Available online at www.CivileJournal.org

Civil Engineering Journal

Vol. 5, No. 10, October, 2019

A Suggestion of a Procedural Method for the Management of Post-War Waste

Aws S. Noaman [a*], Angham E. Alsaffar [b]

[a] Researcher, Department of Civil Engineering College of Engineering, Baghdad University, Baghdad, Iraq.

[b] Professor, Department of Civil Engineering College of Engineering, Baghdad University, Baghdad, Iraq.

Received 18 May 2019; Accepted 19 September 2019

Abstract

The increasing number of disasters (natural or man-made) worldwide has made post-disaster waste management an essential aspect of disaster recovery. This is obvious in Iraq where the Iraqi government faces an important challenge regarding the events of 2014 (ISIS gang conflict) and the accumulation of huge volumes of construction and demolition (C&D) waste resulting from military operations and terrorist destruction. Field surveys by the specialist teams estimated the amount of waste at about 10 million tons in the Nineveh governorate only, much of which comprises potentially useful materials that could be reused or recycled in the reconstruction process. This paper investigates the obstacles to the sustainable management of such waste in the Nineveh governorate. A pilot questionnaire survey of 76 experts working in the waste management sector was carried out to identify the obstacles to the sustainable management of accumulated waste in the Nineveh governorate. Data analysis was carried out using SPSS version 23.0. Based on the identified obstacles, a procedural method of managing post-war waste that accumulated in Iraq has been created. The paper illustrates several conclusions in the strategic, economic, social, and environmental sectors to address identified gaps in sustainable waste management in Iraq. It is hoped that this study's results will support post-disaster sustainable development goals in Iraq.

Keywords: Post-disaster Waste; Sustainable Waste Management; Iraq.

1. Introduction

"A disaster is a non-routine event that surpasses the ability of the affected area to deal with it in different aspects such as save lives, maintain property, and protect the social, ecological, economic and political stability." [1]. Disasters come in two types, natural (earthquakes and floods) and man-made (conflicts and wars), and these disasters have a considerable effect on the environment such as the destruction of buildings and infrastructure as well as social and physical effects [2]. All types of disaster create large volumes of waste that vary according to the nature and severity of the disaster [3]. The volume of waste generated by disasters in a short period exceeds twice the volume of annual waste generated in peacetime [4]. The presence of this huge volume of waste affects all aspects of an immediate response or recovery effort [5]. This waste represents, in many cases, a risk to human health from biological sources (flies, rodents, rotting carcasses), chemical sources (asbestos, oils, solvents), and physical sources (cuts, abrasions, collapse) [6]. In the long term, poor management of a clean-up can cause a slow and costly recovery [7]. However, the same waste could be a worthy source of materials in the reconstruction process and have a positive economic impact if an effective waste management strategy is adopted [1]. There may be valuable materials, such as metals and concrete, in the waste, which can represent a source of raw materials used in the reconstruction process [8]. Disaster waste management is an important

* Corresponding author: aws_ceng@yahoo.com

http://dx.doi.org/10.28991/cej-2019-03091400

aspect of the response and recovery of disasters to reduce the consumption of natural resources and create a positive environmental impact [6]. Disaster waste also represents a risk to human health through direct contact with the accumulated waste, which may contain hazardous waste such as explosive bodies, oils, and asbestos, or indirect contact through bugs and rodents, in addition to sudden collapse or structural failure [9]. The largest component of disaster waste would meet the classification of construction and demolition C&D waste [10]. Recent experiences indicate that the most important obstacle to the response process in a disaster is C&D waste management. The main challenge after each disaster is the management of the accumulated waste in the affected area, which affects the efficiency of the reconstruction process, the economy, and the environment [11].

2. Post-disaster Waste Management

The essential and most important aspects of post-disaster waste management operations are the removal and disposal of waste from the affected area [12]. Post-war waste in Iraq is a mixture of one or more of the following: general household waste, C&B materials, hazardous waste, and sometimes, explosive bodies [13, 14]. All of these types of waste have challenges regarding their disposal. There was an additional challenge after the war as a new mixed-type of waste was created, and this posed increased challenges regarding its collection, separation, cleaning, and disposal.

The sustainable management of post-disaster waste usually comprises the same processes of waste management, which includes collection, transport, processing, and disposal in a landfill, except where the waste is contaminated or contains explosive bodies [10].

In the case of huge amount of waste and in addition to the environmental impact and limitation of landfill sites, a more sustainable process for the management of post-disaster waste is urgently required in Iraq, this process faced by many obstacles that should be identified and removed.

3. Research Methodology

An extensive literature review has been made to explore the application of disaster waste management and its benefits in different countries. After that, a research method was designed to carry out this research work. In the later stage, pilot surveying was conducted to seek experts' opinion for the disaster waste management and the obstacles constraining its application, a set of questionnaire was designed to collect data from the construction industry. And finally a procedural method designed for the management of post-disaster waste based on questionnaire data analysis. The complete research methodology is shown in Figure 1.

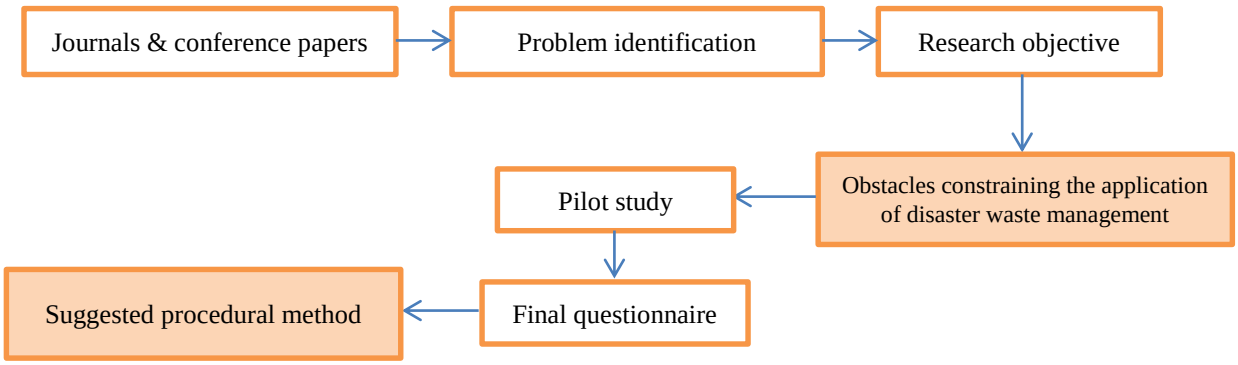

Figure 1. Research Methodology

4. Data Collection and Analysis

The results of surveys by Iraqi teams, supported by many other institutes and organizations in the Iraqi government and the UN, shows that the total number of ruined assets is 8,457 economic assets with a total damage value of 75.306 trillion Iraqi Dinar (ID) n government buildings and structures, also in the residential complexes and private properties. The most damaged governorate was Nineveh [13, 15] as shown in Table 1.

Table 1. Destruction value in the residential private sector [13]

Governorate	Destruction value (million ID)	Destruction percentage
Nineveh	12,580,540	43.5
Al-Anbar	6,040,316	20.9
Salahuldin	5,498,028	19.0
Kirkuk	1,954,827	6.8
Diyala	1,956,030	6.8

Baghdad	480,858	1.7
Babil	391,833	1.4
Total	28,902,433	100.0

A detailed literature review has been made for identifications of the obstacles constraining the application of post disaster management in Nineveh governorate (the most destructed city in Iraq) in this research. The identified obstacles were processed through a short pilot study. Specialist's opinion during pilot study is revised in final set of questionnaire which was send to practitioners working in construction industry and waste management. The respondents were requested to share their experience in assess the degree of effect of each obstacle. Finally, 76 questionnaires were considered for this research which was received during data collection period.

SPSS software V.23 has been successfully used for data analysis of such problems, therefore, same software used for data analysis in this paper.

5. Results and Discussion

As discussed earlier, the respondents were requested to share their opinion based on their experience in construction industry and waste management. 5-point likert scale has been provided to the respondents and requested to weight the degree of effect of each obstacle. Table 2 shows the degree of effect of obstacles constraining the application of disaster waste management in Iraq.

Table 2. Obstacles to the sustainable post-war management of waste

No.	Obstacle	Degree of effect
	Strategic	
1	Missing reliable information about the existence of waste	High
2	Lack of waste management intention in the related institution's policy	High
3	Lack of related regulations	Good
4	Lack of distribution of waste management responsibilities	Good
5	Lack of contractual experience	Good
6	Lack of coordination between the government and destroyed property owners	High
7	Inability to allocate temporary areas for waste management processes	Good
8	Lack of waste management plan	High
9	Lack of private sector partnership in the sustainable management field	High
	Social obstacles	
10	Lack of experts in the waste management field	Medial
11	Lack of awareness in the importance of disaster waste management.	Good
12	Existence of residential assemblies in the destroyed areas	Media
13	Lack of acceptance of the recycled (or reusable) materials in the local market	Good
14	Existence of historical buildings in the destroyed areas	Good
	Environmental obstacles	
15	Variety of waste leads to difficulty separating the components	High
16	Lack of landfill sites for the large amount of waste	Good
17	Inability to prepare new landfill sites according to environmental specifications	High
18	Existence of explosive remains in the waste	High
19	Existence of hazardous pollutants in the waste	High
20	The environmental impact of the waste	High
	Economic obstacles	
21	Not enough governmental financial allocations	High
22	Lack of invitations to the private sector to participate in waste management	High
23	The time required to collect and separate the waste	Medial
24	The time required for the recycling process	Good
25	Lack of specialized equipment and plants	High
26	The cost required to transport waste to the landfill sites	High
27	Waste transportation could hamper road traffic	Good
28	The local market does not absorb the high quantities of raw materials that are predicted to come from the reuse and recycling process	Good

As shown in Table 2, the final result of the questionnaire analysis listed 28 obstacles facing the application of sustainable management of C&D waste that accumulated in Mosul city after the war, distributed into four main sectors: strategic, social, environmental, and economical sectors, and the degree of effect for each one. Fourteen obstacles have a high degree of effect, 11 obstacles have a good degree of effect, and three obstacles have a medial degree of effect.

The 14 high-effect obstacles consist of five strategic obstacles, five environmental obstacles, and four economic obstacles. This distribution indicates an obvious weakness in the strategic management related to C&D waste management including the preparation of plans, the absence of specified and systematic procedures for construction waste management, the absence of coordination between the local governorate and the destroyed building owners in addition to an important aspect, the absence of private sector partnership in the field of sustainable management of post-war waste.

In the environmental sector, the importance of the high degree obstacles comprises the negative impact of the C&D waste on the environment and human health in addition to the explosive remains among the waste. The financial allocations generally represent an important challenge in all disaster responses, especially man-made disasters, because war exhausts most government budgets.

The researcher suggests developing strategic management of the C&D waste by creating a set of management procedures and regulations. The researcher also suggests increasing the awareness of local authorities and related institutes of the importance of construction waste management and the application of its procedures through training, seminars, and continuous improvement. In the financial sector, the researchers suggest taking steps toward private sector partnership in C&D waste management and the reconstruction process by modifying related regulations and learning from other country's experiments in this field. Other obstacles in the environment and social sectors can be passed through a management procedure followed and tracked by the management team responsible for the reconstruction process.

5.1. Suggested Procedural Method

Based on related literature [3, 5, 9, 16, 17] and the questionnaire data analysis, a procedural method has been suggested for managing the post-disaster waste in Iraq; Figure 3 shows the flow chart of the suggested procedure. (Suggested forms can be found in Appendix I.)

6. Comparison with Other Related Studies

The following table presents a comparison of this study's results and methodology with two related recent studies in the region.

Table 3. Comparison with related studies

Study	Work	Results
Ayman A. Awad et al. "Innovative Rehabilitation Methodology of Recycling Building Debris in Damaged Districts" (SYRIA) 2016.	Study of the solid waste generated during the war in Syria through field survey, and investigates an economical solution to make theses waste useful in the rehabilitation process.	Suggest techniques and methodology for recycling debris and rehabilitation strategies of damaged districts in Syria.
Ashraf Ali "Framework for Management of Post-Conflict Waste in Libya" 2017.	Study of the current status of post-conflict waste in Libya (volume of waste accumulated, actions undertaken to deal with it).	Propose a framework for the management of post-conflict waste in Libya.
Current study		
Aws. Noaman "A Suggestion of a Procedural Method for the Management of Post-War Waste" 2019.	Study of the waste accumulated after the war in Mosul city (Iraq) through field survey, and investigate the obstacles to the application of post disaster waste management.	List the obstacles constraining the application of post-disaster waste in Iraq and suggest a procedural method for managing the post-disaster waste.

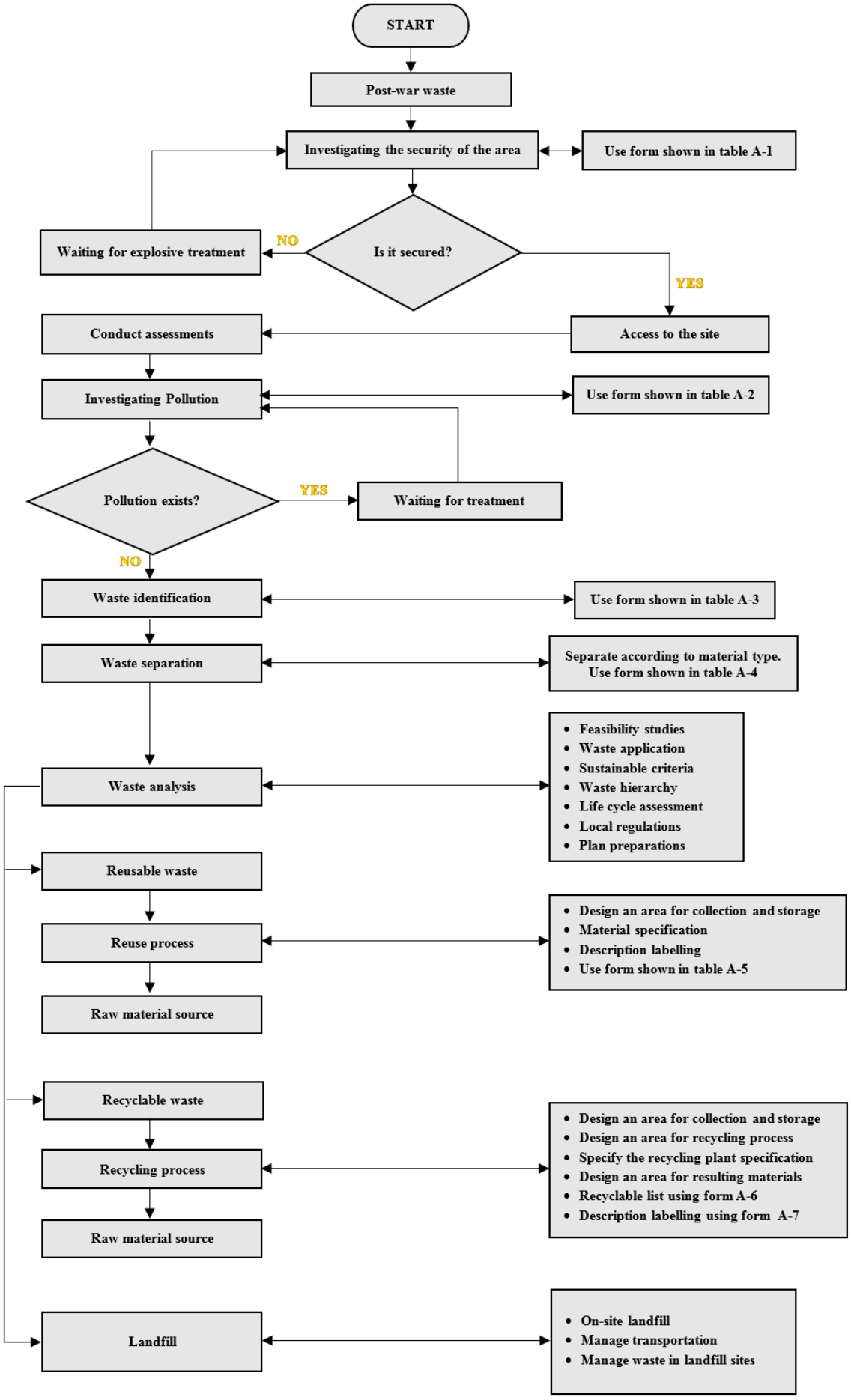

Figure 3. Procedural method flow chart

7. Conclusions

- There is a lack of awareness among those in the reconstruction field of the importance of the accumulated construction waste in the reconstruction process.
- There is a clear lack of landfill sites to dispose of all the construction waste accumulated after the war.
- There is a lack of public and private sector partnership in the construction waste management and reconstruction process.
- There is an obvious environmental impact of the accumulated waste in the damaged cities.
- The management of construction waste accumulated after the war as a significant effect on the reconstruction success targets (time, cost, quality)
- It is recommended that the suggested procedure method and forms should be used in the management of C&D waste.
- The local authorities and institutes responsible for the reconstruction process should consider the results of this research.
- A specialized team responsible for reconstruction management and construction waste management in Mosul city, and other cities liberated from terrorism, should be established.
- Public awareness of the application of the sustainability aspects in construction waste management should be increased by training programs, workshops, seminars, and other advertisement facilities.
- Partnership with the private sector should be considered in construction waste management and strategies, and the obstacles to this should be eliminated.

8. Acknowledgement

The authors are thankful to Baghdad University and, Ministry of planning in Iraq, for providing necessary data to conduct this research at master's level. The authors also extend their gratitude to Nineveh governorate and municipality to their expertise role throughout this research study.

9. Conflicts of Interest

The authors declare no conflict of interest.

10. References

[1] Brown, Charlotte Olivia. "Disaster Waste Management: A Systems Approach." (2012).

[2] Baycan, F., and M. Petersen. "Disaster waste management-C&D waste." In Annual conference of the international solid waste association, pp. 8-12. Turkey: Istanbul, 2002.

[3] Tabata, Tomohiro, Ou Zhang, Yuna Yamanaka, and Peii Tsai. "Estimating Potential Disaster Waste Generation for Pre-Disaster Waste Management." Clean Technologies and Environmental Policy 18, no. 6 (March 29, 2016): 1735–1744. doi:10.1007/s10098-016-1160-9.

[4] USEPA. "Planning for Natural Disaster Debris." Office of Solid Waste and Emergency Response and Office of Solid Waste (2008).

[5] Ulubeyli, Serdar, Aynur Kazaz, and Volkan Arslan. "Construction and Demolition Waste Recycling Plants Revisited: Management Issues." Procedia Engineering 172 (2017): 1190–1197. doi:10.1016/j.proeng.2017.02.139.

[6] Brown, Charlotte, Mark Milke, and Erica Seville. "Disaster Waste Management: A Review Article." Waste Management 31, no. 6 (June 2011): 1085–1098. doi:10.1016/j.wasman.2011.01.027.

[7] Yahya, K., and A. H. Boussabaine. "Eco-costs of sustainable construction waste management." In Proceedings of the 4th International Postgraduate Research Conference, Salford, pp. 142-50. 2004.

[8] Ahmod, Wleed Al. "Use of construction waste by means of recycling in Iraq and Poland." Zeszyty Naukowe Instytutu Pojazdów/Politechnika Warszawska (2017).

[9] Salkini, Hadya, Bashar Swaid, Laura Greco, and Roberta Lucente. "Developing a Multi-scale Approach for Rehabilitating the Traditional Residential Buildings within the Old City of Aleppo (Syria)." In XIV Forum "Le Vie Dei Mercanti", Italy. 2016.

[10] Poon, C.S. "Management of Construction and Demolition Waste." Waste Management 27, no. 2 (January 2007): 159–160. doi:10.1016/j.wasman.2006.10.012.

[11] Fetter, Gary, and Terry Rakes. "Incorporating Recycling into Post-Disaster Debris Disposal." Socio-Economic Planning Sciences 46, no. 1 (March 2012): 14–22. doi:10.1016/j.seps.2011.10.001.

[12] Brown, Charlotte, and Mark Milke. "Recycling Disaster Waste: Feasibility, Method and Effectiveness." Resources, Conservation and Recycling 106 (January 2016): 21–32. doi:10.1016/j.resconrec.2015.10.021.

[13] Environmental Statistics Department and GIS Center. "Damage assessment survey for the terrorism works and fighting ISIS" (2018) CSO.

[14] Al-Rawi, S. M., and T. A. Al-Tayyar. "Solid Waste Composition and Characteristics of Mosul City/IRAQ." Al-Mustansiriyah Journal of Science 23.8 (2012): 19–34.

[15] Wali, Ayad Ayid. "Conservation and Rebuilding of Professional Capacity for Iraqi Cultural Heritage after the Threat and effect of ISIS."

[16] Shirai, Hikaru, Yoichi Kageyama, Azuma Ohuchi, and Makoto Nishida. "Baseline Study to Estimate the Amount of Disaster Waste Using RapidEye Data." Journal of the Institute of Industrial Applications Engineers 4, no. 4 (October 25, 2016): 184–191. doi:10.12792/jiiae.4.184.

[17] Kuramoto, Naofumi. "The actual state of damage and measures undertaken in Hyogo prefecture." In Earthquake Waste Symposium, Osaka. (12–13 June 1995).

Appendix I

Table (A-1). Safety approval form

Site		Surveyed area	Instruments used	Discovered explosive bodies		Notes
Name	Location			Number	Type	
Surveying team approval Signature: Signature: Signature: Member name: Member name: Head of the team						

Table (A-2). Pollutant waste identification checklist

Project name:
Address:
Date:
Verified by:

No.	Waste polluted	Unit and quantity	Pollution effect			
			Soil	Water	Air	Does Not Exist

Table (A-3). Waste identification form

Project name:
Address:
Date:
Identified by:

No.	Waste type	Unit	Approximated quantity	Ability to remove	
				Able	Unable
1	Concrete				
2	Brick				
3	Block				
4	Stone (masonry)				
5	Ferrous metals (steel, iron, etc.)				
6	Non-ferrous metal (aluminum, copper, etc.)				
7	Gypsum (plastering)				
8	Rock, gravel				
9	Soil, dirt, landscape debris				
10	Asphalt				
11	Glass				
12	Pipes, pipe fixtures				
13	Wood				
14	Ceiling tiles				
15	Gypsum board				
16	Roofing materials				
17	Plastics				
18	Cardboard paper				
19	Mixed waste type				
20	Other waste (specify)				

Table (A-4). Waste Separation form

Project name: Address: Date: Identified by:			
No.	**Waste type**	**Unit**	**Quantity**

Table (A-5). Reusable material list and labels

Project name: Address: Date: Approved by:						
No.	**Material type**	**Code**	**Unit**	**Quantity**	**Usage limitation**	**Notes**

Table (A-6). Recycling list

Project name: Address: Date: Approved by:					
No.	**Recyclable material**	**Code**	**Unit**	**Quantity**	**Notes**

Table (A-7). Recycling labels

Project name: Address: Date: Approved by:	
Material name	
Code	
Source	
Specification	
Usage recommendations	