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Solid Waste Management in Ubari, Libya: Reality, Obstacles, and Solutions

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Abstract

This study investigates the current state of solid waste management in the city of Ubari, located in the southwest of Libya, amidst escalating environmental and economic challenges and the absence of an effective and sustainable system for waste handling. The research aims to evaluate the existing situation concerning the collection, transportation, storage, and final disposal of waste, with a focus on daily generated quantities, the composition of household solid waste within the city, the level of public awareness, and the availability of human and material resources. The study estimates the individual waste generation rate to be approximately 1 kg/day, resulting in a total annual production of 17,520 tons. This waste is collected using traditional methods and limited equipment, lacking a sorting or recycling system and exhibiting a near-complete absence of treatment facilities or sanitary landfills. The research also identified several significant obstacles, including insufficient funding and resources, a scarcity of trained personnel, and a weak role in monitoring and law enforcement. The study recommends the necessity of developing a comprehensive waste management strategy grounded in sustainability principles, training local personnel, activating the role of media and environmental education for the community, alongside fostering collaboration between the municipality, governmental bodies, and the private sector to promote and support sustainable waste management.

Keywords: Solid Waste Management, Ubari City, Landfill, Environmental Pollution, Sustainable Waste Management.

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إدارة النفايات الصلبة بمدينة اوباري الليبية: الواقع، المعوقات، والحلول

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الملخص

تتناول هذه الدراسة واقع إدارة النفايات الصلبة في مدينة أوباري الواقعة جنوب غرب ليبيا، في ظل تحديات بيئية واقتصادية متزايدة، وغياب منظومة فعالة ومستدامة للتعامل مع النفايات. تهدف الدراسة إلى تقييم الوضع الراهن لعمليات الجمع والنقل والتخزين والتخلص النهائي من النفايات، مع التركيز على الكميات المنتجة يوميًا، ومعرفة تركيبة النفايات الصلبة المنزلية بالمدينة، ومستوى وعي السكان، ومدى توافر الإمكانيات البشرية والمادية. تقدر الدراسة حجم إنتاج الفرد من النفايات بحوالي 1 كجم/اليوم، وبإجمالي إنتاج سنوي يبلغ 17,520 طنًا، يتم جمعها بطرق تقليدية وباستخدام معدات محدودة، مع افتقارها إلى نظام فرز أو إعادة تدوير، وغياب شبه تام لمحطات المعالجة أو المكبات الصحية. كما كشفت الدراسة عن وجود العديد من المعوقات، منها ضعف التمويل، والامكانيات، وقلة العمالة المدربة، وضعف دور المراقبة وتطبيق القانون. أوصت الدراسة بضرورة إعداد استراتيجية شاملة لإدارة النفايات ترتكز على مبادئ الاستدامة، وتدريب الكوادر المحلية، وتفعيل دور الاعلام وتثقيف المجتمع بيئاً، إلى جانب تعزيز التعاون بين البلدية والجهات الحكومية والخاصة لتعزيز ودعم الإدارة المستدامة للنفايات.

الكلمات المفتاحية: إدارة النفايات الصلبة، مدينة اوباري، مكب النفايات، التلوث البيئي، الإدارة المستدامة للنفايات.

1. Introduction

Waste management encompasses the systematic monitoring, collection, transportation, processing, recycling, or disposal of waste materials, typically referring to refuse generated by human activities. This procedure is fundamentally aimed at mitigating

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detrimental effects on human health and the environment (El-Achkar, 2023). Globally, the escalating generation of solid waste, driven by intensified urbanization, industrialization, and evolving consumption patterns, presents substantial environmental, social, and economic challenges to communities worldwide. Effective solid waste management is therefore paramount for safeguarding public health, preserving environmental resources, and fostering sustainable development (UNEP, 2015). Nevertheless, numerous developing nations, including Libya, encounter significant difficulties in establishing efficient solid waste management systems, often characterized by suboptimal collection efficacy, rudimentary disposal methodologies, and limited resource recovery. Within the southwestern region of Libya, the city of Ubari faces unique complexities in the management of its solid waste stream. In addition to a challenging socio-economic context, the absence of a robust and sustainable solid waste management infrastructure in Ubari constitutes a growing public health and environmental concern. Uncontrolled waste accumulation can lead to the contamination of land and water resources, the proliferation of diseases, and adverse impacts on the aesthetic and ecological integrity of the area. Understanding the current status of solid waste management in the city of Ubari represents a crucial initial step towards the formulation of contextually relevant and effective solutions. This study seeks to address the critical challenges pertaining to solid waste management in the city, which include: Firstly, the notable surge in solid waste generation rates and its subsequent accumulation in urban areas, posing an increasing environmental and health burden. Secondly, the acute deficiency in essential infrastructure required for the efficient and sanitary collection, transportation, and disposal of waste. Thirdly, the environmental degradation resulting from unsustainable waste management practices, negatively impacting soil and water quality. Fourthly, the absence of a comprehensive and integrated solid waste management system that embraces the principles of source reduction, recycling, and safe disposal. Fifthly, the weakness of the institutional and legislative framework governing the solid waste management sector at the local level. Sixthly, the intricate influences of socio-economic factors on residents' waste-related behaviors and patterns. Lastly, the limited access to modern and appropriate technologies for the effective treatment and disposal of solid waste.

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Based on the aforementioned problems, this study aims to achieve a set of interconnected objectives, which are summarized as follows: (1) To establish a comprehensive database on the current state of solid waste management in the city of Ubari, serving as a fundamental reference for future planning and implementation processes. (2) To identify and analyze the primary impediments hindering the adoption and implementation of sustainable solid waste management practices within the local context. (3) To propose practical, effective, and implementable solutions to overcome these obstacles and sustainably improve the solid waste management system in the city of Ubari, in accordance with environmental, health, and legal standards.

1.1. Previous Studies

The study by **(**Al-Jitlawi et al., 2023) concluded that Libya, as a nation, confronts numerous deficiencies in the sound management of solid waste. A key aspect of the factors contributing to these shortcomings in Libya's waste management is the absence of an efficiently designed infrastructure framework to address the proper handling of the solid waste generated within the country. The challenges associated with inadequate solid waste management in Libya include a lack of financial resources for the waste management sector, a shortage of specialized human resources, and a deficiency in technological infrastructure and planning.

The study by (Omran et al., 2011) found that despite a significant portion of the Bani Walid municipality's budget being allocated to solid waste management, poor waste collection and insufficient transportation continue to result in waste accumulation throughout the city of Bani Walid. Currently, no treatment is applied to the waste, which is disposed of after collection. Due to a severe shortage of equipment and basic infrastructure, the government and authorities in Bani Walid should explore the possibilities of private sector involvement to ensure the effective management of solid waste in their areas.

(Al-Jali's, 2020) study concluded that the waste collection and transportation process is not carried out with the required efficiency due to the limited capabilities of the cleaning company, which are disproportionate to the city's population. This is compounded by a lack of field monitoring of waste collection operations, and the final disposal of waste is conducted using traditional methods.

The study by (Rasan et al., 2016) showed that the average rate of household solid waste generation for the city of Baqubah is 0.615

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kg/capita. Household waste from Baqubah city alone produces approximately 2.17 tons daily of paper and 12.5 tons of plastic and other materials. Furthermore, 27% of the total waste is landfilled in a dump.

The study by (Ali et al., 2020), focusing on African cities, indicated that solid waste management faces obstacles related to weak legislation, low community awareness, declining investments in recycling, and the absence of effective monitoring and evaluation systems.

Additionally, the study by (Yousif & Scott, 2007) emphasized the importance of involving the private sector and local communities in improving waste management systems, noting that this approach has proven effective in several developing cities.

In comparison to the previous studies, this research intersects with them in several aspects. However, the key difference lies in the fact that each region has its own specificities and unique problems that distinguish it from others. This study addresses the critical challenges of solid waste management in Ubari, which can be summarized as: high rates of solid waste generation and accumulation; a lack of essential infrastructure for effective waste management; the resulting environmental pollution impacting soil and water; the absence of an integrated solid waste management system encompassing waste reduction, recycling, and safe disposal; institutional and legislative weaknesses; socio-economic influences on residents' waste-related behaviors; and a deficiency in appropriate technologies for the effective treatment and disposal of solid waste. The consequences of these challenges pose an increasing threat to public health and environmental safety in the region.

1.2. Study Methodology

This study utilizes a comprehensive methodological framework to examine solid waste management (SWM) in Ubari, primarily through a descriptive analytical approach. This method involves systematic data collection on waste types, collection methods, and disposal practices to identify existing challenges within the SWM system. Understanding these obstacles serves as a foundation for further research phases.

An inductive approach complements the descriptive analysis by identifying overarching patterns and generating general conclusions from the data. This helps in understanding the complex relationships

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influencing waste management practices and informs the development of tailored, evidence-based recommendations.

The study also employs a mixed-methods approach, incorporating both quantitative and qualitative dimensions. Quantitative analysis focuses on key SWM metrics, such as waste generation rates and composition profiles, establishing the scale of the challenge. Qualitative insights offer context on socio-cultural factors and institutional barriers, enriching the overall findings.

Lastly, a systems analysis perspective views SWM as an interconnected system comprising inputs (generated waste), core processes (collection and treatment), and outputs (disposal and recycling). This approach helps identify strengths and weaknesses within the SWM system, allowing for comprehensive improvements and assessments of the impact of potential changes on interconnected components.

1.3. Study Area

Ubari City, located in southwestern Libya about 1,000 kilometers south of Tripoli, it is the largest urban center in the Wadi al-Hayaa region. Covering an area of 96 km², it includes the city center, Dissah District, and Al-Mashroo District. The population is approximately 35,000 residents registered in the Ubari Civil Registry (Civil Registry, 2025), plus around 10,000 additional residents, including foreigners and expatriates, living in the city for work or trade. Figure (1) illustrates the study area.

Figure1. Geographical Location of the Study Area.

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1.4. Waste Classification and Sources

Waste is categorized based on its source, condition, and environmental impact. Accordingly, waste management involves collection, transportation, treatment, and disposal processes. Table (1) illustrates the different categories and types of waste.

Table 1. Shows Waste Categories, Types, and Sources

Category	Source	Category	Source
Household waste	Residences, hotels, street sweeping waste	Bulky household waste	Residences, industrial facilities, commercial establishments, hotels, artisans, offices, and administrative buildings
Household-like waste	Restaurants, educational institutions and universities, public offices and administrations, retail stores, prisons, and military barracks	Construction and demolition waste	Homes, administrative buildings, public works, infrastructure projects
Garden and green space waste	Municipal and public parks, school and university gardens, hospital gardens, prison and military barrack gardens	Non-hazardous industrial waste	Homes, administrative buildings, public works, infrastructure projects

2. Materials and Methods

The study implemented a series of strategic steps and methods to effectively generate compelling results:

2.1. Study and Analysis of the Current Situation

This step is the most crucial, as understanding, diagnosing, and evaluating the existing conditions and current practices related to waste management are essential for developing effective solutions. The current status of waste management in the city can be assessed through the following steps:

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Data on Solid Waste Management in the City

The solid waste management situation in the city can be summarized with the following data (Ubari Municipality General Cleaning Services Office, 2025):

a) The General Cleaning Services Office is responsible for waste management in the municipality, covering only about 80% of the city's solid waste. Around 10% is taken directly to the landfill by residents, often due to proximity or limited access to services.

b) Waste containers are scarce and available mainly in the city center. Collection occurs daily, both morning and evening, in serviced areas. Two medium-sized compactor trucks (15m³ capacity) each make four trips daily, along with two tipper trucks making eight trips, resulting in an average of 48 tons of waste transported to the disposal site daily (Ubari Municipality Environmental Health Affairs Department, 2025).

c) The Ubari Municipality General Cleaning Services Office lacks a comprehensive database for tracking essential waste management information, including vehicle routes, collection quantities, and maintenance records.

Composition of Household Solid Waste in Ubari City

The study of household waste composition involved the following steps:

1. Random samples were collected from 10 households in the city.
2. The samples were mixed to create a homogeneous mix weighing 55 kg.
3. The waste was spread on a tiled surface to avoid soil contamination.
4. Main categories of waste were identified and sorted manually.
5. Each category was weighed separately.

The results are documented in Table (2) and Figure (2).

Table 2. Shows Categories of Household Waste and Their Weight in kg (Authors)

No.	Waste Category	Weight (kg)
1	Organic Waste	25.5
2	Plastics	10.0
3	Paper & Cardboard	8.5

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No.	Waste Category	Weight (kg)
4	Textiles	7.3
5	Glass	2.7
6	Metals	1.0
	Subtotal (1–6)	55.0
	Total Sample Weight	55 kg

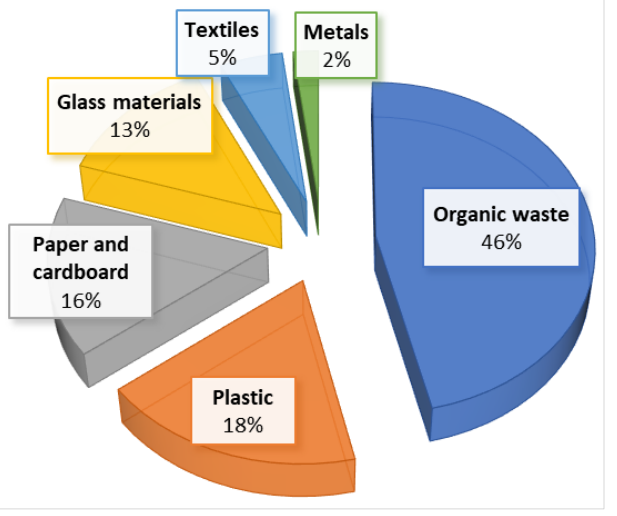

Figure 2. Household Waste Composition in Ubari City

The waste composition chart in Figure (2) shows that organic materials make up the largest portion of the total waste volume, accounting for 46%. This is followed by plastic materials at 18%, which include water bottles and food packaging. Paper and cardboard represent 16% of the waste, while glass materials comprise 13%. Textile materials account for 5%, and metal materials make up a very small fraction, not exceeding 2% of the total waste volume. This low proportion of metal waste is due to its separation at the source for reuse and sale as scrap.

Per Capita Solid Waste Generation and Total Municipal Waste Production

The per capita waste generation can be calculated using:

$$\mathbf{WGP} = \frac{W_{total}}{P}$$

WGP = Waste Generation per Person

W_ total = Total solid waste generated

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P = Population

Given that:

- Total daily waste production = 48 tons/day (17,520 tons/year) (Environmental Sanitation Affairs Department, Ubari 2025).
- Population = 45,000 inhabitants.

Thus:

$$\mathbf{WGP} = \frac{48000}{45000} = 1.06 \text{ kg/person/day}$$

The calculation reveals an average per capita waste generation of approximately 1 kg/person/day. This figure aligns with the standard rate of 1 kg/person/day adopted by the Public Sanitation Company (Municipal Sanitation Services Office, 2025).

Comparative analysis with other countries shows: Saudi Arabia: 1.38 kg/person/day (General Authority for Statistics, 2017), Abu Dhabi: 1.65 kg/person/day, United Kingdom: 1.32 kg/person/day, United States: 2.04 kg/person/day (Al-Breiki, 2017). These higher rates in developed nations reflect the correlation between economic prosperity and waste generation, where increased income and consumption levels lead to greater waste production.

Current Waste Disposal Sites

The city currently operates only one landfill as its final disposal site, and there is no waste transfer station available.

Final Disposal Site: The landfill is located approximately 6 to 10 kilometers south of the city center and spans an area of about 45 hectares. Its operations are irregular and lack supervision. As illustrated in Figure (3), the location of the final disposal site presents several environmental challenges for the city of Ubari, primarily due to the negative impacts associated with the current landfill.

Characteristics of the Landfill:

1. The landfill functions as an open space where waste is dumped haphazardly.
2. It does not meet the minimum technical and health requirements for landfill construction, resulting in deteriorating environmental and health conditions both at the site and in surrounding areas.
3. There are no designated landfill cells or fencing around the site.

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4. Waste is scattered across large areas, left to decompose in the open air, or occasionally burned.
5. Its unsuitable geographical location, situated near mountains and farms in an area with multiple valleys and watercourses, significantly contributes to local pollution.
6. The indiscriminate dumping of waste, coupled with the absence of a designated and enclosed area, has resulted in the spread of garbage across approximately 4.5 kilometers in length and widths ranging from 100 meters to 270 meters.
7. Given the landfill's position south of the city and the prevailing winds that blow from the south and southeast for most of the year, smoke and toxic gases from burning waste directly affect the city. This leads to air pollution that negatively impacts the health of residents.
8. The decline in the landfill's environmental conditions can be attributed to poor management, a lack of machinery and human resources for oversight, inadequate security and fencing, and insufficient financial resources allocated for its operation.

Figure 3. Final Waste Landfill Location in Ubari City (Google Earth, 2025)

Medical Waste

There are no specific measures for managing medical waste, which is often mixed with municipal waste and sometimes dumped randomly at disposal sites. The lack of proper treatment equipment and adherence to environmental standards contributes to a poor health and environmental situation, as this hazardous waste poses significant risks to public health.

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Abattoir and Butcher Waste

There is currently no plan for managing this type of waste, which is randomly dumped at final disposal sites.

Demolition and Construction Waste

There is no effective plan for managing demolition and construction waste, which is often improperly dumped in neighborhoods and streets. Although the Cleaning Services Office conducts occasional collection campaigns, these efforts are usually disorganized.

Street Sweeping and Square Cleaning

Street sweeping is restricted to main streets and public squares in the city center of Ubari.

Working Conditions of Cleaning Center Workers

The working conditions of the municipality's Cleaning Center workers are poor, primarily due to the lack of periodic medical examinations and insufficient work uniforms and protective equipment.

Waste Collection and Transportation Vehicles

The municipality's Public Cleaning Services Office has an inadequate number of vehicles for the city's size and waste volume, relying on just four vehicles: two 15m³ compactor trucks and two Kenworth dump trucks (Public Cleaning Services Office, 2025).

Maintenance Workshop

The current state of the municipal maintenance workshop reflects significant deficiencies in both infrastructure and operational practices. The workshop is limited to performing only basic mechanical maintenance tasks, with no capacity for bodywork, welding, or systematic cleaning. This limitation severely restricts the workshop’s ability to ensure the full operational readiness of the vehicle fleet. Moreover, the available maintenance equipment is outdated, and many tools require replacement or supplementation due to loss or wear, which further hinders the efficiency of routine operations. Another critical shortfall is the complete absence of a vehicle washing station, resulting in irregular cleaning of vehicles and contributing to poor hygiene and the deterioration of equipment. Additionally, the workshop lacks a formal documentation system for recording maintenance activities, leading to gaps in tracking

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performance and identifying recurring mechanical issues. Evaluations conducted regarding the quality of vehicle maintenance were classified as "very poor," while assessments of vehicle cleanliness were also deemed inadequate. These findings indicate an urgent need for comprehensive restructuring and investment in the workshop's infrastructure, equipment, and administrative processes to ensure reliable service delivery and prolong the lifespan of municipal vehicles.

Information and Environmental Awareness Development

This aspect reflects weakness and neglect, as there is no dedicated environmental information office or media space for environmental issues in the municipality.

3. Results and Discussion

The assessment of solid waste management in Ubari city has identified key problems that hinder effective and sustainable practices. Based on these findings, we can propose solutions for improving waste management in the city through:

3.1. Identifying Strengths, Weaknesses, and Developing Appropriate Solutions

Table 4 illustrates the strengths and weaknesses of sound solid waste management and proposes solutions to address these weaknesses.

Table 4. Strengths / Weaknesses / and Proposed Solutions to Overcome Weaknesses

Strengths	Weaknesses	Proposed Solutions
- The municipality's willingness to improve and move toward a better stage in solid waste disposal. - Integration of the cleaning services center (previously part of the General Cleaning Company) into the municipality, supporting decentralization and enabling faster and more efficient support. - The presence of a competent and supportive municipal council staff.	Shortage of equipment and machinery dedicated to waste management.	Support the Cleaning Services Office with the necessary machinery and equipment.

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Strengths	Weaknesses	Proposed Solutions
- Availability of field labor: Despite the limited resources, the presence of sanitation workers indicates an existing operational structure that can be enhanced through training and motivation.	Absence of a database and dashboard for monitoring key performance indicators of the waste management system. Limited coverage of municipal waste collection services across the city.	Develop and implement a dedicated waste management database system. Develop a comprehensive plan to ensure full municipal coverage for waste collection services.
- Designated waste collection sites: The existence of specified locations for waste disposal facilitates the organization and control of waste collection routes and logistics.	Poor condition of the final landfill and absence of an interim transfer station.	Rehabilitate the final landfill according to environmental and health standards and establish a technically compliant interim transfer station.
- Potential for collaboration with the local community and social leaders: The strong communal character of Ubari presents an opportunity to engage residents in awareness campaigns and encourage participation in waste sorting and cleanliness efforts.	Lack of a local plan for managing construction and demolition waste.	Develop a municipal plan for the management of construction and demolition waste.
	Lack of a dedicated medical waste management plan.	Develop and implement a medical waste management plan as a matter of urgency due to its hazardous nature.
	The current condition of the landfill requires urgent intervention.	Immediate rehabilitation and remediation of the current landfill is recommended.
	Lack of human resource development and poor working conditions.	Establish a training and capacity-building program for staff and improve workers' conditions.
- Availability of vast land areas for potential sanitary landfills: The presence of unused land represents a valuable opportunity for establishing future waste treatment facilities or environmentally compliant landfill sites.	The maintenance system for waste collection vehicles is critically weak.	Develop a rehabilitation plan for the municipal maintenance workshop.

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Strengths	Weaknesses	Proposed Solutions
- Suitability for implementing low-cost (low-tech) recycling and treatment models: The local context is conducive to applying simple yet effective environmental solutions, such as source separation of waste and local composting of organic materials.	Absence of functional service zoning in the city, with major inefficiencies in waste collection routes.	Implement a zoning system to divide the city into waste service areas and assign collection routes accordingly.
	Lack of an environmental awareness and media strategy.	Design and launch an environmental awareness and outreach program.
	Absence of an analytical accounting system for calculating waste collection costs.	Establish a cost-accounting system to assess and optimize collection expenditures.
	Lack of enforcement of waste collection fees for commercial activities.	Collaborate with stakeholders to activate legislative provisions related to paid waste collection for economic sectors.
	Weak enforcement and lack of political will to apply regulations.	Strengthen the role of municipal guards and the environmental health unit to enforce compliance.

3.2. Division of the City into Service Zones

Due to the lack of a designated service and organizational division within the city, and recognizing the needs of effective and sustainable solid waste management, it has been proposed to divide the greater Ubari area—comprising Ubari City Center, the Al-Dissah District, and the Al-Mashroo District—into 15 service zones based on population density. This division will facilitate the scientific and practical provision of waste collection and transportation services, leading to organized and efficient waste management rather than randomness. Please refer to Figure (4) for details.

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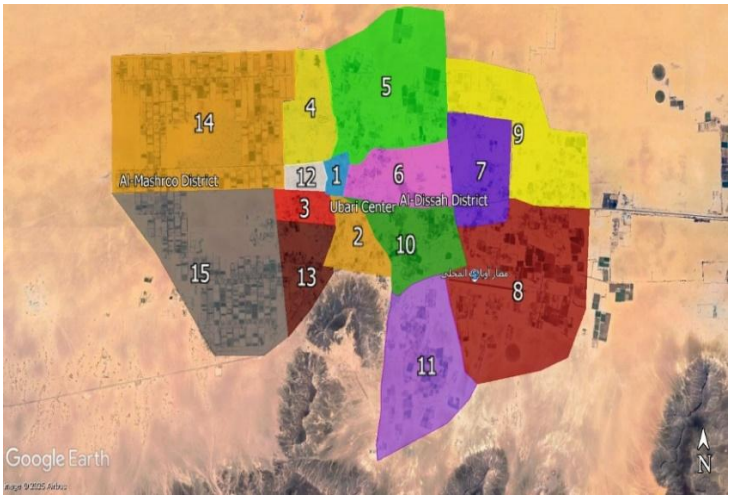

Figure 4. Service Zoning of Ubari City

3.3. Establishing a Transfer Station for Waste Meeting Technical Requirements

The establishment of a waste transfer station that meets all necessary environmental and health requirements for landfill construction is an urgent need in the city's solid waste management system. The design of an integrated transfer station involves creating an efficient and safe facility that serves as an intermediate step in solid waste management. This facility should include:

1. Organized reception and initial sorting areas.
2. Mechanical processing systems to separate recyclable materials and reduce the volume of residual waste.
3. Dedicated storage areas for sorted materials and residual waste.
4. Systems for managing leachate and emitted gases.
5. Integrated service and administrative facilities.

To enhance the environmental performance of the facility, special attention should be given to traffic flow, the inclusion of green spaces, and barriers that minimize environmental impacts. This design approach will also help reduce transportation costs and improve the efficiency of waste treatment in accordance with environmental standards. Figure (5) shows the proposed design for the transfer station. To ensure that the waste transfer station is effective, safe, and environmentally friendly, the following specifications and standards must be met:

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Firstly: Location and Design:

1. The site should be close to areas that generate waste to minimize transportation costs.
2. It should be located away from residential areas and water sources to avoid negative health and environmental impacts.
3. The site must be easily accessible for waste transport vehicles.
4. The design should accommodate the type and volume of waste expected.
5. Separate areas should be designated for storing different types of waste (recyclable, organic, hazardous, etc.).
6. A rainwater drainage system should be included to prevent water pollution.
7. Public safety measures should be implemented.

Secondly: Infrastructure:

1. Floors must be solid and resistant to liquid leakage.
2. Floors should be easy to clean and maintain.
3. Appropriate containers for different types of waste must be provided.
4. Containers should be resistant to corrosion and leakage, and easy to empty and clean.
5. Necessary equipment for loading and unloading waste should be available.
6. Equipment for compacting waste to reduce its volume should be included.
7. Equipment for transporting waste between different storage areas should also be provided.

Thirdly: Waste Management Operations within the Transfer Station:

1. Sorting: Waste should be sorted on-site before storage, with recyclable materials separated from non-recyclables.
2. Storage: Waste should be stored in a manner that prevents unpleasant odors and the breeding of insects. Hazardous waste must be stored safely to prevent pollution.
3. Transportation: Waste should be regularly transported from the transfer station to the final disposal site using appropriate vehicles to prevent leakage.

Fourthly: Environmental Considerations:

1. Odor Control: Measures must be implemented to manage unpleasant odors.

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2. Insect and Rodent Control: Necessary steps should be taken to prevent the breeding of insects and rodents.
3. Water Pollution Control: Measures should be put in place to prevent the leakage of contaminated liquids into groundwater.
4. Air Pollution Control: Emissions from waste should be minimized.

Fifthly: Health and Safety Considerations:

1. Worker Protection: Personal protective equipment should be provided for workers, and they must be trained in safe waste handling practices.
2. Public Safety: Warning signs should be displayed at the site, and unauthorized access must be restricted.

Figure 5. The Proposed Design of the Transfer Station

3.4. Rehabilitation of the Final Disposal Site for Waste

The current waste disposal site in Ubari City is unsuitable, harming residents and the environment. This plan outlines steps to improve the landfill to meet international standards **(World Bank, 2018):**

1. **Conducting an Environmental Impact Assessment (EIA):**
   - Identify waste types.
   - Assess risks to groundwater, soil, and air.
   - Analyze site characteristics.

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2. **Selecting or Improving the Site:** The current location, near agricultural areas and watercourses, poses pollution risks. Ideally, a new site should be chosen away from population centers. If relocation isn't possible, improvements include:
    - Creating 500-meter buffer zones around the landfill.
    - Preventing leachate from contaminating groundwater.
3. **Designing to International Specifications:** This involves:
    - Installing a proper bottom liner.
    - Establishing a leachate collection system.
    - Installing a gas capture system for methane.
    - Dividing the landfill into managed cells.
4. **Effective Management and Operation:** Key practices include:
    - Weighing waste as it enters.
    - Daily soil cover for the waste.
    - Preventing open burning.
    - Assigning environmental monitors.
5. **Regular Monitoring:** Ongoing monitoring is essential to prevent pollution, including:
    - Testing well water.
    - Measuring greenhouse gas emissions.
    - Monitoring local wildlife.
6. **Closure and Rehabilitation Planning:** When landfill cells reach capacity:
    - Seal the cells.
    - Revegetate with appropriate plant cover.
    - Monitor the site for 30 years.
7. **Integration into Waste Management System:** Effective waste management from collection to disposal is vital. To reduce landfill volume:
    - Promote source sorting through education.
    - Encourage recycling and reuse.
    - Establish composting for organic waste.

3.5. Sustainable Management of the Solid Waste File in Ubari City

The city of Ubari in Libya is grappling with significant environmental challenges due to poor solid waste management. Its unique characteristics—such as being located in a desert and having uneven population and urban growth—make the adoption of a

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sustainable waste management model essential for protecting residents' health and the environment.

1. The Concept of Sustainable Solid Waste Management

Sustainable solid waste management aims to reduce waste generation, enhance resource reuse and recycling, and ensure safe disposal while considering environmental, economic, and social factors (Mehta et al., 2018). This approach is based on a waste management hierarchy that prioritizes reduction, reuse, recycling, energy recovery, and, finally, treatment or disposal. By promoting less wasteful practices, this hierarchy is vital for implementing effective waste management strategies (Ali et al., 2021). Figure (6) illustrates this hierarchy.

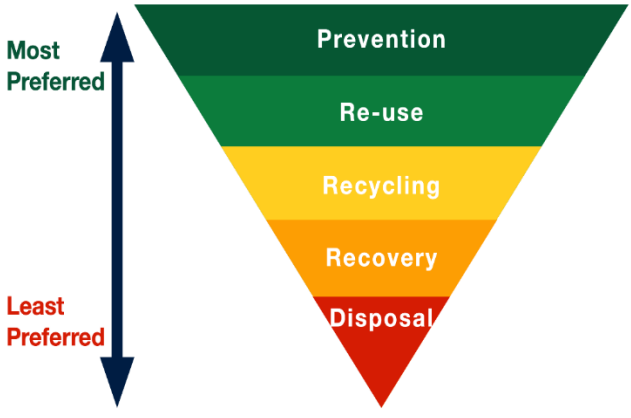

Figure 6. Sustainable Waste Management Hierarchy

2. Components of Sustainable Waste Management in Ubari City

Sustainable solid waste management includes several key components:

a) Waste Minimization:
- Launching awareness campaigns for citizens and institutions.
- Promoting responsible material use in markets and homes.

b) Source Separation:
- Providing colored containers for different waste types (organic, plastic, metal, medical).
- Training workers and citizens on sorting practices.

c) Recycling and Reuse:

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- Establishing neighborhood collection and sorting centers.
- Encouraging investment in projects for recycling plastic, paper, and organic waste.

d) Biological Conversion of Organic Waste (Composting):
- Utilizing microorganisms to convert organic waste into compost, biogas, or biofuel.
- Benefits include reduced landfill waste, useful products for agriculture, and lower greenhouse gas emissions.

e) Efficient Waste Transportation: Enhancing waste transport vehicle efficiency and planning smart collection routes.

f) Safe Final Disposal: Rehabilitating disposal sites to meet environmental standards and implementing engineered landfilling techniques.

g) Institutional Management: Establishing a local waste management unit with administrative independence and involving the private sector in planning.

h) Continuous Monitoring and Evaluation: Regularly assessing environmental impacts and using GIS to track waste generation.

3. Challenges and Opportunities

a) Challenges: Weak infrastructure, insufficient funding, and lack of community awareness.

b) Opportunities: Availability of labor, potential for international support, and economic benefits from recycling.

4. Conclusions

The study reached the following conclusions:

1. Absence of Scientific and Strategic Approach: Solid waste management (SWM) in Ubari city lacks a scientific methodology and a well-defined strategy and plan, mirroring a prevalent issue in numerous Libyan urban centers.
2. Systemic Operational Deficiencies: The SWM system encounters multiple challenges across the waste management continuum, encompassing collection, transportation, and final disposal stages.
3. Lack of Synchronization between Urban Growth and Waste Management Services: A discernible absence of coordination exists between population growth and urban expansion and the

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commensurate provision of waste collection and disposal services.

4. Absence of a Waste Management Database: A fundamental lack of a comprehensive database for tracking and managing the waste management process is evident.
5. Critical Shortage of Machinery and Equipment: A severe deficit in the availability of necessary waste collection machinery and equipment significantly hinders operational efficiency.
6. Lack of Waste Transfer Station: The absence of a designated waste transfer station further complicates the logistical aspects of waste transportation.
7. Substandard Final Disposal Site: The final waste disposal site is characterized by very poor environmental conditions, posing potential ecological and health risks.
8. Per Capita Waste Generation Rate: The per capita waste generation rate in Ubari is approximately 1 kg per person per day, consistent with the regional average for solid waste generation.
9. Dominance of Organic Waste: Due to ineffective source separation practices, organic waste constitutes the largest fraction of the total solid waste stream.
10. Significant Plastic Waste Contribution: Plastic materials represent the second largest component of the solid waste generated.
11. Minimal Metal Waste Quantity: The proportion of metal waste is minimal, attributed to its common practice of source separation for reuse or sale as scrap material.
12. Future Vision: Integrated and Sustainable SWM System: The envisioned future necessitates the implementation of an integrated and sustainable waste management system capable of delivering optimal services to the citizenry.
13. Key Components of Future Vision: This includes the establishment of efficient methodologies for the collection, transportation, and environmentally sound disposal of solid waste.
14. Emphasis on Recycling: Promoting the recycling of recyclable materials is a crucial element of the future SWM strategy.
15. Resource Allocation and Citizen Engagement: Allocating the requisite financial and material resources, alongside engaging and educating citizens, is essential for fostering sustainable development within the waste management sector.

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16. Minimal Metal Waste Quantity: The proportion of metal waste is minimal, attributed to its common practice of source separation for reuse or sale as scrap material.

5. Recommendations

1. Develop and implement an integrated, sustainable solid waste management system tailored to local needs.
2. Establish efficient and environmentally sound methods for waste collection, transportation, and disposal.
3. Emphasis on Recycling: Promoting the recycling of recyclable materials is a crucial element of the future SWM strategy.
4. Resource Allocation and Citizen Engagement: Allocating the requisite financial and material resources, alongside engaging and educating citizens, is essential for fostering sustainable development within the waste management sector.
5. Establish a transfer station with technical specifications for efficient waste transfer.
6. Identify a site for a new disposal facility that meets international standards, or rehabilitate the current landfill.
7. Implement city service zoning and a waste collection mechanism.
8. Create a program for sorting and recycling plastic waste to reduce overall waste.
9. Provide new vehicles for the Public Cleaning Services Office and maintain existing ones.
10. Rehabilitate the maintenance workshop.
11. Develop plans for managing construction and medical waste.
12. Establish a systematic database for waste management.
13. Create training programs to improve employee skills and working conditions.
14. Launch environmental awareness programs to disseminate information.
15. Ensure financial support is allocated based on clear goals.
16. Engage the private sector and civil society in sustainable solid waste management**.**

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