Some aspects of ecological assessment of urbanized territories

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Abstract. At the moment, the concept of safe handling of household waste, including its processing is being implemented all over the world. However, there is no assessment of the development of urban areas with high population density in terms of household waste disposal. Regulatory information is outdated, and integrated development does not consider possible measures to reduce waste generation and waste disposal management. Information about the actual volume of waste generated for certain areas of complex development in Moscow is provided. The relationship between technical signals and integrated education and the actual volume of waste generation. The data on the assessment of complex structures for urban areas with a high population density are presented.

1. Introduction

Currently, around the world in the territories of large urban agglomerations, a concept of ensuring access to municipal household waste (MSW) is required, which needs a partial summary of the complex solution of the following tasks: minimization of waste generation [1, 2, 3]; possible reuse and/or partial (full) recycling [3, 4]; obtaining energy resources with minimizing the disposal of residues [5, 6, 7, 8, 9]. The main activities in the field of minimizing education are requirements for the degree of processability of products, reduction in the share of bio-utilizable elements in the composition of new production products. [10, 11]

However, the volume of MSW formation in urban areas is largely proportional to the urban agglomeration itself, its development, infrastructure facilities, etc., which is most clearly observed in the artificial ecosystems of urban agglomerations, such as single-industry towns. Where migration processes lead to a constant increase in the area of residential and public buildings in the conditions of restraint of administrative borders. This process inevitably leads to an increase in population density in cities, including “temporary”, and, accordingly, the amount of MSW formation per unit area, a change in the logistic patterns of movement and the volume of waste collection equipment.

Thus, a study (Constantine E. Kontokosta, Boyeong Hong, Nicholas E. Johnson, Daniel Starobin, 2018) on the management of municipal solid waste, emphasizes the importance of planning their formation for large cities with accuracy to the building. “Understanding the behavior patterns of household waste on a domestic and building scale is a critical component of effective routing of collection and development of incentives to stimulate recycling and composting” (C. E. Kontokosta). This study presents an analytical approach that combines machine learning and small area estimates to predict building weekly and daily waste generation. Using data from ten years of daily waste collection by the New York City Department of Sanitation (DSNY), together with the individual characteristics of the buildings and the socio-economic indicators of the district in which they are located, regression analysis methods have produced predicted values for the weekly and daily generation of solid waste for more than 750,000 residential properties in the city. It was found that...
after cross-sectional and two-stage spatial verification, the model obtained by the authors can be used as a method for predicting waste generation at the building level with a high degree of accuracy [12].

In (Xinhao Wang, Danilo Palazzo, Mark Carper, 2016), it is proposed to find a “balance” between the urbanized territory and the ecosystem in terms of means of reducing population density through urban planning and design decisions. [13]

As shown above, forecasting the volume and morphology of waste generation, as well as studying the impact on these characteristics of the type of development in urban areas, is a very relevant area of scientific research [12, 13, 14, 15, 16], therefore, the aim of this work is to determine the degree of influence of the type of development of urban agglomeration with related infrastructure facilities, on the volume of education and the morphological composition of MSW (for example, the city of Moscow, Russia).

To achieve this goal, the following tasks were solved: analysis and review of scientific and scientific-technical information sources was carried out; The existing approaches to the development of large cities are analyzed (on the example of the city of Moscow); the influence of the type and degree of development in large urban agglomerations on the degree of MSW formation is determined, the necessary conclusions are formulated.

In the work of 2019, He He, Christian John Reynolds, Zixiang Zhou, Yuan Wang, John Boland, it is said that the process of waste generation depends on the level of economic activity and final demand of a particular region, and accordingly on the region’s GDP [17]. And in a study from 2018, He He, Christian John Reynolds, John Boland, through the modernization of the “input-output” model, directly established the dependence of the volume of direct and general waste generation on cash flows and the influence of the income of the household sector [18].

2018, Miyuru Kannangara, Rahul Dua, Leila Ahmadi, FaridBensebaa, the study is dedicated to the creation of a model for predicting the formation of MSW based on demographic and socio-economic factors in Canada. To build models, decision trees and neural networks were used. Models were obtained by mapping the number of household MSW waste with socio-economic and demographic parameters for 220 municipalities in Ontario, Canada. The approach proposed in this study demonstrates the feasibility of creating tools that help in: regional planning of waste generation, pre-processing, integration and modeling of publicly available data from various sources. [14]

2018, Ying-Chu Chen, in this study, a linear regression model was used to assess the degree of influence of individual urbanization indicators on the composition and volume of MSW, such as: population (P), urban planning area (L), tap water supply (W), electricity sold (El), number of operating plants (I), vehicle density (T), education level (Ed) and annual income (R). The assessment was carried out on five main categories of solid waste - paper, food waste, plastic, metal and glass. It is established that the composition of MSW is closely related to the population (P), the amount of food waste depends on industrialization, and the total volume of solid household and metal waste is proportional to the population and its annual income, referred to the provision of tap water. The volume of plastic and glass wastes is related to annual income related to the level of education. This study provides a quantitative assessment of the impact of urbanization on the composition and volume of solid waste. [16]

2013 S. T. A. Pickett, Christopher G. Boone, Brian P. McGrath, M. L. Cadenasso, J. Morgan Grove, the authors propose to choose a system of components of “sustainability” to achieve sustainable development of urbanized territories. To summarize the dynamics and choice, a “metacity” structure is presented, covering environmental processes in cities, in addition to those associated with society, government and the economy.

2003 Roderick J. Lawrence shows an example of human settlements integration using environmental concepts for territorial development. This document presents some key concepts and principles that stem from a wide range of contributions. It then shows how environmental concepts can be used to interpret settlements. [19]

From all of the above it follows that at the moment the need to change the type of development by organizing an integrated district conglomerate to reduce a given indicator of the volume of formation
and morphological properties of solid waste is not considered. The bulk of research is aimed at creating forecasting models under the current conditions, and not at preventing the volume and morphology for given methods of processing (disposal) of solid waste.

2. Materials and methods
An analysis of the types of development of large urban agglomerations is carried out on the example of the city of Moscow, the Russian Federation. To assess the volume of formation and the morphological composition of municipal solid waste under various types of urban development, the method of direct questioning had been used followed by processing of the received personal data using mathematical statistics methods, data from related infrastructure facilities were similarly obtained. Migration processes are taken into account integrally, in a comprehensive examination of the volume and morphology of waste generation.

3. Results and discussion
Currently, in Moscow (RF), as well as in other large cities of the World, which have a high degree of agglomeration in the existing historical development, several approaches to the organization of residential quarters are used, namely: “point” or “complex” development [20]. “Point” development is characterized by the construction of a building within the existing limited land allotment, while the number of storeys of buildings often increases in order to obtain the greatest economic benefit. "Comprehensive" development is characteristic of construction in new, undeveloped earlier territories or resulting from the transfer of production (otherwise changing the purpose of land use).

Another important factor for assessing the volume of waste generation from a certain area of the city agglomeration is the determination of the volume of waste generation from the associated infrastructure of the housing project.

Obviously, in different types of development, a different number of solid waste is generated, having different morphological composition, therefore, the scheme of service organization, as well as the technical characteristics of the buildings themselves, which are considered promising for future construction (and their purpose), should ensure the minimization of solid waste during operation.

In order to evaluate the quantitative indicators of solid waste depending on the type of construction, housing complexes in Moscow (RF) were considered: “Southern Krasnogorye” and “Rublevskoye 11” as “point-building”, while “Borodino” and “Politra” as “complex”.

The assessment of the volume of education and the morphological composition of MSW for infrastructure objects in different conditions of the organization of development was carried out as follows: within the district of Moscow (RF), districts were selected, additional statistical criteria were applied to them, such as: population density and area of housing stock on its territory. So, in the Eastern District, the Novokosino district was chosen, since it has a low population density with a large area, which simulates the conditions of "complex" development. In the Central District, two districts were considered: Tagansky and Basmanny. Their area and population density are approximately equal, which to some extent models the conditions of "point" development. The data of the Territorial Authority of the Federal State Statistics Service [21] for the city of Moscow are presented in table 1.

Table 1. Data on the total area of retail and housing facilities, as well as population density.

| Names of the district of Moscow | The total area of the halls of retail facilities, m² | Area district km² | Population density, people / km² | Housing area, thousand m² |
|--------------------------------|-------------------------------------------------|------------------|----------------------------------|--------------------------|
| Novokosino                    | 106 826,8                                       | 3,6              | 29974,17                         | 1568,4                   |
| Tagansky                      | 154 391,4                                       | 8,01             | 15405,49                         | 2722                     |
| Basmanny                      | 167 265                                         | 8,37             | 13225,09                         | 1995                     |
Such an approach in the selection of districts and residential complexes for assessing the formation and morphological composition of solid waste has made it possible, as a first approximation, to form an integral quantitative assessment depending on the type of development used.

To analyze the volume of waste generation from residential complexes, housing complexes of the city of Moscow and the Moscow region (RF) were selected: Borodino residential complex, Rublevskoye 11 residential complex, Palitra residential complex, and Southern Krasnogorie residential complex.

In each residential complex, facilities for the temporary disposal of closed waste located in the local area were considered.

It should be noted that the selected objects all have a closed territory, which prevents the possibility of migration of waste from neighboring buildings.

To obtain statistical data on the actual volume of generation of municipal solid waste, a questionnaire was compiled. It was filled with employees of management companies operating in the territory of housing complexes. The survey participant was asked to enter the answer.

The main task of the survey was to determine the amount of municipal solid waste generated on the territory of the housing complex in 2019.

The survey data are shown in (table 2).

| Table 2. The collected statistics on objects of different types are given. |
|-------------------------------------------------|-------|-------|--------------|--------------|
| Unit of measurement | Housing Complex Borodino | Housing Complex Rublevskoe 11 | Housing Complex Palitra | Housing Complex YuzhnoyeKrasnogorye |
| Total area of flats | (m²) | 21392 | 10233 | 63321,6 | 12160 |
| Quantity of trash cans at the area | (pcs) | 8 | 2 | 24 | 2 |
| Volume of trash cans | (m³) | 0,8 | 0,8 | 0,8 | 0,8 |
| Weight of utilized trash | (once a day) | 1 | 1,033 | 1 | 1 |
| Rhythm of utilization | (m³) | 2336 | 603,272 | 7008 | 584 |
| Annual volume of utilized trash | (t) | 405,204 | 3477,863 | 1215,61 | 101,3 |
| Standard [22] for Moscow | (m³ * m²) | 0,027 | 0,027 | 0,087 | 0,087 |
| Standard volume | (m³) | 577,584 | 276,291 | 5508,98 | 1057,92 |
| Standard weight | (t) | 100,188 | 47,926 | 955,59 | 183,51 |
| Difference between actual and Standard [22] | (%) | 24,73 | 45,80 | 78,6 | 55,20 |

After made a research it was announced that is appropriate to take out the teach once in 2 or 3 working days and once on Sunday. But at the same time we need to remove trash at the weekends every day. For taking out the trash in a such manner it must be picked up appropriate volume and quantity for trash cans at the area of temporal location of trash. Essential differences from standard 22 in a high range can be found at all researched objects. For residences Borodino and Palitra there is more trash in comparison with the average number in the areas with lonely block of flats. The rate of utilized trash in that areas was lower. The main kinds of trash are organics, plastics , paper and glass.

For ranging volume and substance of outcomes from objects situated near living areas were chosen markets that located on the 1st floor of blocks of flats. The major markets participated in a survey are food markets.
For the purpose of getting connections with area and volume of trash outcomes we created a questionnaire. It was signed by the cashier of food markets in private markets and supervisor in public. They were offered to answer our questions about trash outcomes by themselves.

The main aim of this survey was to determine a quantity and substance of solid trash waste got from food markets.

The survey data are shown in (table 3)

Table 3. Results of a direct survey of representatives of a network of retail outlets located in residential buildings.

| №  | Object              | Area, m² | Type of waste                  | Volume, kg / day | Waste volume kg / year | Accumulation per 1 m², kg / year |
|----|---------------------|----------|--------------------------------|------------------|------------------------|----------------------------------|
| 1  | Grocery (9 pcs.)    | 80       | Waste paper, plastics, food products | 15               | 5475,00                | 68,44                            |
| 2  | Grocery department | 40       | Waste paper, plastics, food products | 7                | 2555,00                | 63,88                            |
| 3  | Costume shop        | 100      | Waste paper                    | 35               | 12775,00               | 127,75                           |
| 4  | Pyaterochka         | 100      | Waste paper, plastics, food products | 310              | 113150,00              | 1131,50                          |
| 5  | Magnolia            | 90       | Waste paper, plastics, food products | 120              | 43800,00               | 486,67                           |
| 6  | Grocery             | 80       | Waste paper, plastics          | 5                | 1825,00                | 22,81                            |
| 7  | Grocery             | 90       | Waste paper, plastics, food products | 100              | 36500,00               | 405,56                           |
| 8  | Grocery             | 70       | Waste paper, plastics, food products | 120              | 43800,00               | 625,71                           |
| 9  | Magnet              | 210      | Waste paper, plastics, food products | 350              | 127750,00              | 608,33                           |
| 10 | Taste of Villas     | 90       | Waste paper, plastics, food products | 170              | 62050,00               | 689,44                           |
| 11 | Coffee Elliot       | 30       | Waste paper, plastics, food products | 5                | 1825,00                | 60,83                            |
| 12 | Read city           | 150      | Waste paper                    | 20               | 7300,00                | 48,67                            |
| 13 | Grocery             | 60       | Waste paper, plastics, food products | 30               | 10950,00               | 182,50                           |
| 14 | Grocery             | 30       | Waste paper, plastics, food products | 2                | 730,00                 | 24,33                            |
| 15 | Grocery             | 100      | Waste paper, plastics, food products | 60               | 21900,00               | 219,00                           |
| 16 | Grocery             | 20       | Waste paper                    | 2                | 730,00                 | 36,50                            |
| 17 | Bakery "PanPan"     | 40       | Plastics                       | 3                | 1095,00                | 27,38                            |
| 18 | Dixie               | 200      | Waste paper, plastics, food products | 40               | 14600,00               | 73,00                            |
| 19 | Grocery             | 30       | Waste paper, plastics, food products | 5                | 1825,00                | 60,83                            |
| 20 | Grocery             | 40       | Plastics                       | 3                | 1095,00                | 27,38                            |
| 21 | Grocery             | 30       | Waste paper, plastics, food products | 10               | 3650,00                | 121,67                           |
| 22 | Bakery № 8          | 40       | Waste paper, plastics, food products | 11               | 4015,00                | 100,38                           |
| 23 | Grocery             | 50       | Waste paper, plastics, food products | 170              | 62050,00               | 1241,00                          |
| 24 | Billa               | 180      | Waste paper, plastics, food products | 350              | 127750,00              | 709,72                           |
Finally we got that the volume of solid trash waste directly depends on a big number of facts, such as location and appointment of markets, kind of goods and weight of all goods for 1 square meter of area, shelf life of products till utilization. It can be proved that large chain supermarkets have higher rate of volume of solid trash waste in comparison with private food markets, borrowing the similar area and having the same square, but having different trading conditions.

The main kinds of solid trash waste are plastics, paper, glass and food.

The average number for every area was founded with the formula (1):

\[ X = \frac{\sum x_i}{n} \]  

Where: \( n \) is the number of objects.

An average number among researched areas is being counted with the formula (1) we get:

\[ X = \frac{(390.08+102.2+214.40)}{3} = 235.56 \text{ (kg / year per 1 m}^2) \]  

The standard of accumulation of solid trash waste was got from the decrees of government of Moscow since January 12, 1999 about approval of norms of accumulation of solid trash waste and oversized garbage. It runs: 348 kg / year. The results are presented in Figure (1)

![Figure 1. Accumulation of solid trash waste in the different areas of Moscow.](image)

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4. Conclusion

Nowadays the question of reasonable attention to utilization and recycling of solid trash waste goes on to be an issue of heated debates.

For rational handling the cycle of solid trash waste including logistics and necessary machines we need to refer to data of volume and substance of trash, depending on type of urban territory.
However, for the proper management of MSW management (including the planning of traffic routes and the nomenclature of used municipal waste collection equipment), it is necessary to plan the volume and morphology of the generated MSW in urban areas.

A lot of studies considered in the work are devoted to the problem of forecasting the formation of MSW, but they do not include the features of urban agglomeration, such as a single-industry town, its development, infrastructure, which actively affects the volume and morphology of MSW.

In the study, the direct questionnaire method allowed us to establish the following patterns:
- for infrastructure objects of complex development (stores) - the volume and morphology of solid household waste per unit of retail space directly depends on: the territorial reference and format of the store, type of products sold, the ratio of the total mass of goods per unit of trade area, and also the storage time until disposal;
- Large chain supermarkets have a high indicator of the amount of solid household waste emitted per day compared to individual entrepreneurial organizations and less developed retail chain stores, occupying an area comparable to supermarkets, but in different trading conditions;
- housing complexes formed on the principle of "integrated" development - have a significantly higher indicator in terms of the volume of generated MSW compared with the "point" analogous indicator of development;
- the main type of waste, for infrastructure facilities - waste paper, plastic and food products, and for residential buildings organic, plastic, waste paper and glass.

The above main results will make it possible to plan the development of large agglomerations in the most rational way to ensure sustainable development of urbanized areas, as well as ensure effective waste management in single-industry towns.

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