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Responsible consumption for a green economy in Kazakhstan

Consumo responsable para una economía verde en Kazajstán

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Abstract

Currently, with population growth, economic development and the constant improvement of people's living standards, the amount of garbage continues to increase, the composition of garbage has also undergone major changes, and the harm from garbage is becoming more serious. In Kazakhstan, there is a danger to health due to environmental degradation and misuse of waste. To analyze the problems and satisfaction of the population with the waste management system implemented by local authorities in cities, a survey was conducted in two cities of Kazakhstan - Astana and Almaty. For this study, a sample of 978 respondents from each randomly selected city was selected, which included an equal number of respondents. After the survey, we found out that residents of Astana are more satisfied with the waste management system for each category than residents of Almaty. The study examined issues related to the formation of solid waste in


Resumen


Actualmente, con el crecimiento de la población, el desarrollo económico y la mejora constante del nivel de vida de las personas, la cantidad de basura continúa aumentando, la composición de la basura también ha sufrido cambios importantes y el daño de la basura se está volviendo más grave. En Kazajstán, existe un peligro para la salud debido a la degradación ambiental y el mal uso de los desechos. Para analizar los problemas y la satisfacción de la población con el sistema de gestión de residuos implementado por las autoridades locales en las ciudades, se realizó una encuesta en dos ciudades de Kazajstán: Astana y Almaty. Para este estudio, se seleccionó una muestra de 978 encuestados de cada ciudad seleccionada al azar, que incluía un número igual de encuestados. Después de la encuesta, descubrimos que los residentes de Astana están más satisfechos con el sistema de gestión de residuos para cada categoría que los residentes de


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Kazakhstan. As a result of this survey, it turned out that 46.5% of the surveyed residents do not sort the discarded garbage. Residents are concerned about the shortage of garbage collection containers and recycling containers, and residents are asking for an increase in the number of garbage collection containers. The public is well aware of the types of household waste. Most citizens are aware of the importance of the problem of plastic waste and are trying to reduce the size of such garbage, as well as trying to reduce the size of this waste, but a significant part of the residents still do nothing about it. Based on the conducted research, recommendations are given on the application of a set of measures aimed at effective waste management in the context of the transition to the principles of the "green economy" and the achievement of sustainable development goals in Kazakhstan.

Keywords: solid household waste, population, environment, recycling, green economy, waste hazard class, environmental safety, environmental policy.

Introduction

Waste management plays a key role in the transition from a linear economy to a cyclical economy. Efficient waste management can save money in the long run, and the introduction of advanced waste management solutions requires an initial financial investment.

The widespread use of synthetic plastics and their consumption create environmental problems. Agricultural waste is the richest natural source of carbon in terms of a closed-loop economy

Uncontrolled accumulation of garbage is harmful to health and can lead to diseases transmitted by rodents and insects. A lot of attention is paid to the closed-cycle economy in the European Union, where in 2020 the Action Plan for the Closed-Cycle Economy (European Union, 2020) was adopted, confirming the intention to get rid of household waste by 2030.

Waste disposal is one of the most important problems in the field of environmental management, and irrational waste management leads to various environmental problems. Integration into a waste management system is essential, so an important recycling method is needed to create a good and stable waste management system.

Effective waste management reduces the need for natural resources, increases environmental efficiency in the field of environmental protection and waste management. Waste management can be carried out using intelligent systems that ensure efficient recycling. An intelligent waste management system can solve complex waste management problems by reducing human intervention.

The economy can benefit from the formalization and improvement of these processes in integrated systems. Improving waste management systems can improve the condition of cities, the local economy, the value of real estate and the quality of life. There is no standardized way to easily calculate the size of waste, because the context of global waste management varies greatly – for example, the composition of waste, climate, economic and social consequences.

Almaty. El estudio examinó cuestiones relacionadas con la formación de desechos sólidos en Kazajstán. Como resultado de esta encuesta, resultó que el 46.5% de los residentes encuestados no clasifican la basura desechada. Los residentes están preocupados por la escasez de contenedores de recolección de basura y contenedores de reciclaje, y los residentes piden un aumento en la cantidad de contenedores de recolección de basura. El público conoce bien los tipos de residuos domésticos. La mayoría de los ciudadanos son conscientes de la importancia del problema de los desechos plásticos y están tratando de reducir el tamaño de dicha basura, así como de tratar de reducir el tamaño de estos desechos, pero una parte significativa de los residentes aún no hace nada al respecto. Sobre la base de la investigación realizada, se dan recomendaciones sobre la aplicación de un conjunto de medidas destinadas a la gestión eficaz de los residuos en el contexto de la transición a los principios de la "economía verde" y el logro de los objetivos de desarrollo sostenible en Kazajstán.

Palabras clave: residuos sólidos domésticos, población, medio ambiente, reciclaje, economía verde, clase de riesgo de residuos, seguridad ambiental, política ambiental.

To achieve this goal, the article describes the following tasks:

- 1) Consideration of waste classification issues in Kazakhstan;
- 2) Study of waste management problems in Kazakhstan;
- 3) A social survey on solid waste management was conducted;
- 4) Recommendations are given on the application of a set of measures aimed at effective waste management in the context of the transition to the principles of the "green economy" and the achievement of sustainable development goals in Kazakhstan.

Literature review

The efficiency of management in the field of municipal waste management is significantly increased by regulating the flow of household waste in the non-residential sector of the city (commercial waste) and immiscible flows of household waste in the residential sector (MacArthur, 2013; Silvestri et al., 2023).

Municipal solid waste is a heterogeneous mixture of complex morphological composition with valuable components of resources and raw materials, which are a potential source of energy. Effective municipal waste management requires scientific concepts based on municipal waste collection, disposal, recycling and recycling systems in urban areas (Zhou, 2009; Sankar et al., 2021; Saha et al., 2018). This concept is based on a more advanced waste management model and solves the problem of municipal solid waste with a special focus on the use of reserves to increase the economic efficiency of the municipal sector of the city. At all stages of waste management, waste management systems should be a combination of technical operations to separate waste into separate fractions and components, after which they are optimally processed (Zhou et al., 2015). The main direction of solving the problem of household waste is to optimize the collection system and include it in industrial processing based on resource-intensive technologies with low waste content to reduce the negative impact on the environment. In the integrated planning of solid waste recycling, the integration process takes place sequentially (and is based on sampling) with changes in the qualitative and quantitative composition of solid waste (Ferronato et al., 2017). At the same time, not only the problem of recycling many components of household waste has been largely solved, but also the problem of recycling hazardous household waste and ballast components, optimal preparation of some fractions of household waste components for further processing (Bala, 2012). Integrated municipal waste management, based on a proven approach to solving the problem of solid waste, takes into account all technological aspects of waste management in relation to each other (ecology, efficiency and resource savings) (Nurpeisova, 2022; Niyazbekova et al., 2023; Burkaltseva et al., 2022a; Petrova et al., 2022). Based on the real economic situation in the country, it is advisable to solve the problem of solid household waste in stages (Besen, 2006; Szpilko, 2023). To ensure the correct choice of technical and economic policy in the field of municipal waste management, it is necessary to objectively assess the state of the waste management problem for a certain period of time, taking into account the environmental situation in the region and the shortcomings of the existing municipal waste management system.

In general, when evaluating waste management systems, only the costs and revenues associated with the operation and maintenance of wastewater treatment plants are taken into account (Al-Salem, 2014). This may lead to a shift to alternatives such as recycling, which may be more expensive than landfilling, from a purely economic point of view (Nahman, 2011). However, if we include external costs and revenues or impacts related to environmental and social aspects, the results can change and encourage the introduction of alternatives such as recycling, which will bring huge social and environmental benefits. Recycling means reducing the consumption of raw materials, which significantly saves energy and contributes to environmental protection, as well as reducing waste sent to landfills, which increases their service life (Risch, 1978; Ellen MacArthur Foundation, 2016).

With rapid economic growth and massive urbanization, the types and volumes of municipal solid waste continue to increase, and many cities are already faced with the problem of "garbage pollution". Municipal solid waste not only seriously pollutes the soil, water and atmosphere. It also threatens people's health, affects the urban landscape and damages the city's image. The advantages and disadvantages of treatment technologies used in some developed countries are being assessed as driving innovation in new solid waste management methods and ideas (Xiumin et al., 2010). Waste that affects the entire world, including local and global political disputes, assessments of economic and moral values, and concerns about environmental pollution and crises (Boscagli, 2014). Improper waste management creates significant environmental risks, adversely affecting soil, air and water quality. These issues need to be addressed immediately to minimize

the impact of solid waste on public health and ecosystems (Moser, 2002). The linear economy of modern society cannot adequately solve some problems of sustainable development (for example, resource depletion, waste disposal, etc.). Therefore, the scientific community and politicians attach great importance to the implementation of the concepts of a closed-loop economy (Reno, 2014). Improper waste management creates significant environmental risks, having a harmful effect on the quality of soil, air and water. These problems need to be addressed immediately in order to minimize the impact of solid waste on public health and ecosystems. Suboptimal management of medical waste is a serious problem that can be effectively solved by implementing Internet of Things (IoT) solutions to improve waste monitoring and disposal processes (Fazio et al., 2012; Balakrishna, 2012).

Table 1.
Waste management and green economy concepts

Scientists	Keywords	Point of view
Liu et al., (2018)	Waste, Circular Economy, Green Economy	Achieving the Sustainable Development Goals (Liu et al., 2018) requires the collective hard work of researchers, decision makers, and the local community to implement an innovative approach that helps reduce poverty and save resources.
Brydges (2021).	Waste, Circular Economy, Green Economy	Cyclical economics and waste management play an important role in the modern world, especially in the context of sustainable development and combating climate change. A cyclical economy is a model in which resources are used as efficiently as possible and waste is minimized. The main idea is to create closed cycles of consumption and production in order to avoid inefficient use of resources and accumulation of waste.
Morseletto (2020).	Waste, Circular Economy, Green Economy	Many countries and companies are increasingly adhering to the principles of a cyclical economy, implementing various waste management programs, promoting the recycling of materials and developing environmentally friendly technologies and products. These efforts contribute to the conservation of natural resources, the reduction of greenhouse gas emissions and the creation of a more sustainable economy.
Geissdoerfer et al., (2017)	Waste, Circular Economy, Green Economy	One of the basic principles of a cyclical economy is the principle of prevention -reduction -of recycling. This means maximum prevention of waste generation, minimization of their quantity and harmful effects on the environment, as well as maximum reuse and recycling of waste.
Zhu et al., (2019)	Waste, Circular Economy, Green Economy	In a cyclical economy, waste is a resource that can be reused to produce new goods and materials. This reduces the consumption of natural resources, reduces the amount of waste thrown into landfills, and reduces the negative impact on the environment.
Song et al., (2020)	Waste management, ICT, Internet of things, smart city	In order to meet the needs of various business management tasks related to the supervision of hazardous waste, the Internet of Things technology is used in the production, transportation and disposal of hazardous waste. Applied research, development of an intelligent hazardous waste control platform based on Internet of Things technology and creation of a portal for management departments, waste production enterprises and transport.
Jino Ramson et al., (2020)	Waste management, ICT, Internet of things, smart city	The integration of the Internet of Things into the solid industrial waste industry contributes to the full control of the life cycle of solid industrial waste and the implementation of improved management, and also contributes to the transformation of low-value-added products into solid industrial waste; added value; it contributes to the increase of solid industrial waste resources.
Yang & Wang, (2021)	Waste management, ICT, Internet of things, smart city	The use of the Internet of Things in the solid industrial waste production chain mainly includes three links: recovery, recycling and disposal: (a) combining the Internet of Things and waste recycling makes recycling work reasonable and efficient; (b) combining the Internet of Things and recycling links will expand market channels for integrated solid waste disposal and will contribute to cluster development of the solid waste industry; (c) combining the Internet of Things and recycling channels will allow you to obtain expensive products, intensify management and precise control over the integrated disposal of solid industrial waste.
Theodoros (2020)	Waste management, ICT, Internet of things, smart city	The creation of an environmental monitoring network "in real time, accurately, comprehensively and in general" has become an effective tool for addressing issues of supervision of the solid industrial waste disposal industry.
Ramson et al., (2021)	Waste management, ICT, Internet of things, smart city	Air pollution is a serious problem, especially in large cities, and poses a serious threat to both health and climate. Using IoT sensors, cities and private organizations can collect huge amounts of information to identify the largest sources of pollution and warn residents when pollution exceeds acceptable levels.

Vishnu et al., (2019)	Waste management, ICT, Internet of things, smart city	The generally accepted rules for ensuring a more sustainable waste management system is the principle of a hierarchy of waste management methods, in which priority is given to waste prevention (prevention) and recycling, rather than disposal.
Akaateba & Yakubu (2013)	Waste management, waste management service, meeting the needs of the public	The link between public satisfaction and waste management is an important aspect for ensuring the quality of life and well-being of society. Effective waste management can have a direct impact on public satisfaction for several reasons: environmental protection; health; economic benefits.
Chandra-Majumder & Razaul-Karim, (2012).	Waste management, waste management service, meeting the needs of the public	Effective waste management has a direct impact on the quality of life and satisfaction of the population, therefore, the development of appropriate strategies and programs in this area is a key element in ensuring the well-being of society..
Durdyev et al., (2018)	Waste management, waste management service, meeting the needs of the public	By collecting data on complaints and opinions of residents through special portals or referral departments and conducting comprehensive sociological research, including questions about garbage collection as one of the aspects of quality of life, it is possible to more accurately determine the level of satisfaction of the population with garbage collection and identify potential problem areas for further improvement of the quality of services provided. The analysis of these data helps to determine the level of satisfaction of the population.
Khanom et al., (2015)	Waste management, waste management service, meeting the needs of the public	The confidence and responsiveness of the population have a positive and significant impact on public satisfaction. However, reliability, empathy and tangibility do not have a significant impact. As for the guarantee, the cleanliness of the sidewalks and the cleanliness of the paths are indicators that have a significant impact on this aspect.

After table 1, you can see the various thoughts of the authors who studied the concepts of waste management and the green economy. These definitions can be roughly divided into three categories: (1) Cyclical economy and green economy. The green economy emphasizes the need to reduce the negative impact of human economic activity on the environment and gives priority not to economic growth at any cost, but to sustainable development with minimal environmental risks. Proponents of this trend view the economy as a dependent component of the natural environment in which it exists and of which it is a part. (2) Waste management and the Internet of Things. Waste management and the Internet of Things (IoT) can be linked in the context of creating more efficient and innovative waste collection, recycling and disposal systems. Here are some ways that IoT can improve waste management: smart waste containers; waste monitoring and classification; optimization of recycling processes; energy management; waste lifecycle tracking. The use of IoT technologies in waste management can significantly improve the efficiency, environmental friendliness and innovation of waste collection, recycling and disposal processes. (3) Waste management and public satisfaction. Effective waste management has a direct impact on the quality of life and satisfaction of the population, therefore, the development of appropriate strategies and programs in this area is an important factor in ensuring the well-being of society. Increasing public participation is an unavoidable requirement to promote the development of a green economy.

Methodology

This study is based on the use of theoretical and empirical research methods. The authors analyzed the scientific and practical literature, and the main subject of the study (energy, cycling and waste management) The issues of waste management in Kazakhstan are considered.

To analyze the problems and satisfaction of the population with regard to the waste management system carried out by local governments in cities, a descriptive study was carried out on two cities of Kazakhstan, Astana (more than 1.5 million inhabitants) and Almaty (more than 2.5 million inhabitants), which were selected as an area of study. Random respondents were selected, which included a different number of respondents from each city. A sample of 978 respondents from each randomly selected city was selected for this study and included an equal number of respondents. To collect responses, a structured survey was compiled, the survey was conducted in a google form, and a link was sent to the respondents. Respondents answered the survey at a time convenient for them.

Public opinion polls on solid waste management were conducted. For this purpose, a special questionnaire was created with questions and suggested answers on solid waste management. The survey was conducted using questionnaires docs.google.com where 20 questions concerning the ecology of the city were individually asked. The study was conducted for 2 months (from August to October 2023). 980 residents of Astana over the age of 18 from 4 districts of the city were randomly interviewed: Yesilsky, Saryarka,

Almaty, Baikonur. As a result of the survey, we received feedback on waste management, as well as information from the public about waste management and recycling.

Currently, Kazakhstan is fulfilling 17 Sustainable Development Goals proposed by the United Nations in 2015, as the results of the activities of departments and strategic plans for industrial development correspond to the main goals of sustainable development. The article presents six of the 17 Sustainable Development Goals (7, 9, 11, 12, 13 17) In the case of the "green economy", it has been established that it is directly or indirectly related to the issues of effective waste management in Kazakhstan.

Results and discussion

The problem of waste management in Kazakhstan

Based on information from the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan (EGOV, 2023), last year in 2023, about 4.1 million tons of municipal waste were generated in the country, of which 1 million tons were buried in landfills. Last year, space monitoring revealed 5,533 unauthorized landfills in only 39 large settlements, which indicates that the actual volume of waste far exceeds the volume taken into account. The morphological composition of municipal waste is about 70% of useful fractions, namely 16% plastic, 11% waste paper, 9% glass, 37% organic waste, 27% others.

In 2023, thanks to observations from space, more than 5.5 thousand illegal landfills were discovered in Kazakhstan. Of the 3,016 landfills, only 624 (or 21 percent) met environmental and sanitary standards. According to official data, the most problematic regions, where the least number of landfills that meet the standards were found, were the Pavlodar, North Kazakhstan and Abai regions. At the same time, the Ministry of Ecology claims that landfills in Astana, Shymkent, Turkestan and Zhambyl regions are recognized as fully compliant with environmental indicators.

In Kazakhstan, only a limited amount of waste is recycled: mainly plastic, paper and glass. Not all items in these categories are reusable. For example, recycling usually requires only transparent glass, and plastic should not contain impurities, since its purification requires significant resources. Not all waste paper is recyclable. Textiles, medical waste, batteries, as well as other hazardous waste, as a rule, remain unused.

Disposal of hazardous and medical waste is not fully controlled by the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan. Budgetary funds for the processing and disposal of hazardous and medical waste are being used to a greater extent, but the technologies used in their processing do not comply with current standards and regulations.

Therefore, in modern conditions, environmental protection from waste pollution or the development of cost-effective solutions have become an urgent necessity.

The removal, storage and processing of solid household waste (SHW) is a specific and socially important area of municipal services. The sphere of solid waste circulation is an example of a public good, which has all the signs of public goods: indivisibility, lack of competition in consumption and non-appropriateness. The environmental safety of citizens directly depends on the results of the organization of the treatment of solid waste. Therefore, this area is under the jurisdiction of the state. Solid waste management includes issues such as strategic planning, public participation, and financial management. The many stakeholders involved in the collection and recycling of municipal solid waste must develop and establish reliable programs that take into account political, institutional, social and technical aspects (Nurpeisova et al., 2020), (Thakker & Narayanamoorthy, 2015), (Niyazbekova et al., 2022).

The waste management process includes several interrelated stages (Figure 1).



Figure 1. Waste management process.

Waste collection is carried out by homeowners, housing and communal services management companies, HOA, private enterprises. Transportation of solid waste is the removal of garbage from waste collection sites to the sorting station. Sorting of solid waste is carried out at waste sorting stations. Solid waste is processed at waste processing plants. Waste disposal takes place at the landfill.

As a result of daily human activity, a large amount of solid household waste (SHW) is generated. To maintain a normal ecological situation in the city, it is necessary to take out household garbage in time. Garbage collection that remains after production takes place in storage containers specially designed for this purpose. The main way to dispose of industrial waste is their removal to special landfills. In addition, a small part of industrial waste is burned in high-temperature furnaces (Yessymkhanova et al., 2021; Rudyk et al., 2022; Niyazbekova & Nazarenko, 2018; Niyazbekova et al., 2019).

In Kazakhstan, only a quarter of solid household waste is sorted and processed. A lot of waste is generated every day, which must be disposed of in various ways. The Ministry of Ecology and Natural Resources of the Republic of Kazakhstan regularly collects statistical data on the amount of each type of waste. In Kazakhstan, waste is classified as industrial, municipal and agricultural (Figure 2) and is divided into classes according to the degree of harmful effects on the environment (Table 2).

Table 2.

Distribution of waste hazard by class according to the degree of harmful impact on the environment

Waste hazard class	Indicator of the degree of danger, K^*	The nature of ecosystem destruction
Class A – non-hazardous waste	$K \leq 10^4$	The ecosystem is not disturbed
Class B – epidemiologically hazardous waste	$10 \leq K \leq 10^2$	Moderately disturbed
Class B – extremely epidemiologically hazardous waste	$10^2 \leq K \leq 10^3$	Moderately disturbed
class D – toxicologically hazardous waste	$10^3 \leq K \leq 10^4$	Severely disrupted
class D – radioactive waste	$10^4 < K \leq 10^6$	Irreversibly broken
$K_i = \frac{C_i}{P_i}$, K_i – hazard rating of the component; C_i – concentration of a single component; P_i – hazard factor of a single component; $K_i = K_1 + K_2 + \dots + K_n$.		

Source: Created by the authors based on public data

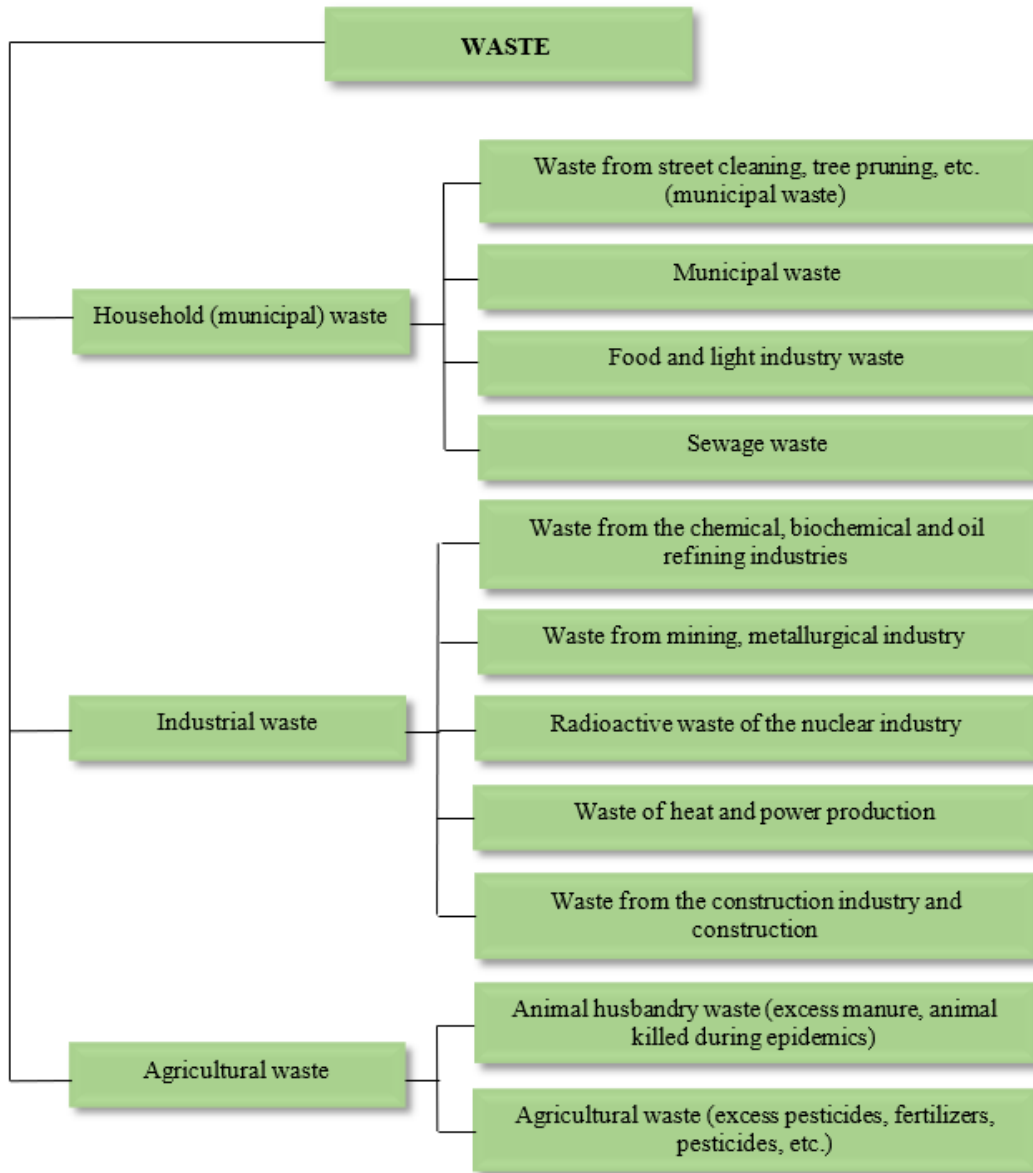


Figure 2. Classification of waste by origin.
 Source: Created by the authors based on public data.

In total, there are 3,292 (unofficial even more) landfills of solid household waste in Kazakhstan, of which the number of landfills that meet the standards is 601 (18.26%). This is a very big environmental problem for Kazakhstan (Table 3).

Table 3.
 Number of solid waste landfills in Kazakhstan in 2022

Rating	Region	Region Number of solid waste landfills, units	Number of landfills that meet the standards, units	Share of landfills that meet the standards, %
	Total for the Republic of Kazakhstan	3292	601	18,26
1	Astana	1	1	100
2	Shymkent	1	1	100
3	Zhambyl region	159	159	100
4	Turkestan region	163	150	92,02
5	Kostanay region	266	111	41,73
6	Mangistau region	24	8	33,33
7	Atyrau region	82	9	10,98

8	Akmola region	130	26	20,00
9	Karaganda region	202	40	19,80
10	East Kazakhstan region	430	26	6,05
11	North Kazakhstan region	458	17	3,71
12	Aktobe region	323	12	3,72
13	Western Kazakhstan region	208	2	0,96
14	Kyzylorda region	145	4	2,76
15	Almaty region	313	13	4,15
16	Pavlodar region	336	5	1,49
17	Almaty	0	exported to Almaty region	

Based on information from the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan (EGOV, 2023).

Source: Created by the authors based on public data.

Waste in Kazakhstan is a serious problem defined by uncoordinated development. Solid waste management is aimed at recycling, but the problem of organizing the modern organization of landfills is largely not solved properly. Waste recycling enterprises do not get the expected results in waste distribution.

The circular economy emphasizes resource intensification and reuse, including increasing resource and energy efficiency, recycling materials, etc. The active development of a circular economy promotes the intensive use of resource-saving technologies and the creation of an industrial system for resource utilization. This is of great importance in ensuring the safety of national resources, promoting the achievement of carbon peaking and carbon neutrality, and helping to build an ecological civilization.

In the process of creating an industrial resource recycling system, waste recycling is an important part of it. The recycling market has been developing in Kazakhstan for decades, but it is still at a relatively early stage of development, and it is urgently necessary to increase the level of use of industry resources. The Closed-loop Economy offers a solution for the transition from the traditional linear economy: to take full advantage of the recycling of resources in order to gradually separate economic activity from the consumption of limited resources.

The population needs to treat the environment, society with a certain responsibility to future generations (Kaushal, Varghese, & Chabukdhara, 2012). The negative consequences of poor-quality waste treatment affect future generations (Zikri, 2012).

Analysis of problems and satisfaction of the population regarding the waste management system

To analyze the problems and satisfaction of the population with regard to the waste management system carried out by local governments in cities, a descriptive study was carried out on two cities of Kazakhstan, Astana (more than 1.5 million inhabitants) and Almaty (more than 2.5 million inhabitants), which were selected as an area of study. Random respondents were selected, which included a different number of respondents from each city. A sample of 978 respondents from each randomly selected city was selected for this study and included an equal number of respondents. To collect responses, a structured survey was compiled, the survey was conducted in a google form, and a link was sent to the respondents. Respondents answered the survey at a time convenient for them.

Almost half of the respondents were men, with an average age of 36. The respondents participating in the selection have higher education (69.2%, Astana), (67.5%, Almaty). The remaining 8.6% (Astana), 1.0% (Almaty) have graduated from secondary school, and the remaining 22.2% (Astana), 31.5% (Almaty) have incomplete higher education (Table 4).

Table 4.
Characteristics of the respondents

Parameters		Astana		Almaty	
		Repeatability	Percentage (%)	Repeatability	Percentage (%)
Gender	Male	561	57.3	478	48.9
	Female	417	42.7	500	51.1
Age	from 20 to 30 years old	312	31.9	282	28.8
	from 31 to 40 years old	339	34.6	292	29.8
	from 41 to 50 years old	269	27.5	301	31.0
	from 51 to 60 years old	58	6.0	103	10.4
The level of education	Middle school	84	8.6	10	1.0
	Incomplete higher education	217	22.2	308	31.5
	Higher education	677	69.2	660	67.5

In the course of the study, we tried to determine the difference in public satisfaction with the waste management system between the cities of Astana and Almaty. Respondents were asked to rate their satisfaction with the waste management system on a 5-step Likert scale from 1 (very satisfied) to 5 (not very satisfied). Satisfaction with the waste management system developed in this study is measured by nine aspects: the frequency of waste collection, the distance of the landfill from the city, waste management, cleanliness of the territory/yard, waste collection fees, used vehicle and equipment, seminars/discussions/information on cleanliness, staff behavior, response to a complaint.

Results

Maintaining cleanliness in the city in order to create an effective waste management system is the task not only of local authorities, but also of the local population. In this study, residents' satisfaction with the role of local authorities in Waste Management was assessed, the main cities of Astana and Almaty were selected to determine residents' satisfaction with urban cleanliness and determine the best city among them.

To assess the effectiveness of the services provided, a survey was conducted using a structured questionnaire using various parameters such as the frequency of waste collection, the remoteness of the landfill, the cleanliness of the territory/yard, the fee for waste collection, the vehicle and equipment used, seminars held, discussions/ cleanliness of information, staff behavior, response to a complaint.

(a) *Frequency analysis*

Table 5.
Frequency analysis of Astana and Almaty respondents

Parameters	Astana					Almaty				
	V.D	D	N	S	V.S	V.D	D	N	S	V.S
Waste collection frequency	30(3)	293(30)	0 (0)	538(55)	117(12)	127(13)	313(32)	0 (0)	333(34)	205(21)
The distance of the polygon	235(24)	274(28)	29(3)	391(40)	49(5)	205(21)	479(49)	49(5)	225(23)	20(2)
Waste management	49(5)	293(30)	39(4)	548(56)	49(5)	98(10)	596(61)	68(7)	195(20)	21(2)
Cleanliness of the territory / yard	49(5)	343(35)	0(0)	518(53)	68(7)	136(14)	489(50)	0(0)	294(30)	59(6)
Waste collection fee	147(15)	195(20)	39(4)	548(56)	49(5)	98(10)	596(61)	68(7)	195(20)	21(2)
The vehicle and equipment used	49(5)	323(33)	39(4)	518(53)	49(5)	117(12)	440(45)	68(7)	294(30)	59(6)
Seminars / discussions/ information on cleanliness	49(5)	127(13)	626(64)	147(15)	29(3)	20(2)	147(15)	557(57)	195(20)	59(6)
Staff behavior	49(5)	343(35)	98(10)	421(43)	68(7)	68(7)	489(50)	68(7)	294(30)	59(6)
Response to the complaint	49(5)	342(35)	49(5)	489(50)	49(5)	68(7)	489(50)	0(0)	353(36)	68(7)

Note: V.D.-Very Discontent, D.- Discontent, N.-Neutral, S.- Satisfied, V.S.-Very Satisfied

Table 5 presents an analysis of the entire questionnaire in the form of a comparison of responses received from both cities. It was found that 30% of respondents from Astana and 32% of respondents from Almaty were dissatisfied, and 55% of respondents from Astana and 34% of respondents from Almaty were satisfied with the frequency of waste collection. In this category, none of the respondents remained neutral.

28% of respondents from Astana were dissatisfied with the nearby landfill set up by city local governments to collect secondary waste, while 49% of respondents from Almaty were dissatisfied for the same reason. 30% of respondents from Astana and 61% of respondents from Almaty are dissatisfied with the way the city government handles waste; very few residents of Astana (4%) and Almaty (7%) remained neutral in this section.

33% of respondents from Astana and 45% of respondents from Almaty were dissatisfied with the vehicle and equipment used for waste collection, while 53% of respondents from Astana and 30% of respondents from Almaty were satisfied for the same reason. Very few residents of Astana (4%) and Almaty (7%) remained neutral in this section.

53% of respondents from Astana and 30% of respondents from Almaty are satisfied with the cleanliness in their locality imposed by the municipality, while 35% of Astana residents and 50% of Almaty residents were dissatisfied with this. 43% of respondents from Astana and 30% of respondents from Almaty are satisfied with the accuracy of the brigade and the behavior of a member of the brigade arriving to clean up garbage. While 35% of respondents from Astana and 50% of respondents from Almaty were dissatisfied with this. Respondents from Astana (10%) and Almaty (7%) were behaviorally neutral.

Only 50% of Astana respondents and 36% of Almaty residents were satisfied with the way their complaints were answered, while 35% of Astana residents and 50% of Almaty residents felt that their complaints were not properly responded to, so they were unhappy.

Accordingly, 20% and 61% of respondents from Astana and Almaty were dissatisfied with the fee charged to users for waste removal. 56% of respondents from Astana were satisfied, 20% of respondents from Almaty were satisfied with the amount collected from them. The majority of respondents, namely 64% from Astana and 57% from Almaty, remained neutral towards the seminar on cleanliness. The respondents were dissatisfied with the monitoring and verification of sanitary conditions.

b) independent samples t-test.

To assess the level of population satisfaction with the waste management system in the cities of Astana and Almaty, we used the t-testing method for an independent sample. As can be seen from Table 6, Astana residents are more satisfied with each category of waste management system than Almaty residents. In addition, the differences between the two groups (Astana and Almaty) are statistically significant on some issues related to population satisfaction with the waste management system.

Table 6.
t-criterion for independent samples

The degree of public satisfaction with the waste management system		Astana	Almaty	t-value
Waste collection frequency	The average value	3.21	2.94	0.0013
	Standard deviation	0.83	0.69	
The distance of the polygon	The average value	2.58	3.13	-2.039***
	Standard deviation	0.71	0.68	
Waste management	The average value	3.78	2.34	-3.524***
	Standard deviation	0.88	0.63	
Cleanliness of the territory / yard	The average value	3.50	3.24	0.0623*
	Standard deviation	0.59	0.57	
Waste collection fee	The average value	4.67	3.66	-6.287***
	Standard deviation	0.69	0.68	
The vehicle and equipment used	The average value	1.52	1.58	0.0001
	Standard deviation	0.67	0.64	
Seminars / discussions / information on cleanliness	The average value	3.58	3.31	0.0000
	Standard deviation	0.69	0.61	
Staff behavior	The average value	3.43	3.40	0.0023
	Standard deviation	0.69	0.64	
Response to the complaint	The average value	3.19	2.84	-2.449***
	Standard deviation	0.62	0.64	

*: p<0.05, **: p<0.01, ***: p<0.001

In Astana and Almaty, private organizations are engaged in the removal of solid and household waste, construction, industrial waste and bulky garbage. Comprehensive work on the collection and transportation

of solid waste is carried out in accordance with the terms of the contract concluded with the Department of Natural Resources and Environmental Management for five years. In Astana and Almaty, the frequency of waste collection is the same 1 time per day. Every day until 8.00 all waste from garbage containers is taken out by private organizations to the landfill of solid household waste. On weekends and holidays, waste is not taken to the landfill. Only the landfills of Astana meet all the requirements. A complex for sorting and processing of solid household items is operating in Astana. But the capacity of the waste sorting and recycling complex is very small. Despite the fact that the landfills of Almaty are located further from the city, the landfill covers an area of several kilometers, while the area of the landfill increases every year. There is no complex for sorting and processing of solid household substances in Almaty.

To identify and compare the average differences between different survey points in Astana and Almaty, a paired sample t-test was conducted for 9 points of the questionnaire. It is clear from the above table that for some parameters there are no significant average differences in people's opinions regarding waste management and collection in Astana and Almaty. A significant average difference is observed in several cases, namely: the nearest waste disposal sites (value $t = -2.039$), which shows that residents of Almaty were more satisfied with the proximity of waste disposal sites, residents of Almaty were more satisfied with the payment of waste collection compared to residents of Astana (value $t = -6.287$). Residents of Astana and Almaty were pleased with the frequency of waste collection, vehicles and equipment used for garbage collection and street sweeping, the behavior and accuracy of employees in the performance of their duties.

c) *Social surveys on solid waste management*

In our study, an empirical study was conducted, during which a survey of the population on solid waste management was conducted. For this purpose, a special questionnaire was developed with questions on the topic of solid waste management and the proposed answer options.

The survey of residents was conducted using questionnaires (using forms docs.google.com), where 20 questions were asked about the ecology of the city in an individual form. The survey was conducted for 2 months (from August to October 2023). 980 Astana residents randomly over the age of 18 from 4 districts of the city were interviewed: Yesilsky, Saryarkinsky, Almaty, Baikonur.

As a result of the survey, it is possible to get an idea of opinions on waste management issues, as well as about the knowledge of the population about waste disposal and recycling.

Surveys included the creation of enterprises in this area (for example, incinerators, landfills), as well as feedback on the preparation for recycling, the volume of waste collected and the service life of each material.

Among all respondents, women accounted for 50.5%, men – 49.5%, respectively. It can be said that both men and women are interested in environmental issues. In general, the answer to the most important question about whether people are engaged in separate collection: 24.7% answered «yes», 28.8% partially answered separate collection (paper, bottles) and only 46.5% answered «no».

931 respondents voted for "recycling" as the safest and most environmentally friendly way (see Figure 3).

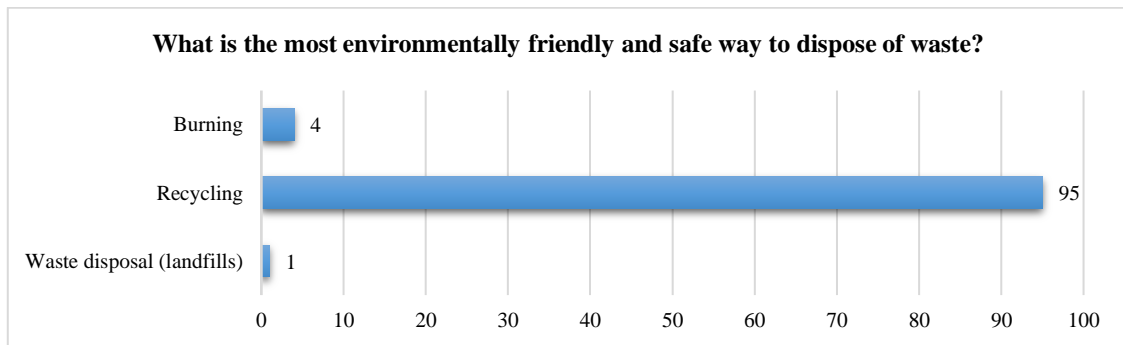


Figure 3. Respondents' answers to the question about a more environmentally friendly and safe way of waste disposal.

Source: Created by the authors based on public data.

As for the most dangerous and non-ecological method of waste disposal, the respondents were almost equally divided between disposal and incineration of waste (Figure 4).

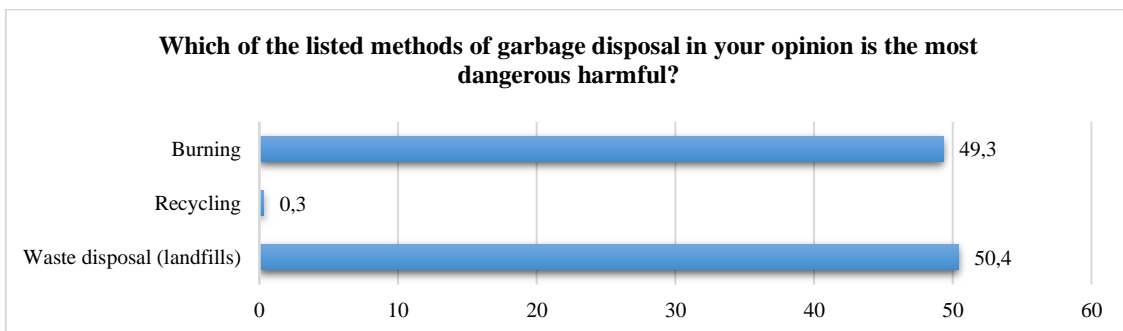


Figure 4. Survey on the most dangerous and harmful method of garbage disposal.

Source: Created by the authors based on public data.

It can be said that residents were not informed that incineration can be an environmentally friendly and even very effective method for the economy if sorted waste is burned and environmentally friendly technologies are applied. CO₂ emissions can be low. In developed countries, fuel is used as an energy supply for all cities and electricity generation (Burkaltseva et al., 2022b; Igaliyeva et al., 2020; Nurzhanova et al., 2020; Barykin et al., 2022)

The question of whether people do waste at work was included in the survey, since many people often spend them outside the home, where they may have established some kind of waste distribution order at work. Only 8.50 % of respondents always sort (Figure 5).

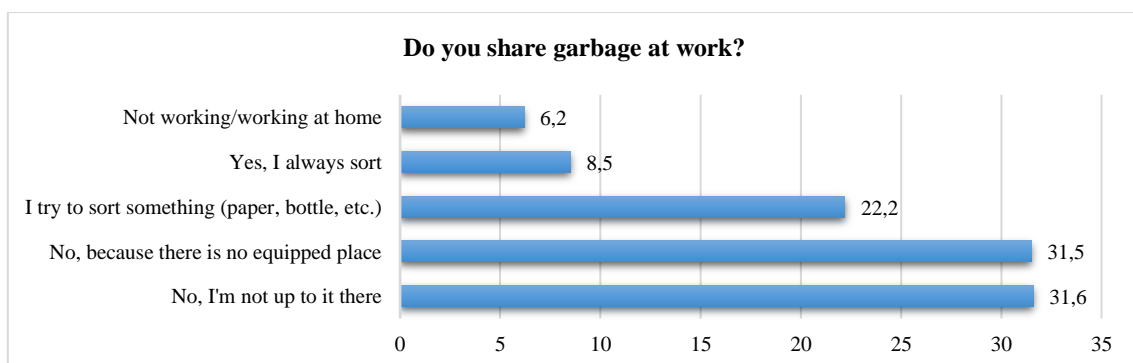


Figure 5. Survey on the distribution of garbage at work.

Source: Created by the authors based on public data.

Additionally, 16 questions were asked to Astana residents. The survey included information about the services provided by the population in the city, the informal sector, informing the population, and waste treatment behavior (Table 7).

Table 7.
Questions compiled by the authors and presented to the residents of Astana

Point of view	№	Questions (Q)	Possible answers to the question (Ai)
Opinions	Q1	What kind of material do you think is separated from solid household waste?	Waste for disposal in a landfill; Materials for recycling; Waste for incineration; I do not know.
	Q2	Would you agree to build another landfill in your city?	Yes; No, I am categorically against it; Yes, this is the best option for my city; I do not know.
	Q3	Would you agree to the construction of an incinerator in your city?	Yes; No; Yes, this is the best option for my city; I do not know.
	Q4	What do you think are the most littered places in our city?	Streets; Courtyards; Recreation area; I do not know.
	Q5	What, in your opinion, is the main reason for the littering of our city?	Insufficient number of bins and garbage containers; Lack of a clear system for collecting and disposing of garbage; Low level of culture of the residents of our city; I do not know.
Knowledge	Q6	What is hazardous waste?	Medicinal substances; Batteries; Chemicals; I do not know
	Q7	Approximately how much food waste is generated in your family per day?	200 g; 2 kg; 20 kg; I do not know
	Q8	What measures can be taken to reduce the amount of waste?	Can use reusable containers and bottles; Switch to digital document formats; Send materials not to landfill, but for recycling; I do not know.
	Q9	What are the benefits of recycling for the environment?	Reducing the volume of untreated waste in landfills; Reducing greenhouse gas emissions; Creating new jobs and saving resources; I do not know.
	Q10	What consequences can there be if you do not follow the rules of waste management?	Nothing will happen; Fines and administrative penalties will be imposed; It may lead to environmental pollution; I do not know.
	Q11	What is hazardous household waste?	Glass; Toxic substances and Medical waste; Industrial and industrial waste; I do not know
Services	Q12	What innovative technologies are used for waste recycling?	Biotechnologies that allow the conversion of organic waste into biogas and compost; Chemical method; Hydrolysis; I do not know
Informal sector	Q13	Do informal collectors collect usable waste?	Never; Sometimes; Often; I do not know
Services	Q14	Is the time of gathering citizens satisfactory?	Never; Sometimes; Yes; I do not know
Informing the public	Q15	Do local governments conduct campaigns to inform the public about recycling?	Never; Sometimes; Often; I do not know
Recycling behavior	Q16	The number of sorting containers near the house with an indication of the marking and drawing.	Not enough; More than two; Enough; I do not know

When asked what material is released from solid household waste, the respondents answered as follows: waste for landfill disposal -32.6%; materials for recycling -41.2%; waste for incineration -18%; waste for incineration -8.2%. When asked if you agree to build another landfill in your city, 38.8% of respondents replied that no, I am categorically against it; 39.6% replied that they did not know. When asked what, in your opinion, are the most garbage places in the city, the majority of respondents replied that these are yards. Indeed, the courtyards of the capital's residential complexes are buried in garbage. Untimely waste removal is becoming one of the main problems of Astana. local authorities admit that the monopolist service company simply cannot cope with the rapidly growing city, and tariffs for the removal of household waste are too low.

As for knowledge, the public is well aware of the types of household waste. To the question whether the official frequency of waste collection (per week), the time of collection of citizens, the residents answered satisfactorily (Q14). It can be concluded that the informal sector is poorly known and not recognized by citizens, and public campaigns are known, but not fully respected and not used (Q13, Q15). Residents pointed out a small number of sorting containers near the house with a note and a picture (Q16).

Table 8.

The results of the survey of the population of Astana. Higher percentages are in bold, while lower percentages are in italics

Questions	A1 (%)	A2 (%)	A3 (%)	I do not know (%)
Q1	32.6	41.2	18	8.2
Q2	8.8	38.8	12.8	39.6
Q3	8.9	68.7	10.7	11.7
Q4	17.8	54.2	15.5	12.5
Q5	16.7	25.2	56.7	1.4
Q6	25.7	14.5	58.1	1.7
Q7	24.4	60.7	3.5	11.4
Q8	12.4	14.8	71.4	1.4
Q9	25.4	50.3	18.7	5.6
Q10	15.7	27.1	51.7	5.5
Q11	5.1	50.1	40.4	4.4
Q12	80.1	4.0	4.2	11.7
Q13	71.2	8.5	7.5	12.8
Q14	2.9	20.7	75.4	1.0
Q15	80.1	4.0	1.4	14.5
Q16	80.2	4.2	1.5	14.1

The results of the survey of residents of the capital are presented in Table 8 and in Figure 6, Figure 7.

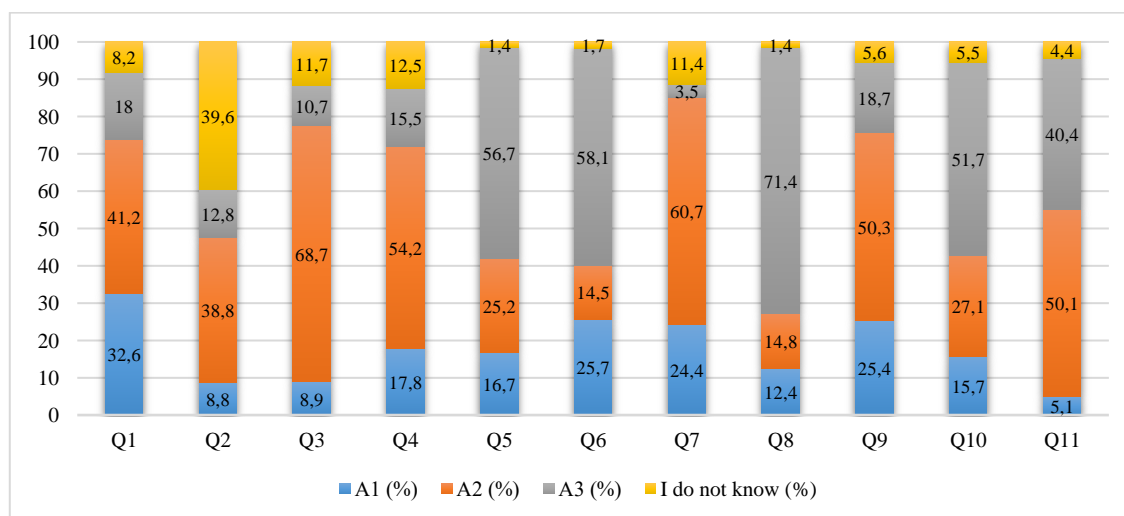


Figure 6. Q1–Q11 results expressed in % (Q: Question; A: Answer).

Source: Created by the authors based on public data.

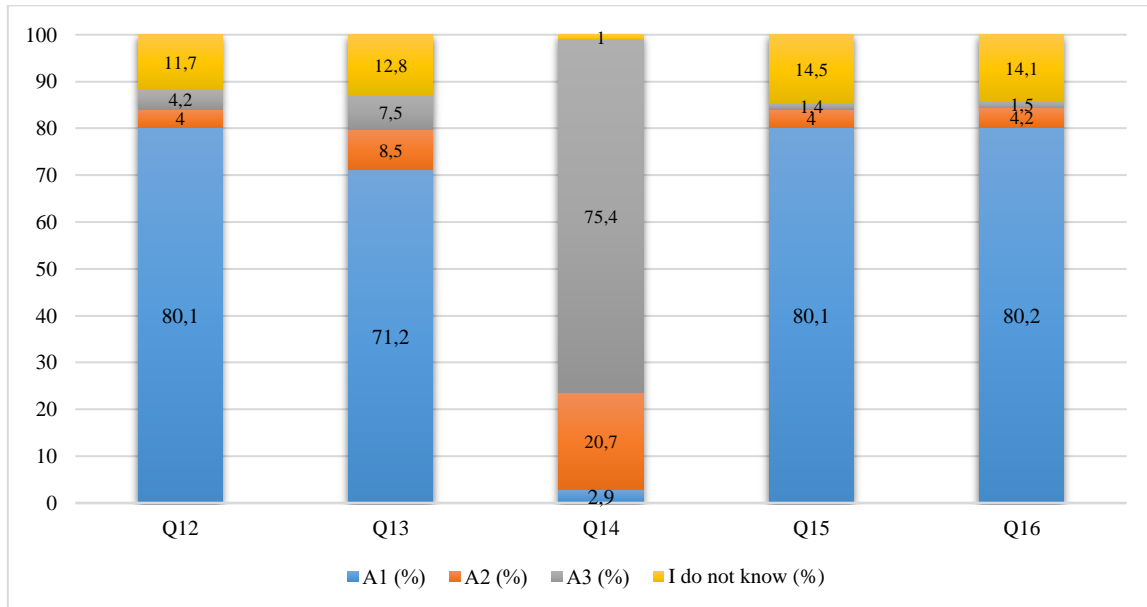


Figure 7. Results Q12–Q16, expressed in % (Q: Question; A: Answer).

Source: Created by the authors based on public data.

As a result of this survey, it turned out that 46.5% of the surveyed residents do not sort the discarded garbage. We can say that the problem of garbage in Astana worries many people. In addition, a small part collects household waste separately, but at the same time many people want this, but face problems because they do not know where the individual garbage collection points are located. Residents are concerned about the shortage of garbage collection containers and recycling containers, and residents are asking for an increase in the number of garbage collection containers. The public is well aware of the types of household waste. However, it is necessary to continue to inform the population and indicate the addresses of the collection points of these wastes. A survey of residents of the capital, conducted based on the results of a survey developed by the authors, showed that most citizens realize the importance of the problem of plastic waste and try to reduce the size of such garbage, and try to reduce the size of this waste, but a significant part of residents still do nothing about it. From the results of an empirical study, information was obtained to clarify the problems of handling solid household waste of the population and to determine recommendations for their solution.

Many studies have been conducted in Kazakhstan that directly or indirectly contribute to solving problems related to the need for proper waste management associated with Kazakhstan's gradual transition to a low-carbon economy in order to achieve Sustainable Development Goals.

In Kazakhstan, in the context of a "green economy", work is underway on effective waste recycling to ensure the sustainable development of the country's economy. Currently, Kazakhstan implements 17 Sustainable Development Goals proposed by the United Nations in 2015, as the results of departments and strategic industrial development plans correspond to the main goals of the SDGs.

Table 9 shows that of the 17 SDGs, six (7, 9, 11, 12, 13 and 17) are directly or indirectly related to the issues of effective waste management in Kazakhstan in a "green economy".

In this regard, we have given below a number of suggestions for solving some of the problems of the research goal (Table 5).

Table 9.
Mechanisms for the implementation and achievement of Sustainable Development Goals

No	Description of the SDGs	Mechanisms for the implementation and achievement of the SDGs	Expected effect
SDGs 7	Not expensive and clean energy	Energy efficiency is increasing, and the electric power sector is making great strides in the field of renewable energy sources.	Economic effect, Social effect
SDGs 9	Building sustainable infrastructure, promoting industrialization and innovation	Innovation and technological progress increase resource efficiency and energy efficiency, search for long-term solutions to economic and environmental problems	Economic effect, Social effect
SDGs 11	Ensuring openness, security, resilience and environmental sustainability of cities and settlements	Rapid urbanization will lead to population growth and worsening air pollution.	Environmental effect
SDGs 12	Responsible consumption and production	Ensuring the transition to rational patterns of consumption and production, which continues to have a devastating impact on the planet.	Economic effect, Social effect, Environmental effect
SDGs 13	Fighting climate change	Climate change has not stopped. The global economy is expected to recover after the pandemic, and emissions will return to higher levels.	Economic effect, Social effect, Environmental effect
SDGs 17	Partnership for Sustainable Development	The successful implementation of sustainable development is impossible without inclusive partnerships at the global, regional and local levels based on principles and values aimed at satisfying human interests.	Economic effect, Social effect, Environmental effect

The data in Table 9 show that if Kazakhstan gradually transitions to low-carbon neutrality in the context of achieving the Sustainable Development Goals, the proposed mechanisms may contribute to solving some problems related to waste management, and the material mechanism proposed as part of the gradual transition to low-carbon neutrality in the context of achieving the Sustainable Development Goals may contribute to solving some problems related to with waste recycling.

The identified (existing) problems of waste management in our country need to be solved in a three-way (three-level) direction: the state, companies and the population.

The identified (existing) problems of waste management in our country need to be solved in a three-way (three-level) direction: the state, companies and the population.

So, based on the above conclusions, we have proposed some recommendations for improving waste management in Kazakhstan (Figure 8).

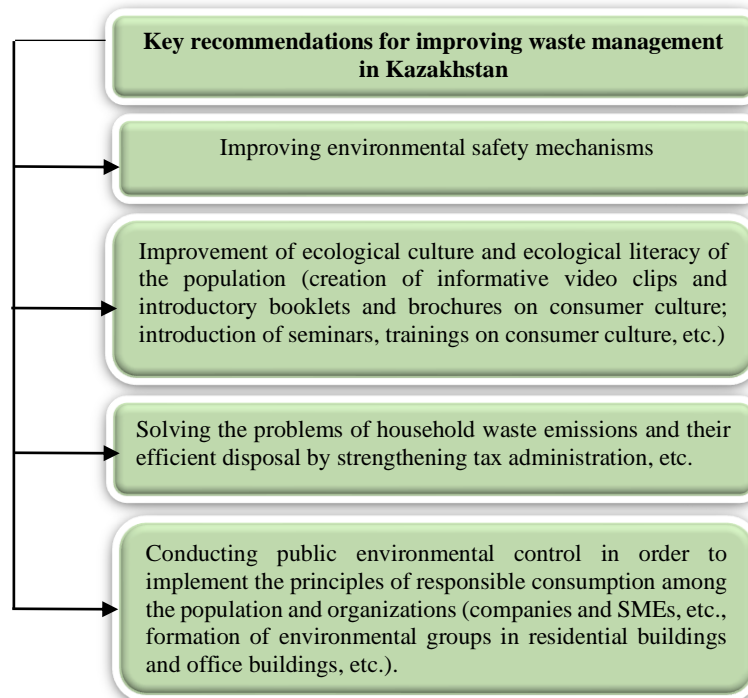


Figure 8. Main recommendations for improving waste management in Kazakhstan.

Garbage collection and sorting can be improved with simple technologies that minimize the total waste incinerated or disposed of. This allows the waste to be used for other purposes, such as the production of fertilizers and biogas. Carbon emissions from waste can be completely eliminated, but an integrated waste management model based on the principles of a sustainable closed-loop economy is needed. The complete elimination of the impact of waste on the environment and health requires a radical transition from existing linear consumption models to a recycling model (Fan et al., 2021; Berenguer et al., 2023; Mukhit & Syafrudin, 2018).

The use of modern technologies, in particular the Internet of Things, machine learning, mobile peripheral computing, blockchain technology and LoRaWAN, has played an important role in the revolutionary transformation of waste management in smart cities. These technologies provide an integrated approach to waste management, allowing the use of innovative strategies such as real-time monitoring, route optimization, automatic sorting and classification, as well as effective forecasting of waste generation trends. Revenues from composting, water treatment and waste have increased the well-being of greenhouse producers to a greater extent than other participants in the supply chain (Hassan et al., 2016; Navghane et al., 2016; Gutierrez et al., 2015; Bartl, 2011).

In order to meet the growing needs of people for a better life, it is necessary to comprehensively modernize existing landfills, integrate landfill resources in one city and develop new technologies through research and development of new technologies, new equipment, learn from foreign advanced technologies and management experience and use the potential of existing garbage stations; at the same time, actively promote environmental education in universities, secondary schools, strengthen the promotion of garbage classification in the community and other methods of social participation to effectively solve the problems of urban garbage removal.

Conclusion

The purpose of the study is to study issues related to the formation of solid household waste in Kazakhstan.

In Kazakhstan, solid waste management is aimed at recycling, but the problem of organizing modern landfills in most cases is poorly solved. Waste recycling companies are not able to achieve the expected results in waste distribution. The relations between the state, local authorities and the population were established correctly, the mechanisms of interaction between them were not implemented. In our study,

empirical research was conducted on a survey of the population on solid waste management. To analyze the problems and satisfaction of the population with the waste management system implemented by local authorities in cities, a survey was conducted in two cities of Kazakhstan - Astana and Almaty. For this study, a sample of 978 respondents from each randomly selected city was selected, which included an equal number of respondents. To assess the level of public satisfaction with the waste management system in the cities of Astana and Almaty, we used the t-testing method for an independent sample. After the survey, we found that residents of Astana are more satisfied with the waste management system of each category than residents of Almaty.

For this purpose, a special survey was prepared with questions about working with solid waste and the proposed answers. After analyzing the respondents' responses to the survey, it became clear which points should be paid more attention to when conducting marketing campaigns. It is important to ensure the smooth and efficient operation of the waste incineration and recycling plant. Based on the analysis, it is proposed to create several public communication channels to inform the public about the problem of separate collection of plastic waste and to study the importance of such events:

It is proposed to create many public communication channels through which it is possible to raise awareness of residents about the problem of plastic waste and explain the importance of such events:

- improvement of environmental culture and environmental literacy of the population (creation of informative videos and introductory booklets and brochures on consumer culture; seminars, trainings on consumer culture, etc.);
- conducting public environmental control in order to introduce the principles of responsible consumption among the population and organizations (companies and SMEs, etc.) (formation of environmental groups in residential buildings and office buildings, etc.);
- creation of children's games on environmental culture and instilling in children the principles of responsible consumption;
- solving the problems of household waste emissions and their effective disposal by strengthening tax administration, etc.
- creating an environmental passport for organizations.

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