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THE WASTE MANAGEMENT IMPACT: PATHWAYS TOWARD SUSTAINABLE MANAGEMENT IN SAMARKAND

Ergash Egamberdiyevich Kobilov, Khidir Fayziyevich Batirov, Mustafa Kurbanovich Tukhtaev, Fariza Sanjarovna Mardanova, Oybakhor Baxritdinovna Niyazova, Mukhtasam Ganiyevna Baratova, Sarvar Ashurmakhmatov, Ciprian Căpățână, Anca Tulbure, Ramona Giurea

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Ergash Egamberdiyevich Kobilov,[1] Khidir Fayziyevich Batirov,[1] Mustafa Kurbanovich Tukhtaev,[1] Fariza Sanjarovna Mardanova,[1] Oybakhor Baxritdinovna Niyazova,[1] Mukhtasam Ganiyevna Baratova,[1] Sarvar Ashurmakhmatov,[1] Ciprian Căpățână,[2] Anca Tulbure,[2] Ramona Giurea[3]

[1] Department of Ecology and Life Safety, Samarkand State University, Uzbekistan
[2] Department of Food Industry and Environmental Protection, Lucian Blaga University of Sibiu, Romania
[3] Department of Industrial Engineering and Management, Lucian Blaga University of Sibiu, Romania

Abstract

The article examines the main issues associated with industrial waste and household waste management. The rapid growth of urbanization and human activity in recent years has negatively impacted the ecological situation in the Samarkand region. Based on statistical datasets, field investigations, and an analysis of the regulatory framework, the study reveals that waste volumes are rapidly increasing while recycling and treatment rates remain critically insufficient. Improper disposal practices, including open dumping and uncontrolled incineration, have been shown to significantly contribute to health problems within the population. The findings strongly demonstrate that, without systemic reforms, waste accumulation will continue to exacerbate environmental degradation and health risks. However, the study confirms that sustainable management through mandatory waste separation, the expansion of recycling infrastructure, the controlled disposal of hazardous materials and the adoption of innovative eco-technologies can substantially mitigate these adverse outcomes.

Keywords

sustainability; waste management; household waste; industrial waste; public health.

I. Introduction

In recent years, Uzbekistan has generated more than 100 million tons of industrial and per year (14% of which is toxic waste), about 35 million tons of household waste. Considering that landfills and waste storage facilities store about 2 billion tons of industrial, construction, and household waste and occupy an area of 12 thousand hectares, it is not difficult to imagine the negative impact of waste. Environmental protection from production and consumption waste is inextricably linked with the problems of rational use of natural resources and the introduction of environmentally friendly technologies. For many centuries, improper waste management has led to changes in natural resources, unexpected changes in nature, but this situation is changing thanks to the new regulations [1-3]. There are studies that emphasize the role of sustainable waste management, as well as the potential of composting strategies in developing cities to reduce landfill pressure [4].

Moreover, medical waste poses a danger not only of direct but also indirect spread of infectious and non-communicable diseases among the population due to pollution of the environment and almost all its elements - water, air, soil, food, and all this requires a serious environmental approach to this problem. In addition, 80% of these wastes are organic substances, and when they are processed in a sustainable and circular way, a large amount of energy and energy carriers can be obtained [5,6].

The main goal of waste management policy is to prevent environmental pollution and protect public health by reducing waste generation and improving recycling practices. In Uzbekistan, the 2002 Waste Law regulates waste management and establishes standards for minimizing harmful effects on health and the environment [2,3,7,8]. Key objectives include:

- Preventing toxic pollution from industrial and medical waste.
- Expanding waste collection and recycling systems.
- Encouraging foreign investment in recycling industries.
- Promoting modern waste-free and low-waste technologies.

However, current legislation does not adequately regulate medical waste, the Ministry of Health is working on the elimination and neutralization of medical waste.

II. Material and methods

This study was conducted to investigate the environmental and public health impacts of industrial waste and household waste across Samarkand and its surrounding districts. A combined methodological approach was employed, incorporating statistical data analysis, field observations and a review of existing regulatory frameworks.

Statistical data on waste generation, recycling and disposal practices have been obtained from national and regional environmental agencies, health departments and publicly available international databases. To assess the regulatory context and medical implications of waste management, official records from the Ministry of Health and the State Committee for Ecology and Environmental Protection of Uzbekistan were also consulted.

A. Data Collection and Processing

Table 1. Data Collection and Processing

Category	Explanation
Waste characterization	industrial, household, agricultural, construction and medical waste were categorized according to international classification standards and national legislation. Hazard classes were identified using both the Federal Classification Catalogue of Waste (FCCW) and Uzbek standards.
Health indicators	Morbidity rates were collected from official health statistics for various districts of Samarkand. Particular focus was given to diseases associated with environmental pollution, such as respiratory.
Environmental monitoring	Reports on the quality of the air, water and soil were reviewed to identify any correlations between waste accumulation and ecological degradation.

B. Limitations

The study relied primarily on secondary statistical data and reports from government and international organizations. Due to limited access to raw field data, it was not possible to quantify some correlations between waste and health outcomes with precision. Nevertheless, combining multiple data sources and using international classification standards allowed for a comprehensive evaluation of the situation.

III. Results and discussions

The industrial and household waste impacts the environment and public health. This section presents the analysis results, focusing on the diversity of waste sources, the classification system used in Uzbekistan, and the environmental and health risks associated with improper waste management. Particular attention is paid to the role

of recycling and innovative technologies in reducing the harmful effects of waste, as well as to the importance of developing effective strategies for sustainable waste management.

A. Waste characterization

Waste classification systems are established by legislation to ensure a systematic approach to environmental protection and public health. According to the legislation of the Republic of Uzbekistan on waste [2], waste is divided into groups according to the source of generation, physical state and recycling potential. Waste is also classified according to the level of danger it poses to the ecosystem.

Regardless of the origin, all waste is classified to minimize its harm to the environment, as well as to create optimal sanitary conditions to prevent the spread of viruses, infections and other pathogenic microorganisms.

Furthermore, waste is categorized according to the degree of hazard it poses to ecosystems. In 2003, the Government of the Russian Federation approved the Federal Waste Classification Catalogue (FWCC), which contains a comprehensive register of waste types, their properties, and associated hazard classes [9].

Table 2. The nature of the origin waste according to FWCC, adapted by authors

Waste type	Description/ Explanation
Chemical	Substances or a complex of substances that have been obtained in chemical laboratories or factories. Such waste can harm human health and disrupt the ecological balance. Chemical wastes such as mercury, alkali, acids, solvents, pesticides, oils and electrolytes are most common
Mineral	This category includes products with minerals in their composition that have expired or have been damaged. Such waste usually occurs as a result of the mining and glass working industries, as well as in the manufacture of fertilizers and building materials.
Organic	This is garbage that can decompose independently and release nutrients. This category includes missing food products, as well as animal and human waste.
Communal	Residues of consumer or industrial products that have lost their properties during use. These include packaging, furniture, equipment and tools. All these wastes arise from the activities of industrial enterprises and humans. Types of waste. The aggregate state is one of the criteria for classifying waste, which helps determine how they are stored and transported. Waste can be: solid, liquid, pasty, gel-like, etc.

The Federal Waste Classification Catalogue is a comprehensive framework that systematically categorizes waste based on their degree of danger. This classification is recognized as a standardized method for the identification of hazardous waste, which divides waste into five distinct hazard classes, ranging from low to high risk, based on their potential to cause harm to the ecosystem, as reported in Table 3.

Table 3. Hazard classes of garbage according to the degree of their harmful effects on the ecosystem, adapted by the authors

Hazard classes	Description
Class I Extremely hazardous	mercury-containing instruments, lamps, and transformers.
Class II Highly hazardous	chemical waste, batteries, tyres, acidic/alkaline solutions.
Class III Moderately hazardous	petroleum products, cement dust, and agricultural residues.
Class IV Low-hazard	glass, furniture, tyres, bitumen, decomposing within 3 years.
Class V Practically non-hazardous	minimal ecological impact, quick decomposition.

A separate classification of waste is medical waste, regulated by SanPiN and classified into: safe, epidemiologically hazardous, extremely hazardous, toxicologically hazardous, and radioactive [10]. Proper collection, sorting, and disposal of medical waste are crucial to prevent contamination and the spread of disease [11].

B. Environmental and health impacts

Waste production and management can significantly impact both the environment and human health if not properly handled. For example [12,13]:

Table 4. Examples of good practices regarding waste management

Direction	Description
Landfills	could release methane and toxic leachates, contaminating air, soil, and water.
Waste incineration	could produce harmful gases containing cadmium, mercury, and lead.
Plastics	persist in the natural environment for hundreds of years and degrade only slowly, leading to the accumulation of

Direction	Description
	microplastics in soil and aquatic ecosystems. Batteries, electronic waste, and used tyres release heavy metals and toxic compounds, creating significant ecological risks and serious consequences for human health

According to national and international statistics, each urban resident generates an average of 500-800 kilograms of municipal solid waste per year [14]. A substantial portion of this waste can be regarded as secondary raw material suitable for recycling and reuse; however, in practice, the recycling rate remains relatively low.

Uzbekistan generates approximately 4 million tons of MSW annually, with projections indicating an increase to 7 million tons by 2030. Additionally, the country produces 100 million tons of industrial waste [15].

Therefore, strengthening systems for waste separation and recycling is a key condition for ensuring environmental sustainability and protecting public health, while education for sustainable development plays a vital role in raising awareness, fostering responsible behaviour, and empowering communities to actively participate in sustainable waste management practices [16-18].

To provide a clearer overview of the environmental and health implications of different waste types, a summary is presented below (Table 5).

Table 5. Selected waste types and their environmental and health impacts

Waste type	Environmental impact	Health risks	Indicator
Plastics	Decompose over 100–400 years, generating microplastics	Adverse effects on the respiratory and digestive systems	Very slow degradation
Batteries	Release of lead, cadmium, mercury	Nervous system and kidney diseases	Classified as hazardous waste
Electronic waste	Contains heavy metals and toxic substances	Respiratory diseases, cancer	~50 million tons/year globally
Tires	Decompose slowly, release toxic compounds	Allergies, respiratory illnesses	Tens of millions of tons/year
Municipal waste	Accumulates in landfills, with low recycling rates	Risk of infectious diseases	500–800 kg/person/year

The severity of the impact of waste treatment and disposal on the environment and public health depends on the volume of waste produced, its composition, the amount of illegally buried waste, the amount of waste disposed of in landfills and the standards at waste treatment plants. The future impact of the waste management process will depend on how these factors change. The final treatment of waste, today, means either their burial in a landfill or incineration, and these two types of final treatment have different, but in both cases negative, effects on the environment and public health. In Table 6 data about public health (anaemia) are reported.

Table 6. The number of people suffering from anaemia in cities and districts of the Samarkand region (compared to 100,000 people)

Cities and districts	2021	2022	2023	2024
Samarkand	147040	143165	146032	144194
Kattakurgan	10625	11244	11326	10985
Surgut district	33171	49442	47525	39623
Samarkand district	43335	35652	34956	38022
Tailyak district	45658	39847	41256	43212
Bulungur district	15226	16425	17023	19366
Dzhamboiskiy district	25432	25057	24856	21412
Akdarya district	20991	22763	23666	26332
Payaryk district	25494	33762	29658	31855
Ishtikhansky district	33889	18931	21332	22432
Pastdargom district	49411	53198	55656	54003
Nurabad district	14051	23517	18802	16089
Kattakurgan district	46862	50332	49856	42362
Kushrabad district	21892	23361	23998	22698
Narpai district	20610	20543	21056	25213
Pakhtachi district	15862	25448	24099	26658

More and more hazardous waste that used to be placed in landfills is now being collected and processed properly, but not all of them. For example, in Samarkand, used electrical and electronics apparatus (televisions, refrigerators, etc.) continue to be taken to the landfill, although harmful substances are present in them. Old landfills contain a large amount of harmful waste and toxic chemicals that have been placed on them for years and have penetrated the environment. Since toxic waste

poses a significant danger to the environment, including human health, its management should be carried out in strict accordance with existing rules and standards [19].

The toxicity of heavy metals and their effect on a warm-blooded organism have been studied [20]. It is known that when ingested, they can affect the function of haematopoiesis, cause changes in the morphological composition of peripheral blood, block sulfhydryl groups, and pose a danger, contributing to the development of carcinogenic, genetic, and other long-term biological effects.

Biochemical decomposition and chemical oxidation of landfill material can be accompanied by spontaneous combustion of waste [20]. In Table 7, some data are reported within the Shahar and the districts.

Table 7. External causes and general morbidity rates in 2023

Name of Shahar and the districts of the Samarkand Region	**2023 r**			
	Whole	**Children under 14 years old**	**A teenager aged 15-17 years old**	**Adults**
Bulungur district	0	0	0	0
Jambai district	0	0	0	0
Kattakurgan district	6422	1724	1287	3411
of Kattakurgan	0			
Kushrabad district	0	0	0	0
Narpai district	0	0	0	0
Akdarya district	0	0	0	0
Payaryk district	0	0	0	0
Pastdargom district	0	0	0	0
Pakhtachi district	1287	0	1287	0
of Samarkand	1307	81	5	1221
Samarkand district	0	0	0	0
Tailyak district	0	0	0	0
Urgut district	0	0	0	0
Ishtikhansky district	15892	2048	1035	12809
Nurabad district	0	0	0	0
By region:	**24908**	**3853**	**3614**	**17441**

During the investigation on waste management, the following main violations were identified: no fence around the waste disposal facility; isolation of the disposed

waste is not carried out; laboratory control of the landfills emissions is not carried out; a disinfectant barrier is not used.

The use of waste as raw materials makes it possible to use natural resources more efficiently and reduce harmful emissions into the atmosphere and wastewater discharges. For example, using wastepaper as a raw material to produce new paper, can reduce harmful emissions into the air by 70-80%, and the pollution of water bodies by 30-35%, compared with the use of primary raw materials [21]. About four cubic meters of wood can be saved by using one ton of waste paper. Thus, thousands of hectares of forest land are preserved, which, in turn, help purify the atmosphere of carbon dioxide.

Eco-wool, a thermal insulation material made from wastepaper, has been produced for many years and represents an ecological solution that is safe for both humans and the environment [22].

With the growth of the automotive industry, environmental impacts have increased. In addition to batteries, plastics, and metal, cars emit a huge amount of waste, particulate matter, microplastics, etc., from the rubber tyres [23,24]. In Samarkand, the majority of waste is disposed of in landfills, with only about 3–4% being recycled, reflecting a significant shortage of recycling facilities, while the existing combustors merely transform one type of waste into another rather than providing a sustainable solution [25,28].

C. Recycling and Innovation

Recycling and innovative approaches to waste treatment play a decisive role in reducing the ecological and health impacts of industrial and household waste. Proper implementation of these methods helps to conserve natural resources, minimize landfilling, and reduce pollutant emissions [29,30].

Recyclable Waste. Most categories of waste can be recycled, which helps to reduce the growth of landfills and conserve natural resources. Waste can generally be divided into two main groups: waste suitable for the production of recyclable materials, and waste suitable for reuse in industrial production. Although recycling requires financial investment, it is economically beneficial in the long term because it produces secondary raw materials.

Waste Treatment and Cleaning. Waste cleaning involves a combination of recycling, treatment, and disposal. Each method has its own purpose:

- Recycling transforms waste into new products, reducing the volume of material sent to landfills.
- Treatment is especially important for hazardous waste, as it reduces its harmful properties before disposal.
- Disposal is used as a last resort when recycling or treatment is not feasible, ensuring safe containment of waste.

The most effective cleaning strategy depends on the type and quantity of waste produced. Recycling is best suited for non-hazardous waste, while treatment is necessary for hazardous materials to reduce environmental and health risks. Disposal should only be used as a last resort for waste that cannot be recycled or treated. The choice between recycling, treatment, and disposal must therefore be carefully adapted to the specific characteristics of the waste in question.

IV. Conclusions

The analysis of waste management approaches allows us to draw several important conclusions and recommendations. Effective waste management requires coordinated efforts from authorities, specialized organizations, and the population.

A. Recommendations for Authorities and Organizations

- Establish collection points for household and industrial waste, as well as recycling facilities, with mandatory licensing for hazardous waste management.
- Define clear regulations for organizations engaged in the disposal and processing of hazardous and non-hazardous waste.
- Organise a selective collection of solid waste and ensure its reuse in economic circulation as an additional source of raw materials.
- Create specialized municipal services for the removal of solid and liquid household waste, ensuring proper licensing for hazardous waste management.
- In areas without municipal waste removal services, local governments should conclude contracts with licensed specialized enterprises or individual entrepreneurs.
- Set deadlines for household waste removal, approve tariffs for waste management services, and provide payment benefits for socially vulnerable groups.
- Conduct regular activities aimed at eliminating unauthorized landfills and preventing their reappearance.
- Develop properly designed landfills with subsequent reclamation of existing authorized disposal sites.

B. Recommendations for the Population

- Practice separate collection of household waste such as textiles, glass, paper, and plastics by using labelled containers or delivering materials to specialized enterprises.
- Follow proper waste disposal practices, avoid polluting the environment, and educate children on responsible waste management.

• Be aware of hazardous household waste, such as mercury lamps and used batteries, which require special storage, collection, and disposal conditions.
• Avoid storing household waste, especially hazardous types, inside dwellings, as improper storage may result in administrative measures.
• Refrain from unauthorized burial or incineration of waste, as these practices pollute the environment and harm public health.

Overall, sustainable waste management requires a balance between recycling, treatment, and safe disposal, supported by clear regulations and public awareness. Authorities must ensure an effective infrastructure for waste collection and processing, while the population should take an active role in reducing waste generation and practicing environmentally responsible behaviour. Only through joint responsibility can society minimize the negative impact of waste on the environment and human health, while moving toward sustainable development.

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