Solid Municipal Waste Management for Sustainable Development

Yu M Grishaeva¹, I V Spirin², S P Kiseleva³, O B Napolov⁴, O Yu Matantseva⁵

¹Professor of Moscow Region State University, 24 Vera Voloshina Str., Mytishchi, 141014, Moscow region, Russia
²Chief Researcher of JSC Scientific & Research Institute of Motor Transport, 24, Heroev Panfilovtsev Street, Moscow, 125480, Russia
³Vice-Rector, professor of International Independent University of Environmental Political Sciences, 23 Varshavskoe highway, Moscow, 117105, Russia
⁴Associate professor of Moscow State University of Geodesy and Cartography (MI-IGA and K), 4 Gorokhovsky lane, 105064, Moscow, Russia
⁵Deputy General Director of JSC Scientific & Research Institute of Motor Transport, 24, Heroev Panfilovtsev Street, Moscow, 125480, Russia

E-mail: j.m.g@mail.ru

Abstract. The article discusses the main directions of improving the management of municipal solid waste in accordance with the requirements of the concept of sustainable development. The concept of "solid municipal waste" is analyzed in its comparison with the concept of "solid household waste". The problems associated with the functioning of the sphere of solid municipal waste management are emphasized. The tasks of the development of this industry for Russia in the near future are defined. Environmental control of MSW is difficult, since the main sources of MSW are households and organizations of municipal services of settlements. These sources are numerous, highly dispersed (scattered throughout the territory). Insufficient eco-cultural training and inadequate self-awareness of the population prevent the regulation of MSW flows and the spread of SD in everyday life. Therefore, the solution to the problem of solid waste should use an adequate methodology, including administrative regulation and systematic improvement of the level of ecological culture of the population.

1. Introduction
The Concept of Sustainable Development (SD) defines the main goals and directions of focusing efforts on a comprehensive solution to current world problems in the interests of present and future generations. This concept was developed by the international community with the participation of Russia at several representative conferences organized by the UN [1, 2, 3, 4]. SD's ideas and concern for environmental well-being are reflected in a number of intergovernmental agreements [5, 6] and in the national legislation of various countries. The legislation of Russia establishes the payment for the use of natural resources, the presumption of environmental danger of production activities, the implementation of state supervision over compliance with environmental law [7]. The main motives for the creation of the SD concept and its main directions were global problems:
the crisis of the economy, mainly based on the ideology of commercial attractiveness for investors (achieving internal results) without taking into account significant external positive and negative results obtained by persons who are not directly involved in commercial projects. Such external results in value terms are often many times more significant than internal results. The contribution of business to sustainable development is not only in the financing of projects, but also in the rethinking of the economic doctrine [8];

- implementation of the predictions of the founders of the noosphere doctrine about the unacceptable anthropogenic impact on the environment, threatening the existence of not only civilization, but also life on the planet. Environmental problems have sharply worsened due to the globalization of economic activity, the accelerated increase in the consumption of various resources per capita, and the point concentration of industrial activity and population in cities. Currently, more than half of all people live in cities, which occupy only about 1% of the land and supply the majority of household and industrial waste to the environment. Cities generate more than 70% of GDP. The rate of growth of waste entering the environment outstrips the increase in the population [9, 10, 11, 12, 13]; the aggravation of social contradictions is caused by the continuing inequality of people, discrimination on various grounds, and the incompleteness of the formation of civil society institutions. Social contradictions are compounded by economic stratification, the crisis of urbanization, and limited access to social services and support measures. The main share of the GDP of developed countries is created by the labor of the cognitariat, which has become the main class of modern society. To support the cognitariat, it is necessary to develop culture and education. Education should become environmentally oriented in the near future [14].

2. The concept of sustainable development and the problem of municipal solid waste

The problem of reducing environmental pollution by solid municipal waste (MSW) is associated with all three of these areas of SD. The economy and industrial relations should be transformed in such a way as to minimize the possibility of the formation of solid waste and create the prerequisites for their profitable disposal. Environmental control of MSW is difficult, since the main sources of MSW are households and organizations of municipal services of settlements. These sources are numerous, highly dispersed (scattered throughout the territory). Insufficient eco-cultural training and inadequate self-awareness of the population prevent the regulation of MSW flows and the spread of SD in everyday life. Therefore, the solution to the problem of solid waste should use an adequate methodology. Within the framework of environmental science, the study of garbage waste and methods of its disposal is carried out by garbology (mentioned in the Oxford English Dictionary, 2nd ed., 1989) [15, 16, 17, 18].

The international agreement establishes 17 main SD goals and defines a list of urgent tasks to achieve them [3]. The study of the relationship between the environmental harm of waste and SD goals allowed us to establish that the most correlated with MSW goals are: (a) Take urgent action to combat climate change and its impacts, (b) Ensure access to affordable, reliable, sustainable and modern energy for all, (c) Ensure availability and sustainable management of water and sanitation for all, (d) Protect, restore and promote sustainable use of terrestrial ecosystems, (e) ensure sustainable consumption and production patterns, (f) Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

Currently, there is no evidence-based monitoring of solid waste. The study of a large number of publications and Internet resources on the problems of solid waste allowed us to determine the extent of pollution of the environment by summarizing expert assessments.

World Bank studies have shown that the main suppliers of solid waste on the planet are the United States-18%, China-15%, Brazil-4.3% and Japan-4%. Another 2.4% to 3.7% of MSW is generated in the territories of each of the following countries: Russia, Germany, Great Britain, France, Italy, Mexico, India, Turkey. About 36% of MSW is accounted for by all other states [https://www.factograph.info/a/28914365.html]. The World Bank's environmental strategy is in line with SD and associates environmental pollution with social problems of poverty and the quality of life of the population [https://refdb.ru/look/1955769.html].
The largest crowdsourcing statistical database NUMBEO contains expert estimates of the share of polluted territories of various countries in 2019, for example: Russia 63%, China 81%, the United States 36%, Finland 12% [https://nonews.co/directory/lists/countries/pollution-rating].

Russia annually produces about 6.2 billion tons of all types of waste [https://rosstat.gov.ru/]. The amount of MSW is 63 million tons/year; on average, 445 kg per person [https://www.vokrugsveta.ru/vs/article/7755/]. A comparison of the structure of MSW in Russia and the United States (the most developed economy in the world) is presented in Table 1. More than 80% of garbage is not recycled and is stored in landfills. There are more than 11 thousand landfills in Russia, and about 82 billion tons of waste is located there. MSW is recycled only by 3 - 4% while industrial waste is recycled by 35%. In Russia, legal measures are being taken to regulate solid waste (89-FL "On Production and Consumption Waste"). A comparison of the structure of MSW disposal in Russia and the leading economies of the world revealed a significant gap between Russia and all methods of disposal (Table 2). The tradition of dumping MSW in landfills should be eradicated through the use of innovative technologies and resource-saving methods of disposal. Many researchers consider the disposal of MSW as an opportunity to generate business income through the reasonable recycling of resources, building a waste-free Circular Economy based on the recycling of solid waste [19, 20, 21].

Table 1. Comparison of MSW structure in Russia and the USA, %.

|         | Paper and cardboard | Food waste | Plastics | Glass | Metals | Other |
|---------|---------------------|------------|----------|-------|--------|-------|
| Russia  | 35                  | 41         | 3        | 8     | 4      | 9     |
| USA     | 37                  | 24         | 11       | 5     | 8      | 15    |

Table 2. Structure of solid municipal waste by disposal methods, %.

| MSW disposal methods | Russia | China | USA | The states of EC-28 | Japan |
|----------------------|--------|-------|-----|----------------------|-------|
| Landfill             | 90     | 60    | 53  | 24                   | 1.5   |
| Incineration         | 3      | 30    | 13  | 27                   | 78    |
| Recycling            | 7      | 2     | 34  | 45                   | 20.5  |
| Other                | 0      | 8     | 0   | 4                    | 0     |

Compared to industrial waste, the logistics of MSW disposal is more extensive: there are many places where waste is generated, and waste is divided into fractions. Optimization of the routes for the removal of solid waste from the places of formation to the places of disposal is carried out using mathematical programming methods [22, 23].

3. MSW as a waste category

Currently, in the Russian Federation, in various spheres of life, one can observe the use of two concepts that characterize waste generated as a result of the daily activities of a person and various organizations: "solid household waste" and "solid municipal waste". Solid household waste includes products and goods that have lost their consumer characteristics; solid municipal waste includes waste of natural and artificial origin that has ceased to be useful. Unlike solid municipal waste, solid household waste is formed only at home, including when cooking, cleaning the house, carrying out minor repairs, removing damaged furniture, and so on. The concept of solid municipal waste (MSW) also includes waste of a similar composition of legal entities (enterprises, organizations, etc.).

Russian Federal Law 458-FL of 29.12.2014 "On Amendments to the Federal Law "On Production and Consumption Waste" amended the very concept of "solid household waste" and led to the emergence of the concept of "solid municipal waste". Currently, the concept of "solid household waste" is used only in colloquial speech, while in official documents the concept of "solid municipal waste" is
used. According to the Federal Law of June 24, 1998 N 89-FZ "On Production and Consumption Waste" (as amended), "solid municipal waste" (MSW) - waste generated in residential premises in the process of consumption by individuals, as well as goods that have lost their consumer properties in the process of their use by individuals in residential premises in order to meet personal and household needs. Solid municipal waste also includes waste generated in the course of the activities of legal entities and individual entrepreneurs, as well as similar waste generated by the population in residential premises.

The list of MSW includes small electronics, street debris (leaves, branches, dust), broken household appliances, old wooden furniture, plant and food residues, household chemicals, small metal and plastic elements, old shoes and clothing, paper and cardboard products, old musical equipment, remnants of old road surfaces. Also, the category of MSW includes other types of solid waste that do not pose a danger to the population and the natural environment and do not require disinfection and disinfection. The main components of municipal solid waste are: food waste-35-50%, paper and cardboard-10-15%, plastics-9-13%, metals-2%, glass-8-10%, textiles-4-6%, construction waste-5%, wood-1% and other waste-10%. MSW does not apply: hot waste, snow and ice, mercury-containing lamps, batteries and accumulators, construction debris, medical waste. MSW should not contain toxic, radioactive, and other harmful and dangerous substances for human health; the content of metal and plastic materials in MSW should be minimal.

According to the Order of Federal Service for Supervision of Natural Resources Management of 22.05.2017 N 242 "On approval of the Federal Classification Catalog of waste" MSW includes all types of waste of the waste subtype "Municipal solid waste", as well as other waste of the waste type "Municipal waste, similar to municipal waste in production, waste in the provision of services to the population" if the name of the waste subtype or waste group indicates that the waste belongs to MSW. For the purposes of federal statistical observation in terms of MSW management, waste generated during the processing of municipal solid waste for the production of secondary raw materials, included in group Waste (residues) of municipal waste sorting, is also taken into account.

MSW is classified as waste of hazard classes 4 and 5, in particular, waste from parks and natural areas, wood scraps, sticks, and large-sized garbage are classified as waste of the fifth hazard class.

The economic potential of MSW as a category of waste is determined by the potential effects of the possible involvement of MSW in the economic turnover: economic, social, environmental, etc. [24]

Based on this approach, the competitiveness of projects to involve MSW in economic turnover is proposed to be critically evaluated using the following set of indicators:

- **Economic indicators:** the profitability of the MSW management project; the volume of attracted investments aimed at solving problems in the field of MSW management; the amount of costs of economic entities for the services of third-party organizations that accept MSW; the amount of consumer demand for products obtained from MSW; the payback period of MSW management projects; the volume of the market for MSW use; the volume of MSW of a given quality; the volume of products obtained from MSW; the payback period of MSW management projects; the volume of MSW management projects; the volume of MSW of a given quality; the volume of products obtained from MSW in accordance with the requests of consumers; the amount of income from the sale of products obtained from MSW.

- **Environmental indicators:** volume of emissions of pollutants into the atmosphere when using MSW; volume of wastewater discharge into water objects when using MSW; acoustic impact (noise) on the environment when using MSW; volume of greenhouse gas emissions when using MSW; innovation of technologies in the field of MSW management; volume of agricultural land used for MSW disposal, etc.

- **Social indicators:** assessment of the image of the enterprise that uses MSW in production; the level of formation in the company of the value of using modern technologies that reduce the level of MSW treatment; the level of involvement and interest of the authorities in solving issues of MSW treatment; the formation of public opinion about the benefits of using secondary resources obtained from MSW; the creation of new jobs and reducing unemployment through the use of MSW; the development of industry, small and medium-sized businesses through the use of MSW; improving human health and
climate through the use of MSW; improving the quality of life of the population through the use of MSW, etc.

The features of the MSW category determine the need to minimize the formation of MSW and environmental pollution at all stages of MSW management; effective management of information and material flows when handling MSW in order to reduce the environmental burden to an acceptable level [21]. The optimal ways to dispose of an increasing amount of MSW are recognized as the following: elemental or separate collection of MSW; export of MSW to sanitary and industrial zones; disposal of MSW by burial in special landfills; waste processing; incineration. [22, 23].

4. Recycling of MSW: experience of different countries

EU. The requirements for garbage sites, containers for collecting and transporting garbage, its transportation, storage and classification are clearly regulated by regulatory legal acts. Educational work with the population, which is actively carried out by the media, house masters, has become widely known. The observance of cleanliness is strictly monitored by the "garbage police", who punish those who throw out garbage in unspecified places with impressive fines [25, 26]. European countries resort to different ways of motivating the population to carefully sort garbage. For example, Berlin teenagers who collect garbage and hand it over for recycling receive a financial reward for this [25, 26]. The Dutch authorities issue special environmental loyalty coupons to citizens of the country who actively participate in the separate garbage collection program. In Barcelona, various garbage collection events occur quite often, in the form of significant discounts on utility bills [26]. There is a powerful incineration industry in Switzerland: heating of many settlements is carried out at the expense of garbage burned at special plants. In European countries, there are various technologies for processing MSW. For example, in the 27 EU member states, about 38% of MSW is buried in landfills, 22% is incinerated, 25% is processed as secondary material resources and 15% is subjected to composting. Waste is burned most often in Denmark (54%), Sweden (49%), the Netherlands (39%) and Germany (38%). Recycling as secondary material resources is the most common method of municipal waste management in Germany (45%) and Belgium (40%). Austria has the highest level of waste recycling and composting in the EU (70%) [27].

USA. Both private and public companies are involved in the MSW management industry in the United States [28]. Each state has several ways to finance the MSW recycling program. According to the laws in force in New York, every house is obliged to sort MSW. Organic MSW is thrown into the garbage chute, the rest of the waste is sorted either by containers installed in basements, or special containers for various garbage are made in the garbage wire. If the residents of the house refuse to sort MSW, a fine is charged, which covers the sorting of MSW at garbage stations [27, 28].

Japan. In Japan, all waste is recycled [30, 31]. The first fundamental law in the field of waste management was the law on waste management adopted in 1970. This law has been repeatedly revised and supplemented with new legislative objects in accordance with the development of the concept of the society "recycling. Thus, in 1992, the Law on Forcing the Use of Secondary Raw Materials was adopted, which stipulates the need to implement the "3R"principle. Currently, the scope of application of this law includes 69 products (from 10 industries), the use of which leads to the formation of approximately 50% of all household and industrial waste [30, 31]. A larger percentage of MSW generated in Japan is incinerated, so the stored waste consists mainly of incinerated and burned residues.

China. According to the first Chinese law on garbage, which came into force on January 1, 2009, waste is not just garbage, but "an inefficiently used resource". Currently, about 60% of the fiber used for the production of paper and cardboard in China is produced from recycled materials [32]. In addition, you can pay for travel in the Beijing subway with empty plastic bottles. With the adoption of the law on garbage, the fight against landfills began. Seventy-three landfills located within the city limits of Beijing are planned to be liquidated, and the garbage will be used for electricity production.

Australia. The Australian Capital Territory (ACT) produces about 1 million tons / year of MSW. In the last decade, approximately 300,000 tons of MSW (30%) are sent annually to landfills for disposal, and 70% are recycled [33]. In accordance with the Waste Management Strategy 2011-2025, the share
of recycling should be 90% by 2025, but this task, as noted, will be difficult to fulfill. According to the climate legislation, the balance of greenhouse gas emissions ACT should reach zero (net zero greenhouse gas emissions) by 2045. Today, 100% of the electricity consumed by the Territory comes from renewable resources (without "energy from waste").

**Brazil.** In Brazil, in residential buildings, they must separate the garbage into organic and inorganic. The first one should be thrown into the waste disposal chute, the second one should be left in a special compartment, from where it is taken away by employees of the management company. However, not everyone follows this rule [34]. However, the environmental policy is still being purposefully conducted. For example, residents of the state of Rio de Janeiro have the opportunity to save money through more environmentally friendly consumption. Since 2009, retail companies have been obliged to give a discount to customers who put their purchases in their own bags.

**Mexico.** The volume of garbage production in the country, according to the Ministry of Environmental Protection and Natural Resources (in Spanish Semarnat), reached 117 thousand tons / day by the end of 2017. Thus, Mexico has taken one of the first places in the generation of waste in Latin America, the UN calculated, despite the fact that there is more and more garbage in Mexico every year, the situation with its collection, not to mention overworking, remains consistently difficult [35]. According to the former head of the Environmental Ministry, Rafael Pacciano, up to 70% of waste is not even sent to landfills or landfills, but falls directly into rivers, forests and ravines. The initiative proposed by Semarnat at the end of 2016 to charge 90 pesos ($4.6) per month from each Mexican family for the export of MSW has not yet been widely adopted. It cannot be denied that one of the serious obstacles to its implementation was and remains the low standard of living of many Mexicans.

**South Africa.** The Western Cape province in South Africa in 2018 announced a complete ban on the disposal of food waste from 2027. This decision is due to the fact that food waste accounts for about 40% of the total annual volume of waste in the country [36]. Instead of burial, it is planned to use composting technologies more actively. Landfills of MSW will have to gradually reduce the number of food waste accepted.

Thus, according to a number of experts, by 2050 the amount of MSW on the planet should increase by 70%. In Russia, this indicator is also growing. Experts believe that the existing regional documents in Russia do not reflect the strategic priorities of both the state strategy and international practice [37]. They are aimed at pinpoint solutions to acute problems, but do not offer a comprehensive approach. Currently, the waste management system is being reformed in Russia. According to experts, by 2030, the amount of treated waste in the Russian Federation should increase from 3% to 97%, recycled-from 1% to 86%. It is also planned to significantly and tenfold increase the number of waste disposal complexes, industrial and technical complexes and waste sorting complexes of MSW.

5. **Conclusions**

The organization and provision of eco-oriented MSW turnover is complicated by the insufficient legal development of provisions on waste as secondary material resources, the lack of an effective system of stimulating economic entities to introduce low-waste energy technologies; extreme conservatism and isolation of certain sectors of the national economy (for example, the construction industry) – potential consumers of secondary resources; high capital intensity of MSW recycling projects; lack of incentives and guaranteed markets for products obtained from MSW; interdepartmental confusion and imperfect regulatory framework; low competitiveness of secondary resources relative to natural resources. For the eco-oriented turnover of MSW, the implementation of the environmental imperative of innovative technological development is critical, formation and development of a closed-loop economy, the greening of education in various areas of personnel training, the formation of a modern ecological culture of the population are necessary for the sustainable development of the economy.

6. **References**

[1] https://undocs.org/en/A/CONF.151/26/Rev.1 (Vol I)
[2] UN Conf. on sustainable development RIO+20 Session 66 Agenda item 19 The Future We Want Outcome document of the Conf. (Rio de Janeiro, Brazil) 11 Sep 2012 A/CONF.216/L.1 https://sustainabledevelopment.un.org/rio20/futurewewant

[3] Full report of the Open working group of the General Assembly on Sustainable development goals is issued as document A/68/970 2015. http://undocs.org/A/68/970

[4] UN World Summit on Sustainable Development. Johannesburg Declaration on Sustainable Development A/CONF.199/20 4 Sep 2002. http://www.un-documents.net/jburgdec.htm

[5] Framework Convention on Climate Change UN Climate Change Conf. COP17 (Durban, South Africa) Nov.-Dec. 2011 https://www.globalissues.org/article/797/cop17-durban-climate-conference

[6] UN Conf. Climate Change COP21 in Paris 12 Dec 2015 The Paris Agreement https://www.un.org/thesummit/cop21/

[7] Newell J P and Henry L A 2017 The state of environmental protection in the Russian Federation: a review of the post-Soviet era Eurasian Geography and Economics DOI: 10.1080/15387216.2017.1289851

[8] Mio C, Panfilo S and Blundo B Jul 2020 Sustainable development goals and the strategic role of business: a systematic literature review Business strategy and the environment doi: 10.1002/bse.2568

[9] Boden T A, Marland G and Andres R J 2017 Global, regional, and national fossil-fuel CO₂ emissions Carbon Dioxide Information Analysis Center, Oak Ridge National lab US Department of Energy Oak Ridge Tenn USA doi 10.3334/CDIAC/00001_V2017

[10] Grishaeva Yu M, Matantseva O Yu, Spirin I V, Savosina M I, Tkacheva Z N and Vasin D V 2018 Sustainable development of transportation in the cities of Russia: experience and priorities South of Russia: Ecology, Development 13(4) 24–46 [In Rus]

[11] Trofimenko Yu, Komkov V and Donchenko V 2018 Problems and prospects of sustainable low carbon development of transport in Russia IOP Conf. Ser: Earth and Environmental Science 177(1) 012014. doi: 10.1088/1755-1315/177/1/012014

[12] Donchenko V, Kunin Y, Ruzski A, Barishev L, Trofimenko Y and Mekhonoshin V 2016 Estimated atmospheric emission from motor transport in Moscow based on transport model of the city Transportation Research Proc. 14 2649-658. doi:10.1016/j.trpro.2016.05.423

[13] The new urban Agenda was adopted at the UN Conf. on Housing and sustainable urban development Habitat III in Quito Ecuador 20 Oct 2016 It was endorsed by the UN General Assembly at its sixty-eighth plenary meeting of the seventy-first session on 23 Dec. 2016. https://habitat3.org/documents-and-archive/

[14] Grishaeva Yu M, Wagner I V, Tkacheva Z N, Lugovskoy A M and Moro P N 2018 Education for sustainable development today: a problem area for overcoming difficulties of pedagogical adaptation (on the example of a higher school) South of Russia: ecology, development 13(3) 159-166. [In Rus] DOI: 10.18470/1992-1098-2018-3-159-166

[15] Mervis J Aug 2012 Garbology 101: getting a grip on waste Science 337(6095) 668-72 DOI: 10.1126/science.337.6095.668

[16] Cote J A, McCullough J and Reilly M 1985 Effects of unexpected situations on behavior-intention differences - a garbology analysis J. of Consumer Research 12(2) 188-94 DOI: 10.1086/208507

[17] Benton R Jr Mar 2015 Reduce, Reuse, Recycle . . . and Refuse J. of Macromarketing 35(1) SI 111-22 DOI: 10.1177/0276146714534692

[18] Bruncilikova L 2017 Waste and value in the post-socialist space Anthropologie-Int. J. of Human Diversity and Evolution 55(3) 385-98

[19] Ivanova O and Gorbina N March 2020 Solid municipal waste: collection and disposal issues Russian J. of Resources, Conservation and Recycling 7 10.15862/03ECOR120 DOI:10.15862/03ECOR120
[20] Taleb Mona and Al Farooque Omar Jan 2921 Towards a circular economy for sustainable development: An application of full cost accounting to municipal waste recyclables J. of Cleaner Production Part 2 280 124047 https://doi.org/10.1016/j.jclepro.2020.124047

[21] Tisserant A, Pauliuk S, Mericiai S, Schmidt J, Fry J, Wood R and Tukker A Jun 2017 Solid Waste and the Circular Economy A Global Analysis of Waste Treatment and Waste Footprints J. of Industrial Ecology 21(3) SI 628-40 DOI: 10.1111/jiec.12562

[22] da Silva R C P, Costa A R S, El-Deir S G and Juca J F T Nov-Dec 2020 Sectorization of solid household waste collection routes by multivariate techniques: a case study of the city of Recife Brazil Engenharia Sanitaria e Ambiental 25(6) 821-32 DOI: 10.1590/S1413-41522020200205

[23] Bulatov N K, Toilybayev A E, Suleyeva N Z and Sarzhanov D K Feb 2021 Development of the model (algorithm) of the efficient transportation logistics with the purpose of collection and transportation of the solid municipal waste to the places of their recycling Environment Development and Sustainability 23(2) 2015-37. DOI: 10.1007/s10668-020-00661-w.

[24] Kiseleva S P, Vishnyakov Ya D, Pukhov S A, Razovskiy Yu V, Makolova L V 2020 Integration of thermal power plant wastes into environmentally-oriented economic development Ugol' 11 64–66 DOI:http://dx.doi.org/10.18796/0041-5790-2020-11-64-66 [In Rus]

[25] Voukkali I, Loizia P, Pedreno J N and Zorpas A A 2021 Urban strategies evaluation for waste management in coastal areas in the framework of area metabolism. Waste Management Research 39(3) 448-465 DOI: 10.1177/0734242X20972773

[26] Cavicchia C, Sarnacchiaro P and Vichi M 2021 A composite indicator for the waste management in the EU via Hierarchical Disjoint Non-Negative Factor Analysis. Socio-Economic Planning Sciences 73 100832 DOI: 10.1016/j.seps.2020.100832

[27] Garbarino E, Orveillon G and Saveyn H G M 2020 Management of waste from extractive industries: The new European reference document on the Best Available Techniques Resources Policy 69 101782 DOI: 10.1016/j.resourpol.2020.101782

[28] Alamu S O, Wemida A, Tsegaye T and Oguntimein G 2021 Sustainability Assessment of Municipal Solid Waste in Baltimore USA Sustainability 13 4 DOI: 10.3390/su13041915

[29] Leang J L, Meyer J E, Manahan C C, Delistraty D A, Rick R J, Powell T P, Smith M N, and Perkins M S 2021 Regulation of Persistent Chemicals in Hazardous Waste: A Case Study of Washington State, USA. Integrated Environmental Assessment and Management 17 2 455-464 DOI: 10.1002/ieam.4365

[30] Homma S and Hu J L 2021 Cost efficiency of recycling and waste disposal in Japan J of Cleaner Production 284 125274 DOI: 10.1016/j.jclepro.2020.125274

[31] Qian K, Javadi F and Hiramatsu M 2020 Influence of the COVID-19 Pandemic on Household Food Waste Behavior in Japan Sustainability 12(3) 9942. DOI: 10.3390/su12239942

[32] Hao J L, Di Maria F, Chen Z K, Yu S W, Yu W T and Di Sarno L 2020 Comparative Study of Construction and Demolition Waste Management in China and the European Union Detritus 13 114-121, DOI 10.31025/2611-4135/2020.14029

[33] Hamilton J, Seyedmahmoudian M, Jamei E, Horan B and Stojcevski A 2020 A systematic review of solar driven waste to fuel pyrolysis technology for the Australian state of Victoria Energy Reports 6 3212-3229. DOI: 10.1016/j.egyr.2020.11.039

[34] Ashton E G and Ashton M S G 2016 Solid waste management in the tourist destination Fernando De Noronha Basil Anais Brasileiros De Estudos Turísticos-Aber 6(2) 82-96

[35] Hernandez-Padilla F and Angles M 2017 Earthquake Waste Management, Is It Possible in Developing Countries? Case Study: 2017 Mexico City Seism Sustainability 13(5) 2431 DOI: 10.3390/su13052431

[36] Kanyimba A T, Richter B W and Raath S 2014 The effectiveness of an environmental management system in selected South African primary schools J. Cleaner Production 66 479-488. DOI: 10.1016/j.jclepro.2013.10.052

[37] Poklonov V A et al 2021 IOP Conf. Ser.: Earth Environ. Sci. 666 032049 DOI: https://doi.org/10.1088/1755-1315/666/3/032049