The Urban Forests Forestry is located on the territory of Ust-Kut, and information about the boundaries of which is included in the materials of forest management and in the Unified State Register of Natural Resources. A resolution of the Ust-Kut administration dated 05/27/2016 No. 624-17 approved the regulation on the Urban Forests Forest Park. The location of urban forest plots is shown in Figure 2, and the list and characteristics of urban forest land plots are given in Table 2.

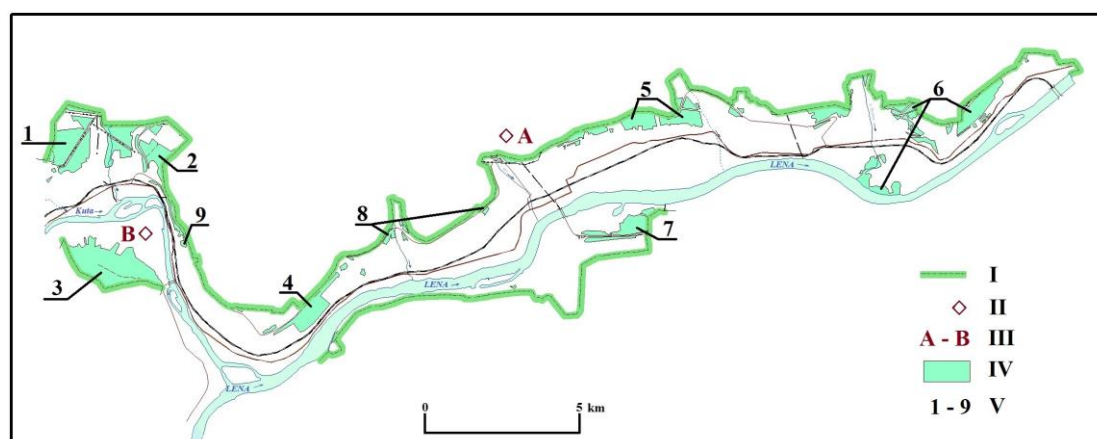


Figure 2. Urban forest sites and natural monuments of regional importance in Ust-Kut. I–City borders; II–Natural monuments; III–Numbering of natural monuments: A–Mir Rock, B–Ust-Kutsky Spring; IV–Urban forests; V–Numbering and location of sites in accordance with Table 2.

Table 2. List of land plots for urban forest conservation.

No.	Land plots	S, ha	Location
1	38:18:000000:1445	85,59	In the northwestern part of the city, on the right and left banks of the Panikha River
2	38:18:000000:1429	95,68	In the northwestern part of the city, in the area called the “Northern Expedition”
3	38:18:000000:1431	146,98	In the area of the Ust-Kut Sanatorium
4	38:18:020101:173	27,62	Between the residential areas “stary Ust-Kut” and “Holbos”
5	38:18:000000:1432	78,2	In the northern part of the city center
6	38:18:000000:1428	136,56	In the eastern part of the city
7	38:18:000000:1442	48,24	In the southern right-bank part of the city center
8	38:18:000000:1447	30,10	In the northern part of the city, from the city cemetery to the highway ring in the area of Nekrasov St.
9	38:18:000000:1448	13,00	In the western part of the city, across the river from the Ust-Kut Sanatorium
Total		661,97	

4.7. *Landscaping objects*

For a city as large in area and extent as Ust-Kut, in the presence of urban forests, which are simply suburban forests included in the city (i.e., the efforts of the Mayor's office were not made to organize them), specially landscaped areas are extremely insufficient, because cities typically try to achieve indicators of 25% for comfortable living. Specifically, the lack of dendroflora is noticeable in residential areas and in industrial areas, where only free-standing trees are found. Taking into account the significant air pollution in winter, in addition to transferring the city's heating to gas produced near Ust-Kut in the future, coniferous non-deciduous tree species (pine, siberian pine or "cedar", and spruce) should be used in landscaping in addition to standard deciduous trees and shrubs.

In functional zoning according to the general plan of Ust-Kut (without the settlement of Turuka), it is noted that the zone of green areas of general use (forest parks, parks, gardens, squares, boulevards, urban forests) is 696.65 hectares or 11.54% of the city area (of which urban forests make up 661.97 hectares). The zone of "green areas for special purposes" is 1.03 hectares or 0.02% and the resort area is 49.9 hectares or 0.83%. The total area of the green areas is 746.58 hectares or 12.37% of the total area of the city (6,034.89 hectares). In Ust-Kut, the population as of 04/01/2024 was 40,783 people. Thus, formally, the area of green areas per person in this city is 183 m², or 23 times the established norm. But with such a declarative approach, one should take into account not only the area of urban forests on the outskirts of the city, but also consider the density of dendroflora, and its condition and distribution within the residential zone and industrial territories. Then, the situation does not look so good.

The improvement of public and courtyard areas in Ust-Kut is provided for by: the state program of the Russian Federation—the Federal project "Formation of a comfortable urban environment" within the framework of the national project "Housing and urban environment"; the state program of the subject of the Russian Federation—the state program of the Irkutsk region "Formation of a modern urban environment" for 2018–2025; and the investment program—the annual all-Russian competition for the best creation projects a comfortable urban environment in small towns and historical settlements. As part of these programs, only 6 territories and 6 courtyards are planned to be landscaped in the city by 2030. Of course, this is extremely insufficient for landscaping and trapping harmful substances from the atmosphere, so the number of such facilities should be multiplied.

4.8. *Alternative landscaping*

The areas of possible landscaping are forest strips along the main highways, railways, and industrial facilities (a functional zone of special purpose green areas), as well as cemetery sites. If the main parameters for special purpose landscaping have strict indicators, then, as a rule, cemeteries do not contain such requirements. Nevertheless, the territories of cemeteries in many countries are green walking areas. There are 3 closed and 5 active cemeteries in Ust-Kut.

Thus, in accordance with the general plan of Ust-Kut, the conditionally landscaped territories of the city amount to 809.71 hectares or 13.4% of the city area. The existing "cores" of landscaping are not yet connected by linear green elements. Based on the quality of plantings and the distribution of green areas in residential and industrial areas, it is now possible to judge the unsatisfactory landscaping of the city.

5. Conclusion

The solution to the environmental problems of cities is often reduced to the inevitability of compromises linking the requirements of economic development with the need to ensure the comfort of citizens. The marked deterioration in the quality of the environment—air, land, and water—indicate the one-sidedness of compromises. Negative additions may be the formation of significant amounts of waste, soil degradation and pollution, reduction of the area of green spaces, and noise pollution.

It is important to mention the existing gasification program of the Irkutsk region for 2021–2025, which provides for the gasification of three sites: 1) Ust-Kut (Verkhnemarkovsky gas); 2) Mainline, Ulkan, Yukhta, and Tarasovo; 3) Zhigalovo (Kovyktinsky gas). The decades-long discussion of this issue casts doubt even on the partial implementation of the program and the shift toward solving environmental problems.

Thus, it can be concluded that the solution of the environmental problems of the city of Ust-Kut is possible under the following conditions:

- Reducing the number of coal and wood-fired thermal power plants (replacing with gas), placing such facilities downwind, and locating residential areas outside the negative impact zone. In the private sector, when abandoning furnace heating, switching to modern boiler heating, including using wood pellets, gas, electricity, and solar and wind energy installations.

- Control of emissions into the atmosphere, as well as effluents into soils and water bodies, with the construction of effective treatment facilities and the introduction of modern technologies in production.

- Landscaping of the urban environment, taking into account the fact that planting trees and further care for them is more expensive than installing a lawn and asphalt. Therefore, city halls usually plant few trees, although it is arboretum that restrains noise and dust, regulates groundwater, and improves the gas composition of the air. Trees provide shade in the summer, and green areas serve as recreation areas for citizens.

- Replacing air-polluting vehicles with environmentally less harmful ones, for example, hybrid or electric vehicles, at least for public transport.

- Sorting garbage and moving to its separate collection, recycling of garbage, and abandoning the formation of landfills for simple storage of solid household waste.

- The introduction of “smart city” technology: devices that regulate the supply of heat, water, and electricity in residential buildings, control urban lighting, and signal the need to remove garbage, etc.

The strategic goal of the environmental policy of Ust-Kut urban settlement in the long term should be to maintain the integrity of natural systems and their life-supporting functions for balanced development, maintaining public health, and ensuring environmental safety of the territory, provided that the competitiveness of the city’s economy increases and the attractiveness of the territory remains.

One of the favorable factors of the environmental condition of the studied territory is the presence of green spaces of natural origin, occupying a significant part of the territory of the urban settlement. However, most of them are located on the outskirts of the city, and landscaping inside residential and industrial zones, as well as along the banks of major rivers and industrial facilities, is extremely insufficient. The development of a system of parks and squares involves their

improvement and the formation of a connection into a single natural framework through linear landscaping objects and connections with urban forest sites.

The use of alternative plots—cemeteries, territories of garage cooperatives gradually moved underground, and sanitary protection zones around enterprises that emit into the environment—will contribute to the formation of a comfortable environment and expand landscaping opportunities.

Use of AI tools declaration

The author declares they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Conflict of interest

The author declares no conflict of interest.

References

1. Dzhamalov RG, Reshetnyak OS, Vlasov KG, et al. (2021) Specific features of water chemistry and quality in the Lena River basin. *Water Ecol* 26: 33–43. <http://dx.doi.org/10.23968/2305-3488.2021.26.3.33-43>
2. Kolesnikov SI, Kazeev KS, Tatlok RK, et al. (2014) Biodiagnostics of brown forest soils' resistance to oil pollution and heavy metals pollution in Western Caucasus. *Siberian Ecol J* 21: 493–500. Available from: <https://innoscope.ru/analytics/publications/4168/?ysclid=lyr79tb4px46644963>.
3. Buluktaev AA (2017) Phytotoxicity and enzymatic activity in soils of Kalmykia under the influence of oil pollution. *South Russ: Ecol Dev* 12: 147–156. <https://doi.org/10.18470/1992-1098-2017-4-147-156>
4. Kislitsina MN, Borisova GG (2016) Responses of *Lemna minor* L. to the exogenous phenolic compounds action. *Scientific Notes of Petrozavodsk State University* 157: 54–58. Available from: <https://cyberleninka.ru/article/n/otvetnye-reaktsii-lemna-minor-l-na-deystvie-ekzogennyh-fenolnyh-soedineniy>.
5. Borlakova TM, Semenov DS (2020) The role of the mineral extraction tax in the Russian budget system. *Vector Econ.* Available from: http://www.vectoreconomy.ru/images/publications/2020/9/taxes/Borlakova_Semenov.pdf.
6. Belovezhets LA, Volchatova IV, Medvedeva SA (2010) Promising methods of processing secondary lignocellulose raw materials. *Chem Plant Raw Mater* 5–16. Available from: <https://cyberleninka.ru/article/n/perspektivnye-sposoby-pererabotki-vtorichnogo-lignotsellyuloznogo-syrya/viewer>.

7. Gao D, Zhou X, Mo X, et al. (2024) Unlocking sustainable growth: exploring the catalytic role of green finance in firms' green total factor productivity. *Environ Sci Pollut Res* 31: 14762–14774. <https://doi.org/10.1007/s11356-024-32106-6>
8. Code of Rules “Territories improvement”. Approved by Order of the Ministry of Construction and Housing and Communal Services of the Russian Federation No. 972-pr dated 12/16/2016. Available from: <https://docs.cntd.ru/document/456054208>.
9. Code of Rules “Building codes and regulations 2.07.01-89 Urban development. Urban and rural planning and development” (2016b). Approved by Order of the Ministry of Construction and Housing and Communal Services of the Russian Federation No. 10/34-pr dated 12/30/2016. Available from: <https://docs.cntd.ru/document/456054209>.
10. Kalikhman TP, Bogdanov VN, Ogorodnikova LYu (2012) *Specially Protected Natural Areas of the Siberian Federal District*, Irkutsk (Russia): Ottisk Publishing House, 384. Available from: <http://savesteppe.org/ru/archives/10541>.



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