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CIRCULAR ECONOMY IN THE FOOD INDUSTRY OF THE ABAI REGION

The article is dedicated to the study of food waste recycling issues in the Abai region of the Republic of Kazakhstan within the context of circular economy principles. It presents quantitative changes in food waste within the overall structure of municipal waste in the region, highlighting its significant share in total municipal waste and its annual growth. The study reveals that food waste in the region is not directed to recycling despite its substantial volumes and growth rates, or it is mixed with other types of municipal waste without sorting or accounting, being classified as mixed waste. This leads to adverse economic and environmental consequences and distorts the real picture of waste management.

At the same time, it was determined that certain types of waste in the region, such as plastics, paper and cardboard, and metals, are suitable for recycling. The necessity and relevance of effective food waste management and its transformation into organic fertilizers for the agricultural sector are substantiated.

The study emphasizes that the development of a circular economy requires a comprehensive approach, including regulatory, institutional, infrastructural, economic, and technological components. Key conditions for the development of a circular model include the creation of infrastructure and modern methods for food waste recycling, promotion of scientific research and startups in the circular economy, and raising environmental awareness in society.

The research employs observation, measurement, and comparison methods, as well as logical induction and deduction, analysis and synthesis, and statistical-empirical approaches. The analysis is based on Bureau of National Statistic's dates and official public sources.

Keywords: circular economy, closed-loop economics, food industry, food waste, municipal waste, environment, food waste recycling, waste landfill.

Кілт сөздер: тұйық циклді экономика, айналмалы экономика, азық-түлік өнеркәсібі, азық-түлік қалдықтары, тұрмыстық қалдықтар, қоршаған ортақ, тағамдық қалдықтарды қайта өндеу, қалдықтар полигоны.

Ключевые слова: циркулярная экономика, экономика замкнутого цикла, пищевая промышленность, пищевые отходы, коммунальные отходы, окружающая среда, переработка пищевых отходов, полигон отходов.

JEL Classification: Q53.

Introduction. Circular economy and its development is becoming one of the key directions for sustainable growth at both global and regional levels. Contemporary societal challenges such as depletion of natural resources, increasing waste generation, and rising production and consumption costs require a transition from a linear economic model to a closed-loop system, which helps reduce environmental pressure and enhance production and consumption efficiency.

These countries transformations are strategically ways for sustainable development, particularly for food industry, and plays the main role in well-being of society.

In this context, implementing circular economy principles in the food industry of the Abai region is of particular importance, as it directly affects region's food security and socio-economic position. At the same time the close attention should be paid on the enterprises in agro sector.

However, the operations of these strategically important sectors in the region are accompanied by the generation of large volumes of organic waste during production, processing, and consumption stages, underutilization of by-products, and high energy consumption. Therefore, the purpose of this study is to examine the opportunities and mechanisms for implementing circular economy practices in the food

industry of the Abai region, contributing to further economic diversification, efficient resource use, and reduction of environmental impact.

The methodological basis of the study includes observation, measurement, and comparison, as well as inductive and deductive reasoning, and analysis and synthesis of existing data. The applied statistical-econometric approach is based on multiple linear regression using modeling tools in Excel and STATA.

The informational basis of the study consists of Bureau of National Statistic's dates and materials available from open sources and specialized online resources.

Literature review. The growing need for a stable food system requires a shift from the traditional linear open-cycle model to a so-called closed-loop economy [1]. According to the widely recognized principles of the circular economy, this transition reflects the adoption of a transformative approach in the food industry aimed at improving the environment, enhancing societal well-being, and supporting economic prosperity [2].

However, the results of numerous studies highlight challenges associated with the lack of circular economy implementation in the food industry and the agri-food sector as a whole [3].

To address potential difficulties in applying circular economy principles in the food industry, a comprehensive analytical framework has been developed for food and agricultural systems, providing an integrated structure for assessing interactions among key elements and tools for evaluating circularity [4].

Circular economy strategies are being examined through a comprehensive and integrated approach to sustainable waste management in the food industry. Successful implementation requires collaboration and innovation across the entire food value chain [5], including the use of Industry 4.0 technologies [6] and long-term measures aimed at achieving national environmental goals [7], [8].

It is encouraging that society is willing to pay an additional amount for food waste recycling within the circular economy framework, which reflects a high level of societal awareness and indicates the potential for market-based utilization of food waste [9].

Despite the broad scope of existing research, domestic scientific and applied studies on the circular economy in the food industry remain insufficiently developed, both theoretically and empirically. This study aims to help fill this gap.

The main part. The circular economy generated by the food industry in the Abai region, in line with widely recognized principles of sustainable growth, aims to address the global challenge of food waste and reduce environmental pressures through shorter food production and supply chains, as well as more efficient use of resources and technologies.

The volume of food waste in the region has shown an upward trend over the past three years (since the establishment of the Abai region in 2022), increasing from 9,130 tons in 2022 to 11,117 tons in 2024.

Within the overall structure of waste, food waste constitutes a significant share of total municipal solid waste in the region (Table 1) and also demonstrates a rising trend, accounting for 15–19% over the past three years (15% in 2022, 17% in 2023, and 19% in 2024) (Figure 1).

Table – 1

Overall Structure of Municipal Solid Waste in the Abai Region, tons*

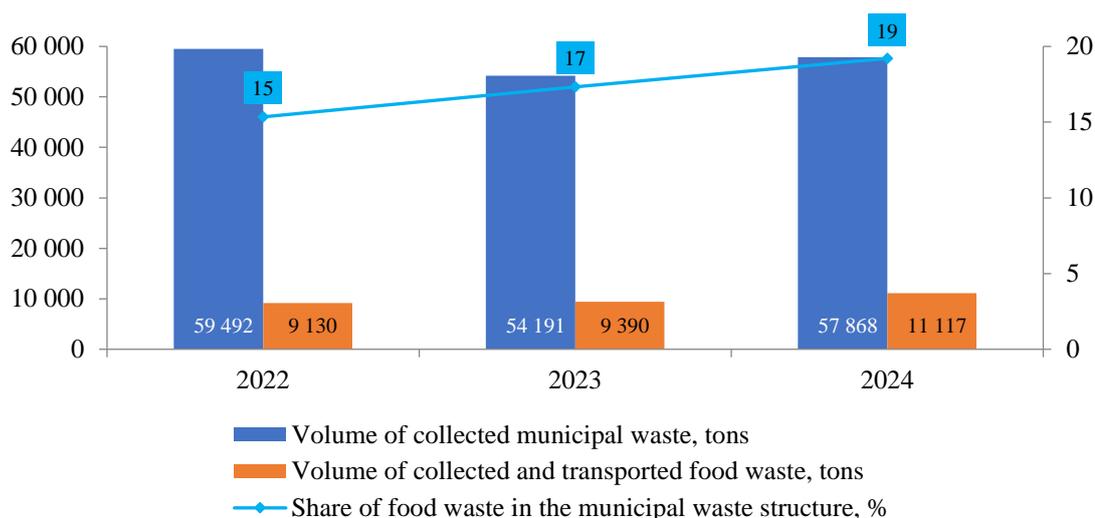| Years	Food Waste	Waste Paper, Carboard, Paper	Glass Scrap	Plastic Waste	Electrical Equipment	Metals	Tires	Clothing, Textiles	Street Cleaning Waste	Market Waste	Other Waste
2022	9130	1665	120	341	-	-	-	-	6320	2380	39 536
2023	9 390	1 707	55	303	-	-	-	-	3 694	2 074	36 968
2024	11 117	2 351	58	499	-	-	-	-	2 483	1 382	39 978

* compiled based on source [10].

Figure –1. **Food Waste in the Structure of Municipal Solid Waste, tons/%**
* compiled based on source [10].

It is important to note that, according to the available national statistical data, food waste in the region is not directed to recycling, which contradicts the principles of the circular economy and generates a range of environmental, economic, and social risks [10]. Alternatively, data on food-waste recycling in the Abai region are statistically unobservable within a separate waste category classified as "food waste." Therefore, the official statistical authority does not report any data for the indicator "food-waste recycling" in the Abai oblast.

The conclusion follows that food waste generated by restaurants, retail chains, and households is removed together with other municipal solid waste without sorting or recording. In such cases, food waste ends up in landfills as mixed household waste, and its volume is therefore not reflected in the official recycling statistics.

According to the data for 2022–2023, the types of waste sent for recycling in the region include plastics, polyethylene, and polyethylene terephthalate (PET) packaging, which together amounted to 2,200 tons over two years (or 49% of all recycled waste in the region). A total of 1,850 tons of paper, cardboard, and paper waste (41%) was sent for recycling; glass waste accounted for 275 tons (6%); and metals for 185 tons (4%). Official data for 2024 are not available (Table 2).

Table – 2

Waste sent for recycling in the Abai region, tons*

Years	Total	Food Waste	Waste Paper, Carboard, Paper	Glass Scrap	Plastic Waste	Electrical Equipment	Metals	Tires	Clothing, Textiles	Street Cleaning Waste	Market Waste
2022	1 080	-	350	180	450	-	100	-	-	-	-
2023	3 440	-	1 500	95	1 750	-	95	-	-	-	-
Total, tons	4 520	-	1 850	275	2 200	-	195	-	-	-	-
Share, %	100		41	6	49	-	4	-	-	-	-

*compiled and calculated based on source [10].

The lack of food waste recycling in the region leads to the rapid filling of landfills, which causes landfill capacities to reach their maximum limits more quickly, thereby shortening their operational lifespan. According to data from 2022–2024, landfill occupancy in the region has already reached nearly 40% of their designed capacity [10]. The construction of new landfills or the expansion of existing ones imposes a potential additional burden on the budget.

Moreover, because food waste has high moisture content and decomposes rapidly, there is an increased risk of leachate contamination of soil and water bodies. The situation is further aggravated by the generation of methane - a potent greenhouse gas - during decomposition, which exacerbates climate risks. Uncontrolled emissions of methane negatively affect the environment. The environmental and sanitary conditions are also worsened by the proliferation of rodents and insects, as well as the spread of pathogens.

The absence of a food waste recycling system indicates, on one hand, institutional and infrastructural challenges in the food waste management chain, and on the other, highlights the urgent need for the reuse and transformation of food waste.

Recycled food waste has a wide range of applications depending on the recycling technology. It can be used for the production of organic fertilizers, biogas, feed components for insects and animals, and the extraction of bioactive compounds.

In this context, under Kazakhstan's circular economy framework, the production of organic fertilizers is particularly relevant for the agricultural sector, especially given the insufficient production and application of such fertilizers not only in the region but across the country as a whole (Table 3).

Table – 2

Use of Organic Fertilizers by Kazakhstani Agricultural Enterprises *

Name	Organic fertilizers (manure, compost, biofertilizers)		
	2021	2022	2023
Total area under crop, mln hectare	15,92	15,84	17,12
of which: area treated with fertilizers, mln hectare	0,076	0,052	0,058
Share of fertilized area in total sown area of the crop, %	0,48	0,33	0,34
Fertilizer consumption, 1000 ton	247,2	170,5	82,0
Fertilizer consumption per unit of sown area of the crop, kg/ hectare	15,53	10,76	4,79

*compiled on source [11].

The Table 3 shows that the use of organic fertilizers is extremely limited, with consumption decreasing threefold over three years (from 247.2 thousand tons in 2021 to 82.0 thousand tons in 2023). The area treated with organic fertilizers amounts to only 0.05-0.07 million hectares, or less than 0.5% of the total sown area (declining from 0.48% in 2021 to 0.34% in 2023). It is important to note that biofertilizers are included within the total organic fertilizers, as official statistics do not track biofertilizers separately. This further highlights the very low levels of biofertilizer use in the agricultural sector.

Conclusion. The recycling of food waste according to the principles of the circular economy is strategically necessary from both economic and environmental perspectives. At the region the sorting and recycling steps are absence and statistical accounting and high landfill occupancy are being. This fact makes it necessary of food waste to organic fertilizers.

Developing a circular economy requires a comprehensive approach, encompassing regulatory, institutional, infrastructural, economic, and technological components. Transitioning to a circular model necessitates the implementation of mandatory separate collection of organic waste, as well as the development of standards for storage, transportation, and further processing of food waste.

A key condition for the development of a circular model is the creation of infrastructure for food waste recycling, including the organization of collection and transportation systems, as well as the establishment of local and regional processing facilities to reduce transportation costs and losses. At the same time, emphasis should be placed on technological development and innovation through the adoption of modern food waste processing methods, such as biogas plants, composting, production of animal feed, and bioenergy generation.

Equally important is the support of scientific research and innovative startups in the field of circular economy, as well as raising public awareness and promoting a culture of waste reduction within the framework of circular approaches and sustainable consumption. These initiatives should also be integrated into educational programs at all levels.

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АБАЙ ОБЛЫСЫНЫҢ ТАМАҚ ӨНЕРКӘСІБІНДЕГІ АЙНАЛЫМДЫҚ ЭКОНОМИКА

Аңдатпа

Мақала Қазақстан Республикасы Абай облысындағы азық-түлік қалдықтарын өңдеу мәселелерін шеңберлік экономика принциптері контекстінде зерттеуге арналған.

Аймақтағы коммуналдық қалдықтардың жалпы құрылымындағы азық-түлік қалдықтарының сандық өзгерістері көрсетіліп, олардың барлық коммуналдық қалдықтар құрылымындағы маңызды үлесі мен жыл сайынғы өсуі анықталды.

Зерттеу нәтижесінде аймақтағы азық-түлік қалдықтары, олардың көлемі мен өсу қарқынына қарамастан, қайта өңдеуге жіберілмейтіні немесе басқа коммуналдық қалдықтармен аралас, сұрыпталмай және есепке алынбай жіберілетіні анықталды, бұл қалдықтардың аралас қалдықтар ретінде классификациялануына әкеліп соғып, экономикалық және экологиялық жағынан теріс салдарға және қалдық айналымының нақты көрінісін бұрмалауға себеп болады. Сонымен бірге, өңдеуге пластмасса, қағаз және картон, металл сияқты қалдықтардың жататыны анықталды.

Азық-түлік қалдықтарын тиімді өңдеудің және оларды ауыл шаруашылығы салалары үшін органикалық тыңайтқыштарға айналдырудың қажеттілігі мен өзектілігі негізделді.

Шеңберлік экономиканы дамыту үшін нормативтік-құқықтық, институттық, инфрақұрылымдық, экономикалық және технологиялық құрамдас бөліктерді қамтитын кешенді тәсіл қажет екені көрсетілді. Шеңберлік модельді дамыту үшін негізгі шарттар ретінде азық-түлік қалдықтарын өңдеудің инфрақұрылымын және заманауи әдістерін құру, шеңберлік экономикадағы ғылыми зерттеулер мен стартаптарды ілгерілету, сондай-ақ қоғамда экологиялық хабардарлықты қалыптастыру аталды.

Зерттеуде бақылау, өлшеу және салыстыру әдістері, индукция және дедукция логикалық әдістері, талдау және синтез, сондай-ақ статистикалық-эмпирикалық әдіс қолданылды. Жүргізілген талдау Қазақстан Республикасының Ұлттық статистика бюросының деректері мен интернеттің ашық дереккөздеріне негізделген.

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ЦИРКУЛЯРНАЯ ЭКОНОМИКА В ПИЩЕВОЙ ПРОМЫШЛЕННОСТИ ОБЛАСТИ АБАЙ

Аннотация

Статья посвящена изучению вопросов переработки пищевых отходов в области Абай Республики Казахстан в контексте принципов циркулярной экономики.

Показаны количественные изменения пищевых отходов в общей структуре коммунальных отходов региона, выявив их значительную долю в структуре всех коммунальных отходов и ежегодный рост.

Выявлено, что пищевые отходы в регионе не направляются на переработку, несмотря на их значительные объемы и темпы роста, или направляются совместно с другими видами коммунальных доходов без сортировки и учета, классифицируясь, как смешанные отходы, что приводит к неблагоприятным экономическим и экологическим последствиям, и к искажению реальной картины обращения отходов. При этом, определено, что переработке подлежат такие виды отходов в регионе, как пластмасса и пластик, макулатура и картон, а также металлы.

Обоснована необходимость и актуальность применения эффективного обращения пищевых отходов и их трансформации в органические удобрения для отраслей сельского хозяйства.

Определено, что для развития циркулярной экономики необходим комплексный подход, включающий нормативно-правовую, институциональную, инфраструктурную, экономическую и технологическую составляющие. Ключевыми условиями развития циркулярной модели выступают создание инфраструктуры и современных методов переработки пищевых отходов, продвижение научных исследований и стартапов в циркулярной экономике и формирование экологической осведомлённости общества.

В исследовании применены методы наблюдения, измерения и сравнения, логические методы индукции и дедукции, анализа и синтеза, а также статистико-эмпирический метод. Проведенный анализ основан на данных Бюро национальной статистики Республики Казахстан, и открытых источниках сети интернет.