«Smart» Solutions of Waste Management in Solving Environmental Problems of Improving the Comfort of the Urban Environment

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Abstract. Currently, problems of the environmental distress for the territories are relevant where the main part of the population and production are concentrated - urban areas. In almost all cities with a population of over 1 million people, environmental distress is rated as «highest» and «very high». The urban environment is inextricably and organically connected with the land, which has a price and value and it is a basic factor of comfort. In this regard, the purpose of the research in this article is to create a comfortable urban environment based on the introduction of "smart solutions" for waste management. In achieving the goal, the following tasks were solved: the problem of spontaneous garbage dumps in the urban environment was studied as a negative factor in the comfort of the urban environment; the practice of forming the comfort of the urban environment in terms of environmental factors is considered; priority eco-friendly technologies and solutions to form the comfort of the urban environment from the standpoint of international and domestic experience are suggested. The object of study is the urban environment. The subject of the research is external and internal factors of implementing «smart» solutions of waste management in the context of creating comfort in the urban environment. The results and conclusions are characterized by novelty, scientific and practical significance in terms of substantiating proposals for the use and implementation of priority energy-efficient and environmentally friendly technologies and solutions to create comfort in the urban environment.

1. Introduction

The attention of the world community to the aggravation of environmental problems on the scale of the whole Earth occurred in 1992 in the Report of the UN Conference on Environment and Development in Rio de Janeiro [1]. Currently, 15% of the urban territory of the country belongs to areas whose ecological state is unsatisfactory and environmental safety is not guaranteed. About 10% of Russian cities have a high level of pollution of the main natural environments - soil, air, and water. In almost all cities with a population of over 1 million people, environmental distress is estimated as «the highest» and «very high», and in 60 cities with a population of 0.5-1.0 million people are characterized by an acute environmental situation [2, 3, 4, 5]. Thus, large areas of land around million-plus cities and industrial agglomerations are characterized by heavy pollution: 200 km in the Moscow agglomeration; 300 km in Sredneuralsk agglomeration; large areas of pollution are observed in Norilsk, Novosibirsk, Abakan, Omsk [5, 6]. The response to the aggravation of these problems was the
realization of the federal program "Complex system of solid municipal waste management", aimed at solving the problem of the formation and disposal of solid municipal (household) waste. In January 2018, the “Industry development strategy for the treatment and disposal of production and consumption wastes” was approved, which creates a new industry in Russia that will allow additional resources to be recycled and reduce the volume of such industrial and municipal waste, and naturally reduce harmful environmental effects [5].

In this regard, monitoring and controlling the state of the urban environment is an important aspect of environmental management - the development and use of natural resources to ensure human livelihoods and improve their well-being. Monitoring of the urban environment allows to correctly orient the socio-economic development, rationally organize environmental management, ensure the preservation and development of the natural possibilities of resource reproduction [7, 8].

2. Study of the problem of natural waste dumps in the urban environment as a negative factor in the comfort of the urban environment

The comfort of the urban environment is a complex of natural-geographical, material, infrastructural conditions that provide physical, psychological, and emotional comfort for people, taking into account their subjective assessment of their situation in the city’s life in the form of social differences, cultural characteristics, and value systems. The surface cover of the earth, the soil is an informative block, reflecting the state and dynamics of the landscape-geochemical system, taking into account all the possible factors influencing these processes. In the soil - the main structural element of the earth - flows of all matter and types of energy are interacting, flowing, passing which connect all components of a landscape in a single whole. In the soil, the main accumulation, transformation, redistribution of incoming substances and organisms of different nature occurs. From the soil, all the substances, contained in it, fall into the vegetation, into reservoirs, into living organisms and into humans. This provision proves the priority role of urban land quality in ensuring the comfort of the urban environment.

In many cities, in particular, the city of Volgograd, there is pollution of urban land, illegal dumping of garbage in unspecified places, which negatively affects the condition and quality of the city. Garbage can be found everywhere, near garbage cans, in playgrounds, but more often we meet with garbage outside the city, near summer garden societies, in forest belts, near roads, etc. Especially, in those places and corners of our cities, where a person can throw something away, without control from others. This act have different reasons for a person [9, 10].

One of the main reasons often is the lack of a sufficient number of garbage cans or containers in specially designated areas. People do not know how to get rid of garbage and do not find anything better how to get rid of it in the nearest forest belt, having driven a few kilometers away from their home, and others will get rid of garbage nearby, a few tens of meters from their houses due to the lack of a vehicle. For this reason, large garbage dumps have formed in most Russian cities. Based on the local mass media, we conclude that every year in every major city of Russia hundreds of new landfills are eliminated and reappear. For example, the reason for the formation of landfills in most areas of the city of Volgograd, is the presence of joined villages in their territories, in which there are not enough garbage containers. As a result, negligent drivers take out various wastes without having relevant documents for export [9].

Another no less important problem in our cities, in particular, the city of Volgograd, is the problem of garbage removal from the house adjacent territories, the results of which is the formation of mountains of garbage near containers. For example, in the Malinovsky Street in the city of Volgograd, for several months now, the formation of garbage mountains has been observed around the filled garbage containers. And there is the entrance to the kindergarten next to it, a few meters from the spontaneously formed garbage dump [9]. Undoubtedly, the residents should actively participate in solving this problem, actively interact with their management companies, monitor their work, and also it is necessary to control the implementation of the rules for landscaping by management companies and constant monitoring of the control effectiveness is also necessary [9].
People often litter where they rest in nature during their free time. Every year, in the summer, we can observe horrific things on the banks of rivers and lakes: bags, plastic and glass bottles, various household and food waste, rotting and decomposing in the sun, as well as an unpleasant pungent smell, a swarm of insects above the garbage. The most common places to form spontaneous landfills are suburban areas of our cities. For example, local media presented that Volgograd activists identified another spontaneous garbage dump of construction, solid municipal and food waste, located on the territory of the Gorodishchensky district of Volgograd, representing a threat to the life and health of the population, harming the environment. Another example of the formation of spontaneous dumps is the roadside near the summer massifs of the city of Volgograd, where garbage dumps have been growing for many years [9, 10].

Undoubtedly, spontaneous garbage dumps create a threat to the ecological situation of cities, and, above all, to public health, especially children. Solid municipal waste is the main component of the natural landfills. As a rule, solid municipal waste in large cities contains more than 100 different toxic substances (lead, mercury, dyes, pesticides, formaldehyde, etc.), which penetrate into the soil, water, and atmosphere, thus posing a threat to life and health of the population, cause harm to the environment, as well as worsen the sanitary and epidemiological situation of our city of Volgograd and the region. It is important to note that if the concentration of various toxic substances in water, air, and soil is exceeded, there can be a huge number of diseases and poisonings in the human body. For natural processing or natural decomposition of solid municipal waste, it takes many decades to occur (table 1).

| Name of solid municipal waste       | Duration of natural decomposition |
|-------------------------------------|----------------------------------|
| 1. Glass bottles                    | more than 1 million years       |
| 2. Aluminum cans                    | more than 80 years              |
| 3. Rubber                           | more than 50 years              |
| 4. Plastic bags                     | about 200 years                 |
| 5. Plastic bottles and dishes       | about 500 years                 |

* it is compiled by the authors

Thus, to improve the ecology of the city, it is necessary to pay more attention not only to the elimination of natural landfills, but also to their efficient processing. Currently, in the Volgograd region, infrastructure facilities are being created for the disposal, sorting and processing of solid municipal waste. Today, four licensed polygons have been built and are already operational, located in the city of Volgograd, the city of Volzhsky, and the Kamyshinsk and Uryupinsk districts. In addition, there is the plan to build waste sorting complexes in these landfills in the near future [9, 10].

However, the presence of existing landfills does not solve the problem of eliminating existing and spontaneously appearing garbage within urban areas. So, in the summer of 2018, the garbage landfill was eliminated in the Kirovsky district of Volgograd by transferring it to the village “Svetly Yar” of the Volgograd region, it did not solve the problem of garbage disposal and the environmental situation in the city of Volgograd and the Volgograd region. As a result, huge tons of garbage were simply transported from one place to another, while spending huge financial resources that could be spent on building waste-processing complexes. Undoubtedly, the causes of the formation of spontaneous landfills may be different. But, the main reason, in our opinion, is the lack of upbringing and culture of management of various types of waste. The authors believe that we all, children and adults, need to improve our culture of solid municipal waste management. And, according to experts, it is necessary to form an ecological culture of the population, which is practically absent in our Russian cities [9]. In modern conditions, it is required not only sorting and complete processing of sorted solid municipal waste, but the introduction of «smart» technologies into waste management, both from the city authorities and from the population [11, 12, 13].
3. The practice of creating comfort in the urban environment according to environmental factors

One of the examples of the “smart” decision to form a comfortable urban environment is the polygon of solid municipal waste in the city of Irkutsk, which is the first and only «Landfill Museum» in the world. The idea of its creation belongs to the head of the Irkutsk polygon Alexander Rastorguev, who suggested putting a gate in the form of prison at the entrance more than three years ago. They built everything themselves in a workshop where they repair equipment. So, with the construction of "prison" began a whole story. And now, for 3 years already, the workers of the landfill have a common hobby: in their free time, they make new exhibits that anyone can see. The museum is open daily. Today, the museum has full exposures: the history of Irkutsk life, a museum of weapons, a whole battery of impressive siege weapons and another detachment of soldiers, led by a commander on a horse, chained in metal mail, as well as many other creative exhibits created by the museum staff! In the “Landfill Museum”, in addition to hand-made exhibits, there is a section of rare things that were found, washed, and put in order by landfill workers. This rarity is from a variety of thematic groups: watches, musical instruments, children's toys since the USSR. There is a total of more than 300 exemplars [14].

There is the interesting example of the introduction of «smart solutions» for the collection and recycling of garbage in the framework of the project «Dustbot» in 2006 in the cities of Spain, Italy, England. The introduction proves the effectiveness of the use of scavenger robots. The project involved two cars: DustClean - autonomous sweeper, which moved around the city on a predetermined route and cleaned the streets; DustCar is a robot-cleaner with the performance of paid services (with a phone call, using video cameras, sensors and GPS) to approach the house and differentiated garbage collection [15, 16, 17, 18]. The Kazan Federal University proposed a project of «smart» garbage containers, which include a special sensor determining the degree of its fullness. Information is accumulated and an optimal route for garbage trucks taking into account traffic conditions is built on its basis. The developers believe that this technology will reduce the number of garbage trucks and the cost of garbage collection, as well as improve the ecological situation in the city. But this is again a financially and technically voluminous solution [14].

All over the world, the approach of promoting and encouraging urban residents to cooperate in the field of garbage recycling is being updated – according to the Pay as you throw (PAYT) program, the cost for garbage collection is lower for those who sorted it into containers [15, 16, 17]. The authors believe that the same approach can be implemented in Russian cities - our resident responds very adequately to material incentives. And taking into account the financial situation in our Russian regions, this environmental solution is the most vital and realizable.

4. Proposals for priority energy-efficient and environmentally friendly technologies and solutions to create a comfortable urban environment

The authors believe that today in our cities, on the basis of the learned experience of successful practices of «smart» waste management solutions, the following is necessary to create the comfort of the urban environment:

- to develop and implement an active policy of environmental and resource conservation based on the introduction of scientific and engineering achievements, the introduction of social and economic measures that encourage the use of environmentally friendly solutions and technologies;
- to apply energy-saving and environmentally friendly technologies and materials, to create and develop waste-processing industry which is the least developed sector of the city economy; to improve the environmental monitoring system for all components of the natural and urban environment at all levels of state and municipal government;
- to save and develop parks, green areas of public spaces, urban areas and suburban areas;
• to create a system of environmentally friendly natural and urban spaces and territories, as well as suburban areas, to develop specially protected natural areas as an important component of the urban natural complex;
• to improve the quality and level of improvement of urban spaces and territories, to improve the management processes of economic and social activities aimed at it;
• to embrace and involve all segments of the population in environmental education and enlightenment, to form reference samples and the attractiveness, significance of active citizenship and responsibility.

Practically every city in the territory of the Russian Federation today manages its own waste, using processes and models from the times of the USSR, which have completely exhausted themselves and do not correspond to modern reality, neither in terms of technology, nor in terms of economics, nor in terms of spatial and territorial division. Most landfills for the disposal and recycling of garbage are suitable for generation of their resources or have already developed their resource, and simple disposal of garbage is not enough considering the amount of produced garbage – 5.4–5.6 billion tons of waste per year. In the current situation, it is time to move from the old Soviet model «collection → transportation → burial» to the new European model «collection → transportation → recycling → burial”. However, the transition to a new model in Russia is caused by the following main problems: 1) a waste management system built on ubiquitous burial; 2) a very low proportion of waste processing and disposal; 3) low efficiency and productivity of communal service for the collection and removal of waste; 4) the lack of equipped sites and landfills for the burial and recycling of waste; 5) a low share of the use of modern technologies and innovations into the market, collection, transportation and waste disposal [18, 19].

In this regard, it is necessary to understand how to improve the efficiency of waste management in a situation of limited economic and technological resources. One of the least resource-intensive ways and the most effective way is to start managing and controlling the main chains of urban waste management using intelligent systems of waste management. The structure of such system will be a modular structure consisting of 5 main elements [5]: the module “Intelligent Operational Center”, which is responsible for processing, analyzing and providing data in various forms; an intelligent video analytics module which is responsible for processing and monitoring real-time work by analyzing video data using artificial intelligence and neural networks; the module of management of transport and mobile teams, which is responsible for the control and distribution of work and buildings between the fleet of vehicles and workers, based on the available resources; a module for monitoring the state of containers, which is responsible for monitoring the filling of garbage containers, in order to form optimal routes for communal transport; the module of production and environmental monitoring of territories, which is responsible for control and monitoring the environmental situation and the situation in the city and at production and industrial sites; the module «The digital model of the territory», which is responsible for the display and visualization of the controlled territory, as well as the actions and events performed on it.

Having also studied the experience of some cities and regions of Russia, in order to form the comfort of the urban environment, the authors propose to use the following measures in each city: 1) to increase the number of garbage containers, bins in the places where garbage is most formed, and to remove garbage containers and bins as needed their filling; 2) to organize points of delivery of waste paper, glass and aluminum bottles, batteries, cans, which will help sort the data of solid municipal waste; 3) attracting students to solve environmental problems and to participate in environmental activities; 4) planting trees, shrubs, perennial flower bushes in places of liquidated waste dumps in order to avoid their repeated pollution; 5) carrying out campaign work among the population in compliance with the procedure for the improvement and maintenance of the urban environment; 6) organization of public control over the sanitary and ecological state of the territory; 7) conducting environmental campaigns (a monthly action «The day of ecological safety of the city»; sports contest «We are for a clean city»; an annual competition to create campaign leaflets, posters about the dangers
of environmental pollution, and threats to the life and health of the population), turning them into a holiday and involvement of all age groups in it. The main purpose of these measures is to promote and nurture environmental culture among the population.

5. Conclusion
In conclusion, we note that since 2013, GOST R54964-2012 is used in Russia, which determines the procedure for evaluating construction objects for compliance with environmental requirements [20]. In particular, this GOST prescribes that residential buildings be equipped with: artificial reservoirs; bicycle parking; posts for charging electric vehicles, as well as the quality of sanitary protection and waste disposal was ensured. This GOST standard defines the framework for monitoring urban areas according to environmental requirements, but sociocultural work is required to improve the ecological situation - with each enterprise, household, individual, ready to work in the system of «smart» technologies for waste management at all levels of their creation and disposal.

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