*Quest Journals*
*Journal of Software Engineering and Simulation*
*Volume 12 ~ Issue 4 (April 2026) pp: 34-39*
*ISSN(Online) :2321-3795 ISSN (Print):2321-3809*
www.questjournals.org

**Research Paper**

# Solid Waste Recycling in Tripoli: Reality, Challenges, and Future Prospects

Najah Eselini
*Department of Environmental Engineering, Higher Institute of Sciences and Technology – Tarhuna, Libya*

***Abstract***
*This study investigates solid waste recycling in Tripoli, Libya, focusing on public awareness, household practices, infrastructure, and institutional performance. A structured questionnaire was administered to 50 household heads across six districts. The findings reveal a critical awareness-practice gap: while 73.3% are familiar with recycling concepts, only 28.9% practice waste separation at home. Infrastructure deficits represent the primary barrier, with 88.9% reporting no dedicated separation containers. Despite challenges, 64.4% expressed willingness to participate in separation programs if infrastructure were provided. The study concludes that addressing Tripoli's waste crisis requires an integrated approach combining infrastructure development, legislative reform, institutional capacity building, and community awareness.*

***Keywords:*** *Solid waste management, recycling, household practices, infrastructure deficit, Tripoli, Libya, circular economy*

*Received 28 Mar., 2026; **R**evised 06 Apr., 2026; **A**ccepted 08 Apr., 2026 © The author(s) 2026.*
***P**ublished with open access at **www.questjournals.org***

## I. Introduction

Solid waste management is a pressing environmental, economic, and public health challenge facing urban canters worldwide (Kaza et al., 2018). Global waste generation is projected to increase by 70% by 2050 without urgent action (World Bank, 2022). The Middle East and North Africa (MENA) region generates approximately 0.8 kg per capita daily, with a projected 50% increase by 2050 (Al-Khatib et al., 2010). Libya, emerging from prolonged conflict, presents a complex case. Waste management infrastructure degraded significantly post-2011, with informal dumping sites proliferating across urban areas (Abusaada & Elshater, 2021). Tripoli, home to over one million residents, exemplifies these challenges with overflowing containers, irregular collection, and unofficial dumpsites (Elmahdawy et al., 2017). Recycling offers a strategic pathway toward the circular economy, providing environmental gains through resource conservation (Marshall & Farahbakhsh, 2013), economic opportunities through job creation (Ferronato et al., 2019), and social benefits through improved public health (Zurbrugg, 2003). However, developing countries face substantial barriers including weak infrastructure, limited investment, and insufficient community awareness (Guerrero et al., 2013).

This study addresses a gap in Libyan waste management literature by providing empirical data on community awareness, practices, and infrastructure needs. It aims to: (1) assess public awareness of recycling; (2) measure household practices; (3) identify barriers; (4) evaluate existing services; and (5) develop evidence-based recommendations.

## II. Literature Review

### 2.1 Key Concepts

Solid waste encompasses discarded materials from household, commercial, and industrial activities (Tchobanoglous et al., 2002). Reuse extends product life without significant processing, while recycling converts waste into raw materials for new products (Ghisellini et al., 2016; Singh et al., 2017). The circular economy shifts from linear "take-make-dispose" models toward closed-loop systems (Kirchherr et al., 2017).

### 2.2 Benefits of Recycling

- **Environmental:** Reduces resource extraction, energy consumption, and emissions. Aluminum recycling saves 95% of energy versus primary production (Das & Kumar, 2020).

- **Economic:** Creates employment across collection, sorting, and processing value chains (Ferronato et al., 2019).
- **Social:** Promotes environmental awareness and reduces local pollution sources (Zurbrugg, 2018).

**2.3 Waste Composition**

In Arab cities, organic waste dominates (50-65%), followed by paper (10-20%), plastics (8-15%), glass (3-6%), and metals (2-5%) (Ezeah et al., 2019).

**2.4 Successful Models**

| Model | Key Features |
|---|---|
| **Germany** | Extended Producer Responsibility (EPR), Green Dot system, mandatory sorting (Giegrich & Vogt, 2019) |
| **Singapore** | High-efficiency incineration, strong oversight, public education (Zhang et al., 2021) |
| **Morocco** | Public-private partnerships, sorting centers, community awareness (Ennaji et al., 2020) |
| **Tunisia** | Informal sector integration through cooperatives (Chaabane et al., 2021) |

**Table 1:** International Models of Waste Management and Their Key Features

**2.5 Legislative Frameworks:** Key instruments include Extended Producer Responsibility (Wilson et al., 2020), deposit refund systems (Lavee & Nativ, 2019), landfill taxes (Mazzanti & Zoboli, 2018), and producer incentives (Sahimaa et al., 2015).

**2.6 Informal Sector:** Informal waste pickers play significant recycling roles in developing countries. Formalization through cooperatives can improve working conditions and efficiency (Gutberlet, 2020; Sembiring & Nitivattananon, 2019).

## III. Methodology

**3.1 Research Design:** A descriptive-analytical cross-sectional design using a structured questionnaire (Fowler, 2014; de Vaus, 2013).

**3.2 Study Area:** Six Tripoli districts: Sidi al-Sayah, Qasr bin Ghashir, Ain Zara, Souq al-Khamis, Msayhel, and Sabia.

**3.3 Sample:** Convenience sample of 50 household heads, appropriate for a pilot study identifying key indicators (Babbie, 2020).

**3.4 Data Collection:** Six-section questionnaire covering demographics, awareness, practices, infrastructure, attitudes, and health impacts. Administered face-to-face (September-November 2025).

**3.5 Analysis:** SPSS version 26 used for descriptive statistics and cross-tabulations.

**3.6 Limitations:** Sample size limits generalizability; findings are indicative, not representative. Gender imbalance (88% male) and cross-sectional design are noted constraints.

## IV. Results

**4.1 Demographics**

| Characteristic | Category | % |
|---|---|---|
| Gender | Male | 88% |
| | Female | 12% |
| Age | 31-40 years | 44% |
| Education | University+ | 66% |

**Table 2.** Demographic Characteristics of Respondents

Average household size: 6.3 persons.

### 4.2 Awareness and Knowledge

- **Familiarity with recycling:** 90%
- **Waste as environmental problem:** 74%
- **Knowledge of recyclable materials:** 76%

**Information sources:** Internet (74%), Television (54%), Universities (24%), Municipal offices (14%), NGOs (0%).

### 4.3 Household Practices

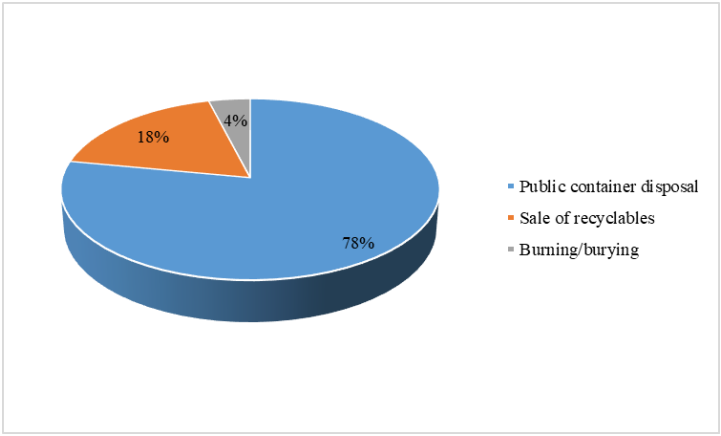


**Figure 1:** Waste Disposal Practices Among Respondents

**Waste separation:** Always 6%, Sometimes 32%, Rarely 24%, Never 38%.
**Reasons for non-separation:** No containers (90.3%), lack of knowledge (22.6%), lack of time (22.6%), not convinced (19.4%).

### 4.4 Infrastructure and Services

- **Difficulties with disposal:** 74%
- **Dedicated containers available:** Only 26%
- **Collection service rating:** Good 30%, Acceptable 30%, Poor 34%
- **Institutional performance:** Adequate 32%, Inadequate 38%, Partial 16%

### 4.5 Attitudes Toward Recycling

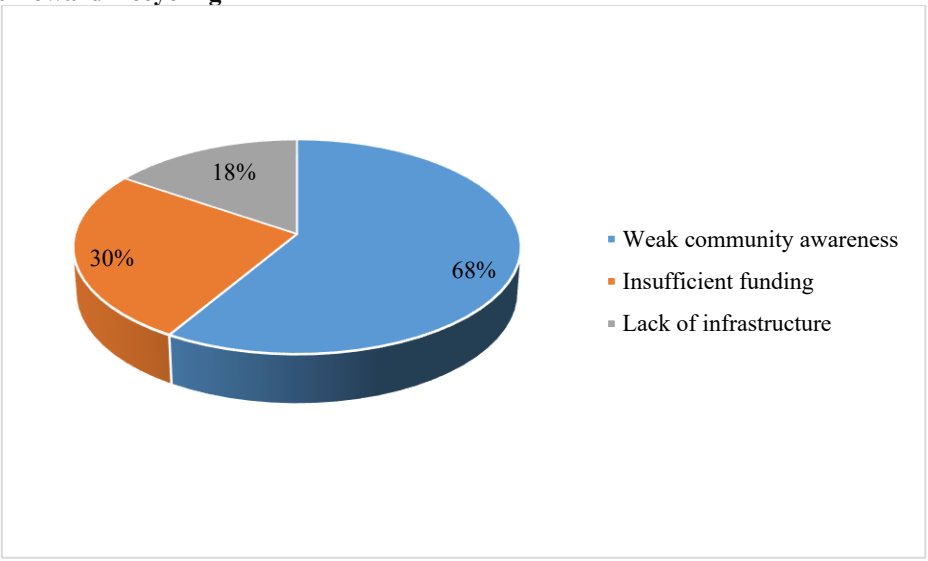


**Figure 2.** Shows attitude towards recycling

- **Willingness to participate if infrastructure provided:** Yes 36%, No 34%, Maybe 12%
- **Belief recycling improves environment:** 94%

**4.6 Environmental and Health Impacts**

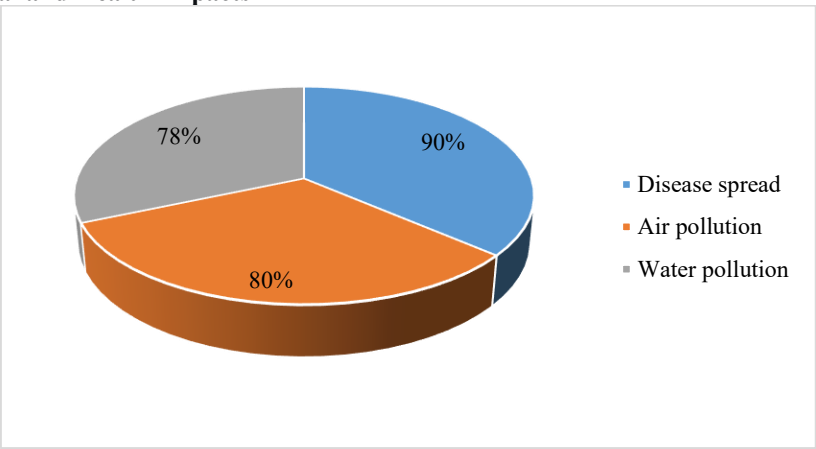


**Figure 3.** Shows environmental and health impacts s per the questionnaire

**4.7 Key Relationships**

- **Education:** University+ participants showed higher awareness (85% vs. 70%)
- **Age:** 31-40 age group most aware (82%); under 20 least aware (57%)
- **Infrastructure:** 100% with containers practiced separation; 70% without never separated

## V. Discussion

**5.1 The Awareness-Practice Gap**

This study reveals a substantial gap: 90% familiar with recycling versus 28.9% practicing separation. This aligns with research documenting similar gaps in developing countries (Kollmuss & Agyeman, 2002; Kennedy et al., 2015). The Theory of Planned Behavior (Ajzen, 1991) explains this through perceived behavioral control—infrastructure availability remains severely constrained despite positive attitudes.

**5.2 Infrastructure as Critical Barrier**

The finding that 90.3% of non-separators cite lack of containers aligns with Guerrero et al. (2013) identifying weak infrastructure as primary constraint. The strong association between container availability and separation (100% of those with containers practice separation) suggests infrastructure provision could rapidly increase participation.

**5.3 Institutional Performance**

Public dissatisfaction (54% rating institutions inadequate) reflects broader governance challenges in post-conflict Libya (Abusaada & Elshater, 2021). Rebuilding trust through transparent service delivery is essential.

**5.4 Public Readiness**

Despite challenges, 64.4% would participate with infrastructure, and 94% believe recycling improves conditions—a strong foundation for future initiatives.

**5.5 Regional Comparisons**

Tripoli's challenges mirror those in Casablanca, where public-private partnerships yielded improvements (Ennaji et al., 2020), and Tunisia, where informal sector integration proved effective (Chaabane et al., 2021).

## VI. Conclusion and Recommendations

**6.1 Conclusion**

Key findings:

1. **High awareness:** 73.3% familiar with recycling
2. **Low practice:** Only 28.9% separate waste
3. **Infrastructure deficit:** 88.9% lack dedicated containers
4. **Institutional weakness:** 53.3% rate institutions insufficient
5. **Public readiness:** 94% believe recycling improves conditions

Tripoli's waste crisis requires integrated solutions combining infrastructure, legislation, institutional capacity, and community engagement.

**6.2 Recommendations**

**6.2.1 Governmental Institutions**

1. **Develop national waste management strategy** with measurable targets
2. **Enact legislation:** Extended Producer Responsibility, landfill taxes, deposit refund systems

3. **Invest in infrastructure:** Separation containers in all neighborhoods, community sorting centers, dedicated collection fleets
4. **Strengthen capacity:** Dedicated recycling department, accountability mechanisms, staff training
5. **Integrate informal sector:** Cooperatives, training, protective equipment, fair pricing

#### 6.2.2 Civil Society and Private Sector

- **Civil society:** Awareness campaigns, school programs, practical demonstrations
- **Private sector:** Invest in recycling industries, corporate social responsibility initiatives, sustainable packaging

#### 6.2.3 Individual Citizens

- Separate recyclables at home
- Reduce single-use plastics
- Reuse products
- Participate in community initiatives

#### 6.2.4 Future Research

1. Large-scale survey ($n \geq 384$) across all Tripoli districts
2. Economic feasibility study for recycling facilities
3. Environmental impact assessment of dumpsites
4. Behavioral research on recycling motivations
5. Informal sector documentation

## References


[1]. Abusaada, Hisham, and Abeer Elshater. 2021. "Urban Recovery in a Post-War City." International Journal of Urban Sustainable Development 13 (2): 215–33.
[2]. Ajzen, Icek. 1991. "The Theory of Planned Behavior." Organizational Behavior and Human Decision Processes 50 (2): 179–211.
[3]. Al-Khatib, Issam A., Monou M., Abu Zahra A. S., Shaheen H. Q., and Kassinos D. 2010. "Solid Waste Management in the Palestinian Territory: Characteristics, Problems and Opportunities." Waste Management 30 (10): 2113–20.
[4]. Babbie, Earl R. 2020. The Practice of Social Research. 15th ed. Boston, MA: Cengage Learning.
[5]. Chaabane, Wiem, et al. 2019. "Shifting Towards Sustainable Integrated Solid Waste Management Systems: Case Study of Tunisia." Waste Management & Research 37 (1_suppl): 101–14.
[6]. Das, Subodh, and Animesh Kumar. 2020. "The Carbon Footprint and Energy Saving Potential of Aluminum Recycling." JOM 72 (2): 712–19.
[7]. De Vaus, David. 2013. Surveys in Social Research. 6th ed. London: Routledge.
[8]. Ellen MacArthur Foundation. 2019. Completing the Picture: How the Circular Economy Tackles Climate Change. Cowes, UK: Ellen MacArthur Foundation.
[9]. Elmahdawy, Khalifa, et al. 2017. "Solid Waste Management in Libya." Journal of Material Cycles and Waste Management 19 (4): 1347–55.
[10]. Ennaji, Walid, et al. 2020. "Municipal Solid Waste Management in Casablanca." Journal of Environmental Management 274: 111191.
[11]. Ezeah, Chaka, et al. 2019. "Analysis of Municipal Solid Waste Composition in Developing Countries." Waste Management & Research 37 (10): 979–96.
[12]. Ferronato, Navarro, and Vincenzo Torretta. 2019. "Waste Management in Developing Countries: A Review of Global Issues." Sustainability 11 (22): 6332.
[13]. Fowler, Floyd J. 2014. Survey Research Methods. 5th ed. Thousand Oaks, CA: SAGE.
[14]. Ghisellini, Patrizia, Catia Cialani, and Sergio Ulgiati. 2016. "A Review on Circular Economy: The Expected Transition to a Balanced Interplay of Environmental and Economic Systems." Journal of Cleaner Production 114: 11–32.
[15]. Giegrich, Jürgen, and Regine Vogt. 2019. "The German Packaging Ordinance." In Handbook of Recycling, edited by Ernst Worrell and Markus Reuter, 539–52. Amsterdam: Elsevier.
[16]. Guerrero, Lilliana A., Ger Maas, and William Hogland. 2013. "Solid Waste Management Challenges for Cities in Developing Countries." Waste Management 33 (1): 220–32.
[17]. Gutberlet, Jutta. 2020. "Waste Pickers at the Heart of the Circular Economy." Waste Management & Research 38 (10): 1047–49.
[18]. Kaza, Silpa, Lisa Yao, Perinaz Bhada-Tata, and Frank Van Woerden. 2018. What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. Washington, DC: World Bank.
[19]. Kennedy, Emily H., et al. 2015. "The Environmental Values-Behavior Gap in Canada." Human Ecology Review 16 (2): 151–60.
[20]. Kirchherr, Julian, Denise Reike, and Marko Hekkert. 2017. "Conceptualizing the Circular Economy: An Analysis of 114 Definitions." Resources, Conservation and Recycling 127: 221–32.
[21]. Kollmuss, Anja, and Julian Agyeman. 2002. "Mind the Gap: Why Do People Act Environmentally and What Are the Barriers to Pro-Environmental Behavior?" Environmental Education Research 8 (3): 239–60.
[22]. Lavee, Doron, and Tomer Nativ. 2019. "Deposit-Refund Systems for Beverage Containers." Resources, Conservation and Recycling 150: 104417.
[23]. Marshall, Rachael E., and Khosrow Farahbakhsh. 2013. "Systems Approaches to Integrated Solid Waste Management in Developing Countries." Waste Management 33 (4): 988–1003.
[24]. Mazzanti, Massimiliano, and Roberto Zoboli. 2008. "Waste Generation and Policy Effectiveness: Evidence from European Countries." Resources, Conservation and Recycling 52 (12): 1412–21.
[25]. Milios, Leonidas. 2018. "Advancing to a Circular Economy: Three Essential Ingredients for a Comprehensive Policy Mix." Sustainability Science 13 (3): 861–78.
[26]. Sahimaa, Olli, et al. 2015. "Climate Change Impacts of Waste Management." Journal of Cleaner Production 88: 111–19.
[27]. Sembiring, Emenda, and Vilas Nitivattananon. 2010. "Sustainable Solid Waste Management System for City of Bandung, Indonesia." Resources, Conservation and Recycling 54 (12): 1193–1200.
[28]. Singh, Jagdeep, et al. 2017. "Towards Zero Waste Manufacturing: A Multidisciplinary Review." Journal of Cleaner Production 168: 1230–43.

[29]. Tchobanoglous, George, and Frank Kreith. 2002. Handbook of Solid Waste Management. 2nd ed. New York: McGraw-Hill.
[30]. Wilson, David C., Costas Velis, and Chris Cheeseman. 2006. "Role of Informal Sector Recycling in Waste Management in Developing Countries." Habitat International 30 (4): 797–808.
[31]. World Bank. 2022. Trends in Solid Waste Management. Washington, DC: World Bank.
[32]. Zhang, Haibi, et al. 2021. "Sustainable Waste Management in Singapore." Journal of aterial Cycles and Waste Management 23 (1): 1–12.
[33]. Zurbrugg, Christian. 2003. "Urban Solid Waste Management in Low-Income Countries of Asia: How to Cope with the Garbage Crisis." Scientific Committee on Problems of the Environment (SCOPE).