Methods of BAT application for restoration of contaminated lands during the integrated development of non-residential areas

Dmitry Spitsov¹* and Igor Yazhlev¹

¹Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, 129337, Russia

Abstract. The article analyzes the content of existing normative and methodological documents, the practice of their application in projects of integrated development of territories (IDT) of non-residential buildings and reorganization of industrial territories in order to create tools for the guaranteed elimination of accumulated environmental damage in urban and industrial territories, the use of the best available technologies (BAT) in conducting research, evaluating sites of territories of integrated development, development of plans for restoration of contaminated lands and reclamation works.

Keywords: best available technologies (BAT), integrated development of territories (IDT) of non-residential buildings, reclamation of contaminated lands, historical environmental damage, negative impact on the environment.

Introduction

The Urban Planning Code of the Russian Federation provides for a mechanism for the integrated development of territories (IDT). The IDT is a set of measures carried out in accordance with the approved documentation on the planning of the territory and aimed at creating favorable living conditions for citizens, updating the living environment and common areas of settlements, municipal districts, urban districts. IDT measures can be carried out in residential and non-residential areas, in undeveloped territories and on the initiative of land owners [1].

The regulatory and legal consolidation of the IDT mechanism allowed:
- to expand the capabilities of regional authorities to include the apartment building (AB) in the projects of the IDT;
- to ensure the development of transport, social, and engineering infrastructure;
- create conditions for the elimination of dilapidated housing and the allocation of subsidies to reimburse the costs of resettlement of residents;
- to attract extra-budgetary funds to finance the renovation of non-residential areas;
- reduce the payback period of construction projects;
- to create a mechanism for the seizure of inefficiently used buildings, structures and land plots for the purposes of the IDT;
- organize additional jobs;

*Corresponding author: dvs43000@yandex.ru

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).
- to increase tax revenues to the budget after the realization of property rights to renovation sites at tenders [18].

**Methods**

The object of the study is BAT and the methodology of their application in the study of the state of disturbed lands and land plots in order to prepare and carry out reclamation. The approaches and methods considered in the article represent the existing best technologies in terms of ecology, economically available, suitable for practical implementation and providing a high level of environmental protection in the implementation of the IDT of non-residential areas [8].

Since 2020, IDT projects have become one of the main tools for the urban development of Russian regions, as a result of which the environmental situation in cities is improving, the efficiency of using territories is increasing, conditions are being created for the modernization of production, infrastructure development, and renovation of built-up areas [18].

According to the Ministry of Construction, 419 IDT projects with a total area of 11.26 thousand hectares are being implemented in 65 regions of the Federation. Their total potential is 78.21 million square meters. m of real estate, including living space – 55.95 million square meters [18].

Since 2020, the reorganization of industrial zones, the elimination of outdated, unfinished and abandoned facilities, and the seizure of inefficiently and inappropriately used land plots have been carried out in Moscow within the framework of the IDT. There are 188 projects under implementation [20].

The industrial territories of the city occupy an area of 18 thousand hectares, 17% of the entire territory of the city. The total number of industrial and scientific facilities is about 2 thousand. At the moment, along with production facilities, there are residential and public development areas within the boundaries of production zones. Territories are often inefficiently used and, due to accumulated environmental damage, have a significant negative impact on the urban environment. According to the materials of the justification of the General Plan of Moscow, 70% of the production areas will retain their functional purpose, and about 30%, about 4 thousand hectares, will be reorganized [20].

The total area of the reorganized territories of the industrial zones will be about 2.5 thousand hectares. Where more than 14.5 million square meters will be built. m of housing, including under the housing renovation program, 6 million square meters. m of production space and more than 14.5 mln. square meters social and business facilities. It is planned to build 85 schools and kindergartens, 19 medical institutions and 48 sports facilities. More than 570 thousand additional jobs will be created at all facilities [19].

In 2023, the total area of the city of Yekaterinburg is 111.069 thousand hectares. The territories of the existing production facilities amount to 7222.31 hectares, which is 6.5% of the total area. In accordance with the General Plan of the city of Yekaterinburg, the main directions of integrated development and reorganization of industrial territories are modernization and development of existing enterprises; changing the functional purpose of inefficiently used production areas; reduction of the area of production areas and the use of vacant land for the development of transport infrastructure; creation of reserves of territories for the development of enterprises.

Among the main indicators of the reorganization of industrial territories, the General Plan indicates that the area of territories that retain their industrial purpose will amount to 6,044.47 hectares, and territories that change their functional purpose 1177.84 hectares.

At the same time, the area of territories planned for housing and civil construction will amount to 339.72 hectares, 181.32 hectares are allocated for the development of recreational areas, and 322.28 hectares are planned for the development of public business, exhibition, and shopping centers [23].
The total area of Kazan is about 63840 hectares. The General Plan of Kazan provides for 4 main types of functional zones: public; residential; industrial; natural. Industrial and communal development zones (non-residential areas make up 5,706.8 hectares, 8.3% of the total area of the city. The General Plan defines the main territories of integrated development: the area of the historical center of the city, with restrictions on building and other activities; zones of reorganization of industrial territories (territories of non-residential development) of the central and middle zones of the city; cargo river port area; centers on the periphery of the city [17].

The maximum negative impact on the environment is recorded in production areas and around busy highways. As a result of the integrated development of these territories, the area of negative environmental impact will decrease from 19% to 14% of the total area of the city [17].

Three pilot projects of integrated development of territories are carried out within the boundaries of non-residential buildings on an area of 1.2 thousand hectares. The IDT projects will allow to increase the volume of housing commissioning in Kazan by 2.3 million square meters. In accordance with regional regulatory legal acts, integrated development of territories is a type of urban planning activity aimed at updating and developing territories, including former industrial zones. It includes demolition, reconstruction of capital construction facilities that do not meet regulatory requirements, construction of new ones, including apartment building (AB), municipal, social, transport infrastructure facilities, and landscaping. The renovation project of the 287 ha river port industrial zone provides for the construction of 1 million square meters of housing, two schools and kindergartens. An embankment stretches along the Volga coast for 9 km. 5 km of new roads will be built and 9 km of existing ones will be reconstructed [16].

The reorganization of industrial territories is an important direction for the development of St. Petersburg, modernization of infrastructure and renovation of built–up areas. Industrial zones account for more than 6 thousand hectares out of 143.9 thousand hectares or 4.2% of the total area of the city. There are more than 3.5 thousand industrial enterprises located within their borders. More than 30% of them border on historical buildings. However, the development of the industrial zones of St. Petersburg in recent years has been non-systematic and fragmentary [20].

For the successful transformation of non-residential areas, it is important to carry out their comprehensive development. In 2022, the IDT mechanism was fixed in the city law "On Amendments to Some Laws of St. Petersburg on the issues of integrated development of territories in St. Petersburg." IDT projects should meet the needs of the city for new housing, urban renewal, creation of new jobs and improvement of social infrastructure [21,22].

To date, 20% of industrial territories have been reorganized, of which 10% are built up by the apartment building (AB), 11% have become public and business zones. The production areas that changed their functional purpose during the reorganization account for about 30% of the total volume of housing put into operation in the city, about 5.6 million square meters, over the past five years.

There are restrictions on 30% of these territories due to the location of facilities of the Ministry of Defense, Russian Railways, special requirements for the placement of enterprises, or enterprises have no incentives to withdraw. According to general estimates, 35% of production areas are possible to implement IDT projects [20].

The common problems of projects for the integrated development of non-residential buildings and the reorganization of industrial areas are:
- increased negative impact of territories on the urban environment due to significant accumulated environmental damage;
- the need for high-quality engineering and environmental studies of land plots, land reclamation and elimination of accumulated environmental damage;
- inefficient use of territories;
- high demands of real estate buyers on the quality of the urban environment and the multifunctional open spaces created for leisure and sports;
- the presence of residential areas and public areas within the boundaries of production zones or in the immediate vicinity, along with production facilities;
- the need to conduct research on the existing engineering infrastructure and the possibility of connecting it, or the construction of new networks and approval for connection to existing engineering facilities;
- additional difficulties and costs are caused by the liquidation of industrial buildings and facilities;
- difficulties in coordinating the projects of the IDT related to the need to change the functional purpose of the land plot. Taking into account the significant areas of industrial zones, this entails additional temporary and financial costs for the developer, which increases the cost and construction time.
- poor transport accessibility and permeability of territories [21].

With the adoption of amendments to the Urban Planning Code (Federal Law No. 494-FZ of 12/30/2020) Chapter 10 "Integrated development of the territory", some problems with the implementation of IDT projects have been solved. For example, the law allows municipal executive authorities to seize industrial zone plots from their owners if they are not engaged in their development, environmental restoration measures, and increased efficiency of use, which greatly simplifies the process of interaction with owners [1].

As noted above, the accumulation of pollutants in industrial areas in the industrial centers of the Russian Federation has been carried out for decades and in some cases reaches significant concentrations that the components of the natural environment themselves (soils, soils, groundwater, surface waters) become a source of pollution. Successful comprehensive development of non-residential areas, reorganization of industrial areas, improvement of the quality of the urban environment in large industrial centers of Russia depends on the development of regulatory, methodological support, including to carry out measures for engineering and environmental research of these territories, the development of projects for the elimination of accumulated environmental damage and reclamation of disturbed lands [8,12,15].

The need for such development is noted in the Decree of the President of the Russian Federation dated 07/21/2020 No. 474 "On the National Development Goals of the Russian Federation for the period up to 2030". The legal framework in the field of identification, assessment, accounting and liquidation of objects of accumulated environmental damage is established by Articles 56.1, 56.2, 56.3, as well as Articles 80.1 and 80.2 of Federal Law No. 7-FZ dated 10.01.2002 "On Environmental Protection" [2,3].

plan for the prevention and elimination of environmental pollution as a result of the operation of a separate production facility and the requirements for the content of such a plan etc.

Their disadvantages are the incomplete content of the measures; the lack of an integrated approach to the study and assessment of the state of the contaminated area; the lack of formalized, standard research procedures; lists of preferred technologies, methods, methods of research and harm elimination and, as a result, the lack of clear approaches to assessing the economic and environmental effectiveness of research and rehabilitation measures [15]. This is an obstacle in the implementation of the provisions of the above-mentioned documents when using mechanisms that ensure the guaranteed elimination of accumulated environmental damage in industrial areas [9]. For example, when providing financial guarantees for the implementation of an action plan for the prevention and elimination of environmental pollution as a result of the operation of a separate production facility or risk management during surveys and reclamation works.

Industrial or other functional areas are potentially disturbed lands if substances of the 1,2,3,4 hazard class were used, produced, stored, regenerated, disposed of in the course of past or current economic activity. The types of production, use of certain types of products, raw materials in these areas, which can cause pollution of buildings, structures, soil, soils, groundwater or surface waters, include the following: production and processing of acids and alkalis; electric batteries; cleaning products; bitumen; diesel fuel; degreasing agents, dyes, inks, ink; electrical equipment and devices; explosives and weapons; fertilizers; gasoline; hydraulic fluids and lubricants; insulating materials; motor oils; oil sludge and waste oil; paints pesticides, herbicides and insecticides; plastics; polymers and epoxy compounds; refrigerants and coolers; soaps; solvents; surfactants; wax and others [5,7].

The current regulatory and methodological documents, standardization documents do not contain approaches that allow for the assessment of the state of the reorganization site, its research, the development of a reclamation plan during a step-by-step decision-making process, the application of formalized procedures, which begins with the characteristics of the site, the collection of required data, and is accompanied, if necessary, by field studies, including using BAT [8]. Such approaches would increase transparency, economic, environmental efficiency, and reliability of the results of the assessment of the state of the territories of integrated development [10] (Fig. 1).

The assessment of the site's condition is aimed at determining:
- violations of regulatory requirements for the condition of environmental components in the investigated area of the site;
- negative impact on fauna and flora;
- the level of negative impact on human life and health;
- the possibility of spreading the established pollution beyond the boundaries of the studied area;
- the presence of a significant amount of hazardous waste at the site that poses a threat to public health or the environment [10, 15].
Fig. 1. The process of researching industrial areas and non-residential areas for the preparation of a reclamation plan [8,15].

During the study of a site area for the purpose of developing a reclamation project, it should be:

- to find out the condition, features of the surface layers of the soil, subsurface conditions and site features, including topography and depth of groundwater;
- establish the boundaries of the horizontal and vertical distribution of the pollutant, the level of pollution and the mass of pollutants in all media and its spread beyond the boundaries of the site;
- identify sources of pollution, routes of movement, and actual or potential recipients of pollutants through air, soil, rock, precipitation, groundwater, surface water, infrastructure and buildings on the contaminated site, without regard to the boundaries of real estate ownership;
- to investigate the data necessary to evaluate alternative actions for the restoration of disturbed lands;
- to investigate the data necessary to assess actual and potential threats to public health and the environment. Make an assessment of all current and potential ways of negative impact;
- to identify the data necessary for the development of restrictions on any permitted discharge/release of pollutants into the environment, which may be required in the implementation of alternative remediation measures [4].

Soil condition research is performed as part of field research. At the same time, they must meet the conditions and requirements given (Fig. 2).

Fig. 2. The process of soil research in industrial areas and non-residential areas for the preparation of a reclamation plan [8,15].
Soil research should be carried out in accordance with the objectives of site research, the requirements of quality control of research results and environmental safety.

Special attention should be paid to the detection of buried metal containers, reservoirs, fragments of engineering networks, waste using exploration pits, remote sensing radars, magnetometers and other devices and methods suitable for the detection of metal containers, objects, waste [15].

The study of the groundwater condition should be carried out in order to establish the hydrogeological characteristics of the site, pollution conditions and must meet the requirements for the quality of work and environmental protection (Fig. 3). Groundwater sampling methods include, but are not limited to, sampling groundwater from wells, including control wells, drinking water intake wells water, artesian wells, etc. [15].
Fig. 3. The process of studying groundwater in industrial areas and non-residential areas for the preparation of a reclamation plan [8,15].

If the surface water reservoir is located on the studied or adjacent site and has been adversely affected through groundwater from the contaminated site, storm sewers, ditches or other ways of spreading pollutants, then it is necessary to conduct a study to determine whether there have been discharges of pollutants into the surface water reservoir (Fig. 4).

Research should cover:
- known past or ongoing discharges of pollutants into surface reservoirs;
- depressed vegetation, spots on the water, leaks, discoloration of the soil or precipitation along the coastline, on the bottom, or surface, hydraulic characteristics such as outflow (movement) of the stream (the rate at which the stream receives or loses water);
- data on the negative impact of the flow of past emissions, discharges, including environmental studies conducted in the past, documented differences in the density and diversity of the population of organisms in areas potentially exposed to the contaminated site relative to areas that were not adversely affected by pollutants from the site;
- existing local groundwater pollution exceeding the established standards. Local groundwater pollution exceeding the established requirements for surface waters must be contoured. Groundwater samples in accordance with the pollution contour should be taken along the direction of groundwater flow between the study area and the surface water reservoir and examined for suspected pollutants [8,11,15].

![Diagram](image)

**Fig. 4.** The process of studying surface waters in industrial areas and non-residential areas for the preparation of a reclamation plan [8,15].

Capacitive equipment for various purposes can be operated on production sites. These are tanks and technological equipment for storing oil, water, various petroleum products, fuels and lubricants, settling tanks. There are tanks for receiving, storing and processing food and liquids. Specialized storage tanks for acids and other chemicals are operated. Acid tanks are complex products that are equipped with main pipelines, measuring equipment, etc. (Fig. 5) [15].
Engineering and environmental studies for the purpose of studying the possibility of carrying out rehabilitation measures must meet, inter alia, the requirements of sampling at the locations of storage tanks and auxiliary facilities, including, without limitation, storage tanks located and decommissioned, associated pipelines, switchgear and refueling points.

In places where waste and materials are buried within the boundaries of the study area, the study should include an assessment of the places where waste and materials are buried and should be carried out as follows (Fig. 6):

1. it is necessary to assess the properties of waste, materials in landfills, their areal and vertical placement and the degree of their negative impact on soil, groundwater, air and surface waters, including the determination of the presence of pollutants in them;

2. to investigate the possibility of carrying out measures for the reclamation of landfills, materials, it is necessary to identify the location, vertical limits, and physical features of the buried waste, materials, using drilling, exploration pits or trenches. If the volume of waste and materials disposal extends below the groundwater horizon, then exploration pits should extend below the groundwater horizon in order to establish a vertical boundary for the disposal of waste and materials (Fig. 6) [15].
Fig.5. The process of researching the locations of reservoirs, storage tanks, main pipelines in industrial areas and non-residential areas for the preparation of a reclamation plan [8,15].

Results and discussions
Based on the analysis of the accumulated experience in the implementation of projects of the KRT and the reorganization of industrial territories, factors have been identified that reduce the effectiveness of organizing activities for the study and assessment of the condition of sites of integrated development territories, preparing projects to eliminate accumulated environmental damage and carrying out measures for the reclamation of disturbed lands:

- the current GOST standards and information and technical reference books on the best available technologies do not contain provisions that allow, during the course of research, to conclude that it is inappropriate to carry out further measures, develop a reclamation plan. For example, if it became obvious that the material damage from the negative impact does not exceed the potential costs of its elimination;
- another example may be the absence in standardization documents, for example, SP 502.1325800.2021, ITS NDT 53-2022 of provisions defining the procedure for conducting research, evaluating sites of industrial territories, territories of non-residential development, on which buildings, structures, reservoirs, storage tanks, main pipelines and other facilities may be located [4,6];
- in the course of research and evaluation, there is no provision for the collection and analysis of data indicating the possibility of natural degradation of pollutants and a decrease in the level of negative effects, opportunities for self-healing of components of the natural environment;
- the disadvantages of the current regulatory and methodological framework are not the full content of the measures; the lack of an integrated approach to the study and assessment of the state of the contaminated area; the lack of formalized, standard research procedures; lists of preferred technologies, methods, methods of research and harm elimination and, as a result, the lack of clear approaches to assessing the economic and environmental effectiveness of research activities and rehabilitation.
Conclusions

At the moment, there is a fairly significant regulatory and methodological framework that allows regulating various aspects of the reclamation of disturbed lands, the elimination of accumulated environmental damage during the implementation of CRT projects and the reorganization of production purposes, changing their functional purpose [14]. However, to a large extent, the available volume of methodological documents, documents on standardization, is fragmentary and does not reflect all the conditions and obstacles that arise. GOST standards,
JV, ITS BAT, rules, regulations approved by resolutions of the Government of the Russian Federation often do not contain direct legal regulations and do not create prerequisites for the use of tools to ensure the achievement of the goals and objectives of the projects of the KRT and the elimination of accumulated environmental harm. In the context of a variety of regulatory instruments, updating the database of standardization documents could ensure the unity of approaches to its various aspects. In particular, amendments to ITS BAT 53-2022, GOSTR 70082-2022, GOSTR 59057-2020 regarding the development and inclusion of formalized, standard research procedures, lists of preferred technologies, methods, methods of research and harm elimination [13,15].

References

5. GOSTR 54003-2010 "Environmental management. Assessment of the past accumulated environmental damage in the locations of organizations. General provisions" (Access mode: https://docs.cntd.ru/document/1200082700, accessed 12/22/2013);
6. Information and technical handbook on the best available technologies of ITS NDT 53-2022 Elimination of objects of accumulated environmental damage (Access mode: www.burondt.ru/NDTDocsFileDownload.php ... Date of application: 12/15.23);
9. GOSTR 59057—2020 Environmental protection. Land. General requirements for the reclamation of disturbed lands (Treatment regime: https://docs.cntd.ru/document/566277874?ysclid=lqqqdodbe6722957258 Date of requests: 12/25/23);
17. The general plan of the Kazan city district. Appendix to the decision of the Kazan City Duma dated 02/28/2020 No. 5-38.
20. Moscow will continue the comprehensive development of the territories. (Mode of access: Telegram: Contact @mos_sobyain, date of access: 12/16/23).
23. The general Plan of Yekaterinburg will adjust the industrial zones. (Mode of treatment: https://ural.octagon.media/ekonomika/genplan_ekaterinburga_skorrektiruet_promzony.html ?ysclid=lqqpu75af8945600664 Date of requests: 12/20/23)