

## ASSESSING GLOBAL TRENDS IN MUNICIPAL SOLID WASTE MANAGEMENT: IMPLICATIONS FOR PUBLIC HEALTH AND ENVIRONMENTAL SUSTAINABILITY

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### Abstract:

Rapid industrial and technological development has significantly improved the quality of life around the world. However, this advancement has also created a significant challenge in terms of waste management and disposal. This issue has become crucial for the 21st century as the rate of waste accumulation is exceeding the rate of urban growth. Since the onset of industrialization, humanity has produced 8.3 billion metric tons of plastic waste. Of this, only 9% has been recycled and 12% incinerated, leaving the majority buried in landfills or simply discarded. This waste causes serious environmental problems, including pollution of air and soil that can lead to health issues such as diarrhea, respiratory disease, and even cancer. In addition, uncontrolled use of natural resources and ineffective environmental management exacerbate the situation, reducing the quality of life of people living near landfills. This study aims to comprehensively assess the epidemiological situation in areas with solid waste landfill sites around the world. Special attention will be given to the investigation of techniques used to mitigate the negative impacts of landfills on human health and the environment. The aim of this review is to carry out a comprehensive analysis of current practices in municipal solid waste management and to evaluate their impact on the environment and public health. The analysis will pinpoint the main obstacles posed by ineffective and outdated methods, and propose solutions to address these issues. This study has practical significance as it can inform the development of strategies to optimize waste management. Findings from this research can form the basis for creating guidelines to improve environmental conditions in regions, enhance legislative and regulatory frameworks for waste management, and raise public awareness of environmental concerns.

**Keywords:** Solid household waste; landfill, environmental pollution; recycling, quality of life.

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## INTRODUCTION

Landfilling is a significant environmental challenge on a global scale, with solid waste from households in most countries, including Kazakhstan, being largely unrecycled and stored in landfills. This practice has a long-term, negative impact on the environment, as waste decomposes and releases toxic substances that pollute air, soil, and groundwater. These pollutants disrupt environmental balances and pose serious health risks to those living near landfill facilities. Additionally, land plots utilized for landfilling are removed from circulation, limiting their future use for economic purposes and exacerbating the issue of efficient land use.

Human-induced environmental degradation is the primary cause of the exacerbation of environmental issues, which are increasingly widespread and alarming. Open dumps not only pose significant environmental risks but also adversely affect the quality of life for the population, occasionally leading to catastrophic outcomes (Shilkina, 2020). The global issue of waste management, both from production and consumption, affects everyone – from individuals who deal with recycling issues to government agencies that are responsible for providing waste management services. As urbanization continues to grow, so does the economic and demographic development. Therefore, the issue of waste recycling has become increasingly significant (Laktionov *et al.*, 2021).

The World Bank predicts that solid waste will increase from 2.01 billion tons in 2016 to 3.4 billion tons by the year 2050. Currently, at least 33% of all waste is disposed of unsustainably through burial or incineration, leading to environmental problems (Ladik & Kamyshanchenko, 2021). According to data collected by international experts for the World Bank in 2016, 2.01 billion tons of municipal solid waste were produced worldwide, averaging 0.74 kg per person per day. These figures emphasize the need for a swift transition to more sustainable and environmentally friendly waste management methods to reduce the negative impact on both nature and human health (Khertek & Tatarenko, 2022). Low-income developing countries face not only an increase in municipal solid waste volumes, but also a lack of effective local administration control over waste removal and disposal processes. In some cases, up to two-thirds of the generated waste ends up on streets or nearby natural landfill sites. This situation can lead to serious environmental, social, and health consequences, such as environmental pollution, worsening of the sanitary and epidemiological conditions, and threats to public health (Baikenova & Gyncha, 2020).

The need for efficient waste management has

become particularly urgent in light of rapid urbanization and increasing waste production. The aim of this study is to conduct an in-depth analysis of current methods of municipal solid waste (MSW) management and to assess their impact on environmental quality and public health. This review will examine the key issues arising from the utilization of inefficient and obsolete approaches, as well as propose solutions to these problems. The practical relevance of this research is that it will provide valuable insights for the formulation of strategies aimed at optimizing waste management. The findings of this study can serve as the foundation for the development of guidelines to enhance the environmental situation in regions, improve legislative and regulatory frameworks in the field of waste handling, and raise awareness about environmental issues among the general public.

## METHODS

This study involved a literature review aimed at exploring the global trends in municipal solid waste (MSW) management and its implications for public health and environmental sustainability. A search of prominent databases, including NCBI (PubMed), Scopus, Medline, and Google Scholar, was conducted to identify relevant publications published between 2019 and 2024 using keywords such as "municipal solid waste landfill," "environmental contamination," "disposal techniques," and "quality of life."

The search yielded a total of 394 articles. To ensure the relevance and quality of the data, a two-stage selection process was implemented. In the first stage, titles and abstracts were screened to exclude studies unrelated to the direct impact of municipal solid waste landfills on health or the environment. As well as those that focused on waste categories other than MSW. As a result, 132 studies were retained for further consideration.

In the second stage, the full texts of these articles were thoroughly reviewed based on the following inclusion criteria:

1. Language: Articles had to be published in English or Russian.
2. Peer-reviewed publications: Only peer-reviewed journal articles, systematic reviews, meta-analyses, and clinical investigations were considered.
3. Relevance to the topic: Studies had to focus specifically on the effects of MSW landfills on public health, environmental contamination, and sustainability.
4. Recent advances: Preference was given to studies that discussed the application of new technologies, such as automation and innovative waste treatment methods.
5. Study design quality: Studies with well-defined methodologies, appropriate sample sizes, and robust

data analysis.

This narrative review approach allowed us to qualitatively assess the selected studies by emphasizing the relevance and synthesis of the available evidence. Following a detailed evaluation, we selected 26 articles for inclusion. These articles were chosen based on their high relevance to our research objectives and their insights into waste management practices and emerging technologies' role in mitigating landfill risks. The use of the narrative review method allowed us to integrate diverse research findings and comprehensively explore the implications of municipal solid waste (MSW) landfills on health (Ferrari, 2015)

## RESULTS

The issue of municipal solid waste (MSW) management in advanced nations is assuming increasing significance in the pursuit of achieving environmental sustainability. A clear correlation exists between the expansion of recycling and the reduction of waste disposal. Typically, the decline in disposal volumes outpaces the increase in recycling, attributable to the shift from conventional approaches to more integrated management systems encompassing recycling, incineration, and mechanical and biological treatments (Bulekova & Gabdullina, 2021).

In Europe, efforts to develop an environmental policy regarding solid waste management have been ongoing for many years. A significant milestone was the European Commission's communication on the strategy for preventing waste generation and promoting recycling, released in December 2005. This strategy aims to mitigate the adverse environmental consequences associated with resource exploitation (Alharbi, Alhaji & Qattan, 2021). The European Union has established minimum requirements for the management of various categories of waste of various categories, which demonstrates a serious attitude towards this issue. The recommendations for managing solid waste are based on a hierarchy of waste management principles. A notable example of successful implementation of this approach is the increase in the rate of municipal waste recycling rates, including recycling of materials, composting, and anaerobic digestion of biological waste. In 2014, the countries within the European Economic Area achieved an overall recycling rate of 33%, which is significantly exceeding the 23% rate recorded in 2004, according to data from Eurostat (Magrini, D'Addato & Bonoli, 2020).

The implementation of efficient waste management practices in developed nations not only contributes to enhancing the environmental landscape but also fosters the improvement of living standards for the population

while mitigating the adverse impact on the ecosystem. In this context, it becomes imperative to devise and execute effective strategies for managing household waste management, which serves as a pivotal aspect in safeguarding the environment and promoting the sustainable development of urban infrastructures. The concepts of "smart waste management" and the utilization of intelligent systems for waste recycling and disposal have emerged as crucial elements in contemporary urban planning (Vinti *et al.*, 2021).

In the past two decades, there has been a paradigm shift in the approach to municipal waste management in European countries. Instead of merely disposing of waste, these nations are now prioritizing prevention and recycling. This shift not only reduces the environmental footprint but also generates economic benefits through resource recovery and job creation (Kenny & Priyadarshini, 2021). Although municipal waste accounts for only 10% of the total waste generated in the European Union, its impact on the environment remains significant. Addressing this issue not only benefits urban residents but also minimizes damage to the environment throughout the product lifecycle, from production to final disposal (Mazzei & Specchia, 2023). Between 2004 and 2014, notwithstanding population growth, there was a slight decrease in the volume of municipal solid waste generated in European countries. This positive trend indicates the efficacy of preventive measures.

Germany serves as an exemplar of successful waste management practices, owing to the implementation of the "Federal Waste Prevention Program" in 2013. This program is actively employed to reduce waste generation and enhance waste disposal practices (Azevedo *et al.*, 2021). The Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety continuously updates the "Waste Prevention Concept." The most recent edition was published in November 2019 and encompasses various aspects of waste reduction. Some key areas include enhancing recycling rates, launching educational initiatives for citizens, and integrating innovative technologies in the field of waste management systems (Chioatto & Sospiro, 2023).

In the United States, the annual amount of solid waste produced is approximately 260 million tons, making it the world's leading country in this regard. Of this total, about one third is recycled, 13% is burned at waste-to-energy facilities, and over half goes to landfills. Government efforts focus on reducing the primary volume of waste (Law *et al.*, 2020). For example, in New York, residents are required to sort their waste into three categories: paper and cardboard, plastic, glass, and metal, as well as items that can't be recycled. This sorted waste is processed locally or exported to other countries. Glass containers are

recycled for beverage production. A program adopted by authorities in 2015 aims to completely eliminate urban waste disposal in New York by 2030 (Mulya *et al.*, 2022), which will be achieved by reducing primary waste and increasing recycling.

Japan is actively developing infrastructure for solid waste incineration due to a lack of available land for new landfills. Despite its smaller size compared to Russia, the country's population is comparable, making the waste disposal problem more complex. Only 5% of household waste is disposed of, with up to 70% being recycled or incinerated. Most incinerators are located in cities, where modern technologies ensure combustion at temperatures above 1200 °C (Iyamu, Anda & Ho, 2020). These methods, coupled with highly efficient filtration systems, minimize harmful emissions, making Japan the world's leader in the number of incinerators, with over 1,900 facilities.

An important aspect of the successful operation of this system is the strict adherence to the rules of waste sorting by the population. Up to 40 different types of containers can be installed in homes for various types of waste, such as paper, plastic, metal, and glass. Even plastic yogurt cups must be rinsed before being discarded. In addition, Japan exports some of its most toxic waste to other countries, which raises a number of environmental and ethical concerns. "Garbage islands", also known as new lands created in Tokyo Bay from recycled paper and ash from incinerators, have become another method of waste disposal. These areas are used for the construction of luxury housing, parks, metallurgical plants and airports (Mekonnen & Tokai, 2020).

Until 2018, China was the largest importer of garbage in the world, accounting for up to 45% of all plastic waste produced globally. This waste was mainly from developed countries, such as the European Union (EU) and the United States (US). Since 1992, around 95% of EU recycled plastic and 70% of US plastic has been shipped to China for recycling (Ding *et al.*, 2021). In 2016, China accounted for 56% of global plastic waste imports, worth \$3.7 billion. Due to environmental concerns, China imposed strict restrictions on garbage imports in 2018. Private recycling companies often failed to meet environmental standards, leading to some non-recyclable waste ending up in unauthorized landfills. To address this issue, China aims to completely stop importing waste by the end of 2019.

The increase in population and consumption has led to an increase in solid waste production, necessitating the development of effective measures for domestic waste disposal. The main focus of the article is on the construction of incinerators. By 2020, it is planned that 50% of garbage will be incinerated (He *et al.*, 2020). To reduce the amount of solid waste, developed countries

use various strategies, including recycling and garbage incineration. Although recycling is preferred from an environmental perspective, the construction of incinerators is becoming a priority for many countries.

More than 3 billion kilograms of solid waste are generated annually in Kazakhstan, averaging about 156 kilograms per person. The Ulytau region has the highest per capita solid waste generation, with an average of 373 kilograms per inhabitant each year (Nukusheva *et al.*, 2023). However, the recycling rate in this area is only 0.1%, negatively affecting the environment and pollution levels.

According to statistics, Kazakhstan generates 4.5 million tons of solid waste annually, but only one ton is processed and sorted. Management and disposal methods for MSW vary across regions. The capital and larger cities have the most efficient systems, with a 75% solid waste recycling rate in Astana in 2022. The Ministry of Ecology of Kazakhstan has noted that in order to achieve a 40% target for sorting solid waste, it is essential not only to improve the performance of state environmental services but also to enhance citizens' responsibility for waste sorting (Bayazitova *et al.*, 2022).

Rapid advances in industry and technology have greatly improved the quality of life worldwide. However, the resulting issues with waste management and disposal have become a major challenge for society in the 21st century. The amount of garbage generated exceeds the rate of urbanization, and research shows that since the start of the industrial age in the 1950s, humans have produced 8.3 billion tons of plastic waste. Only 9% of this has been recycled, 12% has been burned, and the majority has been dumped in landfills worldwide. These waste products arise from daily activities and frequently lead to significant environmental issues, including air and soil pollution, as well as health problems such as diarrhea, respiratory illnesses, and cancer (Vinti & Vaccari, 2022).

Problems also arise due to the irrational use of natural resources and improper environmental management, which negatively affects the lives of people living near landfills of solid household waste. Even in developed countries, despite the existence of waste recycling and disposal policies and strategies, the effectiveness of their implementation remains limited. For example, in 2017, only 25.8% of waste in the United States was recycled, while in the European Union this figure was only 30%. Environmental factors have a significant impact on the quality of life of the population (Zupančič *et al.*, 2022). In Vietnam, in 2015, the amount of household waste in urban areas was 38,000 tons per day, and 85% of it was collected and recycled. However, in rural areas, the volume of waste reached 32,000 tons per day, while only about 55% was

collected (Tong, Huynh & Khong, 2021). The main method of solid waste disposal in Vietnam remains burial, accounting for 70% of the total volume. This has led to growing discontent among residents living near unsanitary landfills, as the harmful effects of waste on the aquatic and soil environments have not been sufficiently investigated.

Incineration without closed recycling technologies, which can worsen air quality, accounts for up to 28% of waste disposal in Vietnam. This method is likely contributing to the country's low ranking in environmental assessments, as it ranked 77th out of 132 countries in the 2015 Environmental Efficiency Index. According to a study conducted in Ho Chi Minh City, an increase of 10 micrograms per cubic meter of pollutants in the air increases the risk of respiratory and cardiovascular diseases by 0.7-8.0% and 0.5-4.0%, respectively (Phua *et al.*, 2021).

Based on these research findings, it is urgent to improve waste management systems in the country to minimize negative impacts on public health and the environment. Measures need to be taken to increase waste recycling rates, improve incineration technologies, and effectively manage landfills. Joint efforts from government agencies, local communities, and non-governmental organizations can significantly contribute to improving the environmental situation. Increasing awareness of the importance of environmental protection, encouraging active participation from the population in sorting and recycling waste, and introducing educational programs on pollution's effects should be priorities in the strategy for improving the quality of life.

Solid waste disposal can have a significant negative impact on the aquatic and soil environments. Problems related to garbage collection and transportation can lead to unpleasant odors, dust, and other issues that negatively affect the quality of life for people living nearby. It is important for the responsible authorities to strengthen their control over this issue, as it can help protect the environment and improve the living conditions for citizens. For instance, updating waste recycling technologies and moving landfills and incinerators away from residential areas by at least 5 kilometers can be effective measures to reduce the negative impact of waste disposal on the environment (Tomita *et al.*, 2020). It is also worth considering other ways to reduce the negative impact of municipal solid waste (MSW) on air quality. For example, installing protective panels to cover waste during transportation can help reduce odors from garbage trucks. Additionally, it is important to control dust emissions by regularly spraying soil with water during transportation to moisten the soil and reduce pollution.

Unsustainable practices in MSW management lead

to several negative consequences for public health and the environment. Although each recycling method has drawbacks, some are less harmful. The main consequences of poor MSW management include:

- Organic waste left in dumpsters and landfills attracts pests such as rodents, insects, and reptiles, which can spread disease. As waste decomposes, an unpleasant odor forms, especially in warmer months, and filtrate contaminates groundwater and surface water.
- Open landfills emit methane, which is formed as a result of the breakdown of biodegradable materials. This gas contributes to global warming and can lead to fires and explosions.
- Non-biodegradable waste, such as tires and plastic, pollutes the soil and accumulates water, creating conditions for mosquito breeding and increasing the risk of diseases like malaria.
- The open burning of solid waste releases toxic substances into the air, worsening human health and increasing the incidence of respiratory and allergic diseases.

The challenge of managing MSW requires a collaborative effort between local authorities, businesses, NGOs, and residents to find effective solutions that minimize negative impacts on health and the environment.

## DISCUSSION

A review of current trends in municipal solid waste management reveals that effective waste management is crucial for protecting the environment and public health. We analyzed the MSW methods implemented in different countries, including the USA, Europe, Japan, and developing countries like Vietnam and Kazakhstan, to compare their approaches.

Our comparative analysis shows that Europe has made significant progress in increasing waste recycling. The percentage of recycling in the European Union has increased from 23% in 2004 to 33% in 2014. This confirms the effectiveness of policies aimed at reducing waste disposal. Our findings support this trend, emphasizing the need for comprehensive strategies to increase recycling rates and reduce landfill waste. In the United States, where the annual production of municipal solid waste reaches 260 million tons, only a third of it is recycled, with the rest being either incinerated or sent to landfills (Law *et al.*, 2020). Both the United States and Japan are seen to use innovative technologies such as energy waste management. The Japanese waste management model stands out due to its strict sorting practices and technological advancements in recycling, which allow 70% of waste to be recycled or incinerated (Iyama *et al.*, 2020).

A comparative analysis with developing countries, such as Vietnam, shows that waste management issues are particularly significant in rural areas. In these areas, the waste collection rate is only 55%, compared to 85% in urban centers (Tong *et al.*, 2021). This data is consistent with our study's findings on the need for reform in waste management systems in Kazakhstan. In some regions, the recycling rate is only 0.1%, highlighting the need for stronger government controls and better waste management infrastructure (Nukusheva *et al.*, 2023). The research also confirms the findings of Mekonnen and Tokai (2020) that the construction of incinerators has become a priority due to limited land resources. However, inadequate regulation and open incineration techniques in developing countries present serious environmental and health hazards (Phua *et al.*, 2021).

This study emphasizes the importance of a comprehensive approach to waste management, including increasing recycling rates, improving infrastructure, and raising public awareness about waste sorting. By comparing with other regions, we can identify common trends and challenges in waste management, which can help develop effective strategies to address them. For Kazakhstan, it is essential to develop a comprehensive and integrated approach to MSW management, based on best practices from Europe, Japan, and the United States. The study's recommendations focus on enhancing recycling, modernizing waste treatment infrastructure, and increasing public awareness of sorting issues.

The proposed strategies for developing a national waste management plan are crucial for reducing environmental impacts from MSW and protecting public health, as well as ensuring the long-term sustainability of urban ecosystems.

## CONCLUSION

The rate of solid waste generation worldwide is increasing faster than the rate of urbanization. This is leading to inadequate recycling systems, which in turn leads local authorities and urban residents to resort to unsustainable practices. The mixing of household and commercial waste with hazardous materials during storage and processing, along with the use of outdated or poorly managed facilities, has a negative impact on the environment.

Imperfect transportation methods and the use of open-air incinerators and informal landfills contribute to serious environmental problems, such as air and water pollution, land degradation, climate change, and emissions of methane and harmful filtrates. These impacts cause significant damage to the environment and human health, particularly affecting marginalized

social groups who are already vulnerable.

The aim of this research was to examine current trends in solid waste management on a global scale and evaluate the success of different strategies aimed at minimizing environmental and public health impacts. Our analysis shows that while advanced economies have made progress, significant challenges remain in developing countries. The purpose of this review is to highlight key issues in solid waste management and suggest solutions. The findings of this study can serve as a foundation for developing more efficient waste disposal methods, improving environmental conditions, and protecting public health. Additionally, the information gathered can assist governmental and non-governmental organizations in creating programs to increase public awareness and promote sustainable waste management practices.

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