On the issue of forming a unified system of assessment and logistics schemes for the management of solid municipal waste, depending on the type of urban agglomeration development

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Abstract. At the moment all over the world there is an acute problem of solid municipal waste (MSW) management. A significant number of studies in recent years devoted to this topic are reduced to predicting the volume of waste generated in urban agglomerations with the subsequent construction of logistics schemes. However, the authors of these studies consider the total amount of waste generated per capita within the municipalities with the subsequent extrapolation of the obtained analytical or statistical data in order to make predictive estimates, for which, in these studies, the corresponding mathematical relationships are given. The study of the influence of the development processes of the territory, together with the assessment of the formation of MSW from various groups of objects within the urban agglomeration and the subsequent planning of the development of this agglomeration, as well as the model for the formation of logistic schemes, are not fully presented. The dependencies proposed for the assessment by various researchers are not always adaptive, since in most cases, the authors of the studies are not interested in the criteria affecting waste generation, but in the very fact of the possibility of predicting the construction of logistics schemes for waste management. Therefore, this paper analyzes the volume of MSW education in educational institutions, using the example of the city of Moscow (Russian Federation) in various construction options. The authors take into account: the degree of population of the study area, and integrally, in the volume of MSW formation - the processes of internal interdistrict migration; food system built in an educational institution, waste generated by the staff of these institutions.

As a result, the authors concluded that already at the planning stage of the development of an urban agglomeration, from the standpoint of waste generation from accompanying social facilities, preference should be given to more concise construction schemes (for example, "infill" construction), while for uniform loading of processing (recycling) facilities should be allocated to the modes of operation of preschool educational institutions and schools in time.

1. Introduction

The problem of processing and disposal of solid municipal waste is directly related to predicting their volume of formation and morphological composition, taking into account different groups of buildings
within the urban agglomeration. You need to know from which objects (housing stock, social and commercial facilities, offices, etc.) in what volume and what kind of waste is supplied for recycling. This need is associated with the assessment of the rationality of the use of various technological methods of disposal, as a consequence, the choice of the best one for this type of waste. Also, this approach fully allows you to rationally locate, plan the loading and capacity of enterprises for processing (utilization) of solid municipal waste (MSW), taking into account the capacity (carrying capacity) of machinery and equipment used during their transportation, as well as the logistics component (transport route and the required multiplicity) of MSW removal. [1-5].

2. Research questions

For example, a study by Constantine E. Kontokosta, Boyeong Hong, Nicholas E. Johnson, Daniel Starobin dedicated to MSW management in New York City emphasizes the need to plan waste generation for individual buildings in large cities in order to build a logistics system. "Understanding patterns of municipal waste generation behavior at the household and building scales is a critical component of efficient collection routing and the design of incentives to encourage recycling and composting" [6]. Hussein I. Abdel-Shafy and Mona S.M. Mansour, in his analytical review [7] speak about the need to determine the composition and volume of formation of solid municipal waste, for their correct management - “The quantity and the composition of the municipal solid waste are critical for the determination of the appropriate handling and management of these wastes. Such information is essential and useful to put up the solid waste to energy conversion facility within the municipality. ” The need for differentiated operational planning for different development sites is also emphasized in the study by Steven Cohen, Hayley Martinez and Alix Schroder - "Removing garbage from residential, institutional and commercial locations in cities is a major logistical and operational task" [8].

However, at the moment, most reviews and studies boil down to a general determination of the amount and morphological composition of waste generated per capita within municipalities for different countries with the subsequent extrapolation of the analytical or statistical data obtained in this way in order to make predictive estimates, for which, in the indicated researches, the corresponding mathematical dependences are given [8 - 13]. The study of the influence of the development processes of the territory, together with the assessment of the formation of MSW from various groups of objects within the urban agglomeration and the subsequent planning of the development of this agglomeration, as well as the model for the formation of logistic schemes, are not fully presented. It is not always possible to adapt the models developed by various researchers in the context of the local specifics of the existing urban development.

For example, the mathematical model of the reverse logistics network, proposed by the authors of Giovane Lopes Ferri, Gisele de Lorena Diniz Chaves and Glaydston Mattos Ribeiro in their study on the example of the municipality of San Mateus (Brazil), makes it possible to determine the feasibility and number of objects for sorting MSW as intermediate points between recycling (disposal) and waste "producers" (population) [14]. The authors took into account all the elements of the logistics chain, including transportation, which made it possible for them to redistribute economic costs within the chain, making sorting objects less costly in the overall chain [14]. However, it should be borne in mind that in the municipality of San Mateus in the urban district of San Paulo, there is a problem of the location of favelas in the city, significant spatial and social segregation and a shortage of housing. These problems are associated with the rapid growth of the urban agglomeration of San Paulo, therefore, the results obtained in the study have a relatively narrow specificity of their application, as stated by the authors of the study - “This study can guide practices in other countries that have realities similar to those in Brazil” [14].

Similarly, the environmental-economic assessment of the logistics network, proposed in the study by Eleonora Bottani, Giuseppe Vignali, David Mosna and Roberto Montanari, for the collection of food waste from retail grocery stores in the Emilia-Romagna region (Italy), made it possible to determine the optimal number of objects in the logistics system (education - recycling (disposal)) and vehicle routing. The results obtained by the authors show that direct collection of the entire amount of food waste,
although expensive in terms of transportation costs, is the preferred option from an environmental point of view [15]. It should be noted that in the Emilia-Romagna region, considered by the authors of the study [15], there are no large urban agglomerations (megalopolises), which, similarly to the one shown above, using the example of the municipality of San Mateus, introduces specifics into the results obtained by the authors.

A study by Miyuru Kannangara, Rahul Dua, Leila Ahmadi and Farid Bensebaa is dedicated to modeling point prediction of MSW generation based on demographic and socio-economic factors for the province of Ontario (Canada). The work demonstrates a tool that allows planning per capita waste generation at the regional level, taking into account the integration into the model of publicly available data from various sources [10], however, it does not provide feedback in the form of building optimization. That in one form or another is present in the work of Ying-Chu Chen, [11]. Where the assessment of the impact of urbanization indicators on the volume of education by types of MSW per capita is carried out by a mathematical model built by the author based on linear regression [11]. The following were selected as the main indicators of urbanization: population size, area of urban planning, availability of piped water and electricity, the number of operating industrial enterprises, the density of vehicles, the level of education of the population and its annual income [11]. The assessment was made by the volume of formation for five main categories of MSW - paper, food waste, plastic, metal and glass [11]. It has been established that the composition of waste is closely interrelated with the size of the population [11]. The volume of food waste directly depends on the degree of industrialization, and the total volume of municipal solid waste and metal waste is proportional to the size of the population and its annual income, as well as their provision with piped water [11]. The amount of plastic and glass waste generated, respectively, is related to the annual income adjusted to the level of education [11]. This study is aimed at quantifying the impact of urbanization on the volume of education by types of MSW, however, the degree of urban agglomerations is taken into account by the author integrally, which does not fully reflect the required amount of initial data for the subsequent construction of a developed logistics chain.

So the authors of P. P. Anilkumar and K. Chithra in [16], using the example of India, show that the method of estimating the amount of generated municipal solid waste by land use type instead of the currently used estimation system based on per capita system is more rational. The results obtained in the study show that when an attempt is made to estimate the volume and morphological composition of solid waste generation based on land use parameters in residential areas, not only factors such as household size and income are important, but also factors such as housing typology, house size, family lifestyle, etc., which in turn can have a decisive role in the assessment of waste generation [16].

3. Purpose of the study
Considering all of the above, it can be concluded that often existing urban planning solutions in urbanized territories, the purpose of land tenure, as well as plans for the development of cities and land tenure, are developed without taking into account any system for further rational management of municipal solid waste. Predominantly predictive models are used that allow, in the current realities, to form logistics networks for MSW management, as well as a per capita estimate of the volume and morphology of MSW formation. Thus, to some extent, a “normative” approach is being built, which is not applicable in particular cases of planning and managing waste management. Thus, most studies do not take into account the feedback of the development of urban agglomeration, namely, the choice of the type and type of development depending on all elements of the logistics scheme for MSW management, including the selected, most appropriate in a particular case, waste processing (disposal) technology.

There is pluralism in the formulation of factors that affect the per capita estimate of the volume of MSW education. Logistic planning is strongly associated with regional features, and most of the developed and available models do not allow varying these features within their limits of applicability. Therefore, the purpose of this study is to assess the volume and morphological composition of the formation of solid municipal waste from social infrastructure facilities in various conditions of urban
agglomeration, which will allow in the future to plan the development of development of territories, a transport and logistics scheme for handling MSW, and also to choose the most acceptable processing technology (disposal) waste for the serviced area. To achieve this goal, the following tasks were solved: an analysis of the legislation of the Russian Federation and the EU countries on the management of solid municipal waste was carried out to reflect the relevant national specifics; a conceptual diagram has been drawn up that allows planning construction taking into account the management of solid municipal waste in the territory of urban agglomerations, as well as ensuring rational waste management; an analytical review of scientific and technical sources of information was carried out in order to preliminary determine the volume of formation and morphological composition of waste from social infrastructure facilities in urban agglomerations; using the direct questionnaire method, the actual volume of formation and the morphological composition of solid municipal waste generated by social infrastructure facilities (educational institutions) in the urban agglomeration, with various construction options (for example, Moscow), was determined; formulated the necessary conclusions based on the results of the study.

4. Research methods
The analysis of the volume of MSW education in educational institutions of the city of Moscow (Russian Federation) in various construction options is carried out. The data were obtained per student per year, since in the overwhelming majority of studies, it is the per capita estimate that is given.

The data were obtained by a direct questionnaire method with subsequent processing of the results obtained by statistical methods. The city of Moscow (Russian Federation) was chosen by the authors as an example of a high degree of agglomeration, while the authors take into account the degree of population of the area under study. Integrally, in the volume of MSW education, the following is taken into account:

- processes of internal inter-district migration;
- food system built in an educational institution;
- waste generated by the personnel of these institutions.

The above approach was chosen due to the fact that the main aspect of this study is to obtain actual data on the volume of solid municipal waste generation in relation to educational institutions (as a concomitant element of the development of districts) of large urban agglomerations with varying degrees of population and layout, with the aim of a future rational building planning (city development).

4.1. Analysis of features of the Russian legislation on the treatment of MSW
Legislatively, the following system has been built in the Russian Federation: in accordance with Federal Law No. 89 "On Production and Consumption Wastes" [17], for each constituent entity of the Russian Federation, a "Territorial Waste Treatment Scheme" [18] is developed, which reflects: the location of sources and the amount of waste generated; target indicators for neutralization, utilization and disposal of waste, as well as at the expense of which infrastructure facilities of the logistics chain they are achieved; places of waste accumulation; the balance of quantitative characteristics of the formation, processing, utilization, disposal, disposal of waste; waste stream diagram; handling of certain types of waste.

The general scheme of waste management in the RF is shown in Figure 1.
All waste in the Russian Federation, including solid municipal waste, has its own accumulation rate for different types of objects, including housing and communal facilities. For each of the objects of social infrastructure, it is also defined. For example, the standard for the accumulation of waste for educational institutions in Moscow is 0.21 m$^3$ per place per year [19]. The waste accumulation rate is approved annually in each constituent entity of the Russian Federation based on statistical data accumulated over previous periods. The procedure for calculating the waste generation rate is determined by the relevant decree of the Government of the Russian Federation [20].

However, this technique boils down to calculating the arithmetic mean for different periods (day, season, year) throughout the municipality, due to which the data on seasonal fluctuations in the volume of waste generation, changes in their physical and mechanical properties, are not taken into account, the features of various types of buildings are not taken into account, which makes it difficult targeted processing (utilization) of waste, due to the choice of the most acceptable technology and the formation of an optimal logistics network, complicates the future local planning of the development of the urban agglomeration territory.

The European Union Directive 2008/98/EC3 [21] establishes a hierarchy of stages in waste management, which, from the highest level to the lowest, is as follows: prevention of waste generation; reuse; recycling and reuse; use as energy resources; placement on landfills; at the top or priority level is waste prevention. Recycling efficiency indicators directly depend on the quantity and “quality” of waste. The latter is achieved by sorting by morphological composition with the organization of selective waste collection 5.

The general scheme of waste management in the EU countries looks somewhat different and is shown in Figure 2.
In the EU countries, the volume of waste generation at the objects of housing and communal services and educational institutions is not legally determined. However, various sources [22, 23] provide data ranging from 250 to 500 kg of municipal solid waste per person per year.

In contrast to the Russian Federation, in the EU countries, at a higher level, it is practiced to reuse waste suitable for this in the economic circulation, for example, for the reuse of glass containers, the cost of the container directly is reimbursed when the used container is returned to the store.

The introduction of separate waste collection in the EU countries is stimulated by the state, for example, through a mechanism to reduce utility bills, and its goal is to maximize the recovery of recyclable waste, while, as in the Russian Federation, the goal is to increase the recyclability of waste.

Taking into account the above legislative features of the Russian Federation, in general terms, the conceptual scheme of solid municipal waste management, when planning local development of large urban agglomerations, at the stages of the life cycle of objects can be represented as follows (see Figure 3).

**Figure 2.** General scheme of waste management in the EU countries. (compiled by the authors)
Figure 3. Conceptual scheme of management and planning of development of large urban agglomerations from the point of view of MSW management.

(compiled by the authors)

Investigation stage - involves a joint analysis of: existing development objects, namely, waste generation is determined - the volume and morphological composition of MSW differentiated for different types of objects; methods (technologies) of MSW processing (utilization); existing logistic schemes for waste management in the considered territory and adjacent to it. This is how the transport availability is analyzed, as well as the throughput of roads within the considered and adjacent areas, the possibility of arranging reloading hubs, construction of additional and most technologically rational, processing/disposal facilities, etc. is considered.

Building design - solutions for the planned building must comply with the following principles: minimization of waste generation at all stages of the object's life cycle, taking into account their different service life; if it is not possible to reduce the design volume of development, then it is necessary to provide for the construction or expansion of existing waste disposal facilities, while preference in technologies should be given to the one that is able to best process waste that is morphologically dominant from the project facilities, taking into account the assessment of the life cycle; design a predominantly complex development with the transformation of existing logistics systems for waste management, having previously foreseen various options for operation, for example, when using complex development, predominantly provide for retail space not for large stores, but not for chain retailers, etc. [24]; consider the most rational schemes for the management of municipal solid waste, at the stage of liquidation of urban development objects, namely, the choice of technical and organizational solutions to reduce waste generation, ensuring optimal logistics schemes when organizing the liquidation of a development object.
As shown above, at the pre-design and design stage, there is already a direct need for an initial assessment of waste generation, both from the existing agglomeration and from the options for future development. If waste generation in existing agglomerations can be determined by direct surveys on the ground, then the hidden interconnections of the objects of the future logistics network for waste management, which may be useful when choosing a particular type and type of development, are not so obvious. Therefore, this study is devoted to determining the volume of waste generation from construction sites accompanying the housing stock, such as social facilities (using the example of educational institutions in the city of Moscow, the Russian Federation, with varying degrees of population) with the aim of the future formation of an integrated system for the development of large urban agglomerations.

4.2. Literary review of scientific literature sources on the volume and morphological composition of MSW formation from educational institutions

For a preliminary analysis of the volume and morphological composition of MSW formed from objects of educational institutions, as well as in order to determine the factors that most affect them (for subsequent consideration in the analysis of data obtained by direct questionnaire), an analytical review of scientific literature sources devoted to similar studies.

Belén Derqui and Didier Grimaldi report data from a 2018 survey of 548 public schools with and without food services in Catalonia, Spain, on sustainability and municipal solid waste management. Data was collected using a questionnaire. "Scholars have found school canteens to be a relevant source of food waste, which is a growing ethical, environmental and economic problem" [25]. The authors have established the inefficiency of the existing system of municipal solid waste management in schools [25]. A similar conclusion was made in works Falasconi L., Vittuari M., Politano A. and Segrè A., and Boschini M., Falasconi L., Giordano C., Franco S., Cicatiello C., Marangon F. and Troiano S., aimed at assessing the effectiveness of catering in schools in Italy, where results were found similar to the previous study [26, 27].

Falasconi L., Vittuari M., Politano A. and Segrè A. call one of the main sources of MSW education - the school feeding system. They cite data on the unused main dishes in school canteens up to 12.59% of their total. When comparing between summer and winter menus, the percentage of unused portions of meals did not differ significantly (15.00% and 16.08%, respectively). On average, the amount of unclaimed food was 49.77 kg per day in winter and 58.92 kg per day in summer. The data is given for 6 schools located in Verona (Italy). So 64 full meals and 62 incomplete meals were disposed of as waste every day [26].

In a study by Boschini, M., Falasconi, L., Giordano, C., Franco, S., Cicatiello, C., Marangon, F. and Troiano, S. 2018) using 2-week school monitoring, it was found that - “During the period of investigation the total amount of wasted food represented an average of 29.4%. The percentage of wasted food to 29.6% for the first course, 38.3% for the second course and 57.7% for the side dish, while for both bread and fruit portions it approximately to 13.0% (13.1% bread and 13.4% fruit)” [27]. Loss was calculated based on total servings.

In the ORICON study, based on data from a survey of canteen workers, the loss from the total number of prepared meals in the general food system was 13% [28].

In the article by Vezzosi S., Bonaccorsi G., Piccioli P. and Santomauro F., food losses for 2 primary schools in the province of Pistoia (Italy), during 9 days of observation were about 20% of the total amount of food, equal to - 425 kg, which in absolute terms amounted to about 200 g per serving [29].

The authors Hjördis Steen, Christopher Malefors, Elin Röös, Mattias Eriksson in the study of Hjördis Steen, Christopher Malefors, Elin Röös and Mattias Eriksson, analyzed the generation of municipal solid waste from public catering facilities in Sweden, such as schools and preschools. that these institutions generate about 70,000 tonnes of food waste annually Quantification of municipal solid waste generated in public sector canteens by correlation analysis and statistical analysis Empirical data taken from 177 kitchens in the municipalities of Falun, Malmö, Sala, Uppsala and Örebro (Sweden), via direct questionnaire Survey data show that waste in schools and preschools increases with age of children.
High schools can potentially reduce the amount of municipal solid waste generated by introducing more structured lunch breaks. Strokes increase with an increase in the capacity of canteens, which may be associated with an increase in stress and noise levels. The amount of waste was significantly higher in the companies served (in the case of off-site cooking (to order)). The average amount of municipal solid waste per serving in the study was 18 grams [30].

The morphological composition of solid municipal waste in schools and preschool institutions, based on the analysis [18, 19, 21], is different.

So, according to the article by Falasconi L., Vittuari M., Politano A. and Segrè A., it was found that the share of the main waste was: side dishes (vegetables) - 24.67% of the total amount of delivered vegetables, risotto was in the highest degree unclaimed (waste accounted for 9.6% of the total waste), followed by pasta with tomato stew (7.1%) and soups and noodles (6.75%), bread was disposed of as waste at 17.7% of the total supply of bread, further in the waste prevailed - beef (3.0% of the total waste), eggs (1.8%), fruits (1.51%). The main waste in the study of Boschini, M., Falasconi, L., Giordano, C., Franco, S., Cicatiello, C., Maragon, F. and Troiano, S. indicated: bread (62.1% of the total servings) and fruits (57.1% of total servings). Vezzosi S., Bonaccorsi G., Picciolli P. and Santomauro F. cite data as the morphology of the main food waste for primary schools - side dishes (57% of the total serving) and bread (15% of the total serving) [26, 27, 29].

Based on the analytical review, it was found that the volume of MSW education per student depends on such factors as: the type of educational institution and its mode of operation, and the main source of MSW is food waste. What was further taken into account during the direct survey.

5. Findings

To analyze the accumulation of MSW in educational institutions, various districts of the city of Moscow were selected: Tagansky District, Basmanny and Novokosino. The choice is due to the different population density and area of districts. The Novokosino area was chosen due to the fact that it has a small area with a high population density, which makes it possible to simulate a densely populated area ("infill" buildings). Districts - Tagansky and Basmanny were chosen because of the comparative equality of their areas and population density ("complex" development) [24].

In order to obtain a regularity between the number of students and the total number of education in MSW, a questionnaire was drawn up for the heads of the economic part of educational institutions. The questionnaire included the following main questions, to which officials were asked to answer: "Type of education in this institution?", "How many MSW is formed in an educational institution per year?", "Total number of students in the institution?" The survey was carried out in 2019 from March to May. The survey data are listed in Table 1.

**Table 1.** Data from questionnaires for educational institutions of the city of Moscow, on the actual volume of waste generation.

| №  | The name of the educational institution | Address | Type of education | MSW quantity, m³/year | Number of places | Norms, m³/person | For 1st place |
|----|----------------------------------------|---------|------------------|----------------------|-----------------|-----------------|--------------|
| 1  | School № 2128, Section 2, st. Suzdal, 12 | general education | 96 | 2210 | 0.21 | 0.170136 |
| 2  | School №2128 "Energy", st. Novokosinskaya, 13B | general education | 120 |   |   |   |
| 3  | School №2128 "Energy", Section 1, st. Suzdal, 12b/1 | general education | 160 |   |   |   |
| №  | The name of the educational institution | Address                          | Type of education                          | MSW quantity, m³/year | Number of places | Norms, m³/person | For 1st place |
|---|----------------------------------------|----------------------------------|---------------------------------------------|------------------------|------------------|-----------------|---------------|
| 4 | School № 1200 with in-depth study of the English language School № 1200 | st. Suzdal, 24b                   | general education                           | 120                    | 1548             | 0.21            | 0.242894      |
| 5 | Gymnasium № 1925                      | st. Suzdal, 22b                   | general education                           |                        |                  |                 |               |
| 6 | Preschool department № 4, School № 1200 | st. Novokosinskaya, 13a           | general education                           |                        |                  |                 |               |
| 7 | Preschool department № 4, School № 1200 | st. Suzdal, 22a                   | preschool                                   | 80                     | 312              | 0.8             | 0.25641       |
| 8 | Center for Child Development-kindergarten № 2321 | st. Novokosinskaya, 17Б          | preschool                                   | 80                     | 250              | 0.8             | 0.32          |
| 9 | Kindergarten number 2052 "Dolphin", Preschool department of School number 2128 | st. Suzdal, 18a                   | preschool                                   | 80                     | 329              | 0.8             | 0.243161      |
| 10 | Kindergarten № 2053                   | st. Novokosinskaya, 25            | preschool                                   | 120                    | 609              | 0.8             | 0.197044      |
| 11 | Child Development Center - kindergarten № 2343 | st. Novokosinskaya, 15           | preschool                                   | 96                     | 453              | 0.8             | 0.211921      |
| 12 | Preschool building, School № 1925     | st. Suzdal, 10a                   | preschool                                   | 80                     | 248              | 0.8             | 0.322581      |
|   |                                         |                                  |                                             |                        |                  |                 |               |
| 13 | School № 444                          | per. Nizhny Zhuravlev, 3          | general education                           | 180                    | 1025             | 0.21            | 0.17561       |
| 14 | "School on Yauza", № 1               | Semyonovskaya nab., 5, building 1 | general education                           | 90                     | 1549             | 0.21            | 0.240155      |
| 15 | School № 2104                         | Rubtsov per., D10 / 14           | general education                           | 96                     |                  |                 |               |
| 16 | School № 2105                         | Gospitalny Val, 5, bldg. 19       | general education                           | 90                     |                  |                 |               |
| 17 | Education center № 1641              | Kondrashevsky blind alley, 3A     | general education                           | 96                     |                  |                 |               |
| 18 | Multidisciplinary School № 1374       | Palekhskaya st., 16, bldg. 1      | preschool                                   | 96                     | 215              | 0.8             | 0.446512      |
| №  | The name of the educational institution | Address                  | Type of education | MSW quantity, m³/year | Number of places | Norms, m³/person | For 1st place |
|----|----------------------------------------|--------------------------|-------------------|------------------------|------------------|-----------------|---------------|
| 19 | Municipal autonomous preschool educational institution kindergarten №. 299 | st. Bolshaya Pochtovaya, 14a | preschool         | 50                     | 120              | 0.8             | 0.416667      |
| 20 | School № 1374 | st. Golyanovskaya, 1a | general education | 90                     | 1469             | 0.21            | 0.187883      |
| 21 | School № 1374 | st. Fedoskinskaya, 4 | general education | 96                     |                  |                 |               |
| 22 | School № 1374 | ул. Плехеская, 10 | general education | 90                     |                  |                 |               |

**Tagansky District**

| №  | The name of the educational institution | Address                  | Type of education | MSW quantity, m³/year | Number of places | Norms, m³/person | For 1st place |
|----|----------------------------------------|--------------------------|-------------------|------------------------|------------------|-----------------|---------------|
| 23 | School № 1270 “Vector” Library street, 19 | preschool               | 50                | 1638                   | 0.21            | 0.233211        |
| 24 | School № 1270 “Vector” Nikoloyamskiy lane, 3A, building 3 | preschool               | 50                |                        | 0.21            |                 |               |
| 25 | School № 1270 “Vector” | | general education | 96                     |                  |                 |               |
| 26 | School № 1270 “Vector” Bolshoi Fakelny Lane, 21 | | general education | 96                     |                  | 0.8             |               |
| 27 | School № 1270 “Vector” | | general education | 90                     |                  | 0.8             |               |
| 28 | School № 2104 on Taganka”, building 1 Tovarishche lane, 21 | preschool               | 80                | 170                    | 0.8             | 0.470588        |
| 29 | School № 2104 on Taganka”, building 1 | | preschool               | 80                     | 186              | 0.8             | 0.430108      |
| 30 | School № 2104 on Taganka”, building 5 Lavrov lane, 9 | general education | 96                | 1649                   | 0.21            | 0.174651        |
| 31 | School № 2104 on Taganka”, building 5 | | general education | 96                     |                  |                 |               |
| 32 | School № 2104 on Taganka”, building 3 Nikoloyamskiy lane, building 3A, building 2 | general education | 96                |                        |                 |                 |               |

Total MSW for educational institutions, m³/person: 0.203506
Total MSW for preschool institutions, m³/person: 0.331499

Compiled by the authors using data from the Decree of the Government of the Russian Federation of April 4, 2016 N 269 "On the determination of standards for the accumulation of solid municipal waste" of April 11, 2016 N 15 Art. 2100 [31].
When comparing the survey indicators (actual data, see table 1) and normative (data from the order [32], see table 2), there is an excess of the normative indicators for preschool institutions relative to the actual data, by about 2.5 times, and the approximate correspondence of indicators for schools.

Based on the actual data obtained, it was established that the volume of MSW education per student depends on such factors as the type of educational institution, so for schools the volume of waste generation in the study period was 1.5 times less than for preschool institutions.

When planning future development, it should be borne in mind that in areas with a high population density, with a small building area ("point" building), waste formation rates are lower per 1 student in educational institutions of preschool education than similar ones in areas with "complex" buildings, the difference is about 2 times.

6. Conclusion

A preliminary review of the sources of scientific and technical literature, carried out in the introduction, shows that often existing urban planning solutions in urbanized areas, the purpose of land tenure, as well as plans for the development of cities and land tenure, are developed without detailed building of any system for further rational management of municipal solid waste. Predominantly predictive models are used that allow, in the current realities, to form logistics networks for MSW management, as well as a per capita estimate of the volume and morphology of MSW formation. Thus, to some extent, a “normative” approach is being built, which is not applicable in particular cases of planning and managing waste management. Thus, most studies do not take into account the feedback of the development of urban agglomeration, namely, the choice of the type and type of development (its future formation at the project stage), depending on all elements of the logistics scheme for MSW management.

There is pluralism in the formulation of factors that affect the per capita estimate of the volume of MSW education. At the same time, logistics planning is strongly associated with regional features, and most of the developed and available models do not allow varying these features within their limits of applicability.

The analytical review carried out by the authors, as well as the data obtained by the direct questionnaire method (for various types of buildings in the city of Moscow, RF), show the need for the management of municipal solid waste in educational institutions, as an element of the accompanying infrastructure of residential buildings, since the volume of waste generation in them essential.

It is necessary to take into account the features of waste generation already at the planning stage of development, such as:

- the main source of MSW in educational institutions is food waste;
- inconsistency between the actual data on waste generation and regulatory values, which is primarily associated with the built-up nationwide waste management system;
- the dependence of the volume of MSW education per student on the type of educational institution, so for schools the volume of waste generation, during the study period, was observed 1.5 times less than for preschool institutions;
- Seasonality of MSW formation, and significant dependence on the mode of operation of the educational institution;
- dependence on the type of building, so in areas with a high population density, with a small building area ("point" building), the waste formation per student was observed lower than in educational institutions of preschool education, similar areas with "complex" building, the difference was approximately 2 times.

Taking into account the above, at the planning stage of the development of an urban agglomeration, from the standpoint of waste generation from accompanying social facilities, preference should be given to more concise construction schemes (for example, "infill" construction), while for uniform loading of processing (utilization) facilities should be distributed modes of operation of preschool educational institutions and schools in time. At the same time, one should rely on the regulatory data specified in the Decree of the Government of the Russian Federation of April 4, 2016 No. 269 "On determining the
standards for the accumulation of solid municipal waste” should be only in the case of primary planning and assessment of logistics schemes at the pre-project stage, since the actual volumes of MSW generation in preschool institutions differ in the smaller direction by about 2.5 times.

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