Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 196 (2017) 779 – 784

Procedia Engineering

www.elsevier.com/locate/procedia

Creative Construction Conference 2017, CCC 2017, 19-22 June 2017, Primosten, Croatia

The development of a waste management system in Kerbala during major pilgrimage events: determination of solid waste composition

Muhammad Abdulredha[a,c] *,Rafid AL khaddar[b], David Jordan[b], Khalid Hashim[b]

[a]*PhD Student, Liverpool John Moores University, Peter Jost Centre, Liverpool L3 3AF, UK*
[b]*Liverpool John Moores University, Peter Jost Centre, Liverpool L3 3AF, UK*
[c]*College of Engineering, University of Kerbala, Iraq*

Abstract

Several religious events take place annually in Kerbala, Iraq, attracting approximately 20 million pilgrims. Consequently, huge amounts of solid waste are generated which have a direct effect on both the environment and human health. The management of such waste poses a serious and complex problem for the city authorities. Therefore, establishing accurate and reliable information about this issue is valuable in terms of waste management planning and resource recovery application. The aim of this study is to analyze the composition of said solid waste during these religious events. To achieve this goal, a field investigation was conducted at three temporary transfer stations, over 10 days, during one event in Kerbala. Sampling and data analysis were carried out based on the ASTM D5231-92 (2003) standard method. Sixty samples of unprocessed solid waste were collected and manually sorted into six different categories: organics, plastics, paper, metals, glass and miscellaneous wastes. The results show that organic waste constituted the main waste category (57%) with paper, plastics and miscellaneous at 15%, 14.6% and 6.5%, respectively. These findings indicate that because of the high percentage of food waste, there exists a strong potential for energy generation or composting. In addition, plastics, papers, metals and glass have the potential to be separated and collected for recycling purposes. These results can be taken as a baseline for developing a successful waste management system in Kerbala city and other cities that have similar major pilgrimage events.

Peer-review under responsibility of the scientific committee of the Creative Construction Conference 2017

Keywords: Major events, Kerbala, solid waste, MSW, Recycling, waste compositon.

* Corresponding author. Tel.: +44(0)7404791603.
E-mail address: M.A.Abdulredha@2015.ljmu.ac.uk

Peer-review under responsibility of the scientific committee of the Creative Construction Conference 2017
doi:10.1016/j.proeng.2017.08.007

1. Introduction

Each year, various religious events take place around the world, attended by 300 million participants [1]. Growing volumes of Municipal Solid Waste (MSW) are produced in consequence of these events. Most of the waste generated in many countries is disposed of in landfills, meaning there is the potential to cause severe damage to the environment by increasing air, water and soil pollution in addition to increasing the possibility of severe impacts on human health [2, 3].

Establishing accurate and reliable information about the composition of this MSW is crucial in terms of waste management planning and resource recovery application [2]. Reliable data about the quantity and type of waste can provide a clear picture to waste management authorities about the materials that might be captured or recovered before being designated to landfill [4]. Studies about solid waste composition are vital as they provide detailed information about the physical, chemical and thermal properties of said waste. Such information is also necessary for the design of waste processing equipment and the implementation of the waste treatment system in addition to estimates of the amount of waste that could be recovered [3-5]. Solid waste composition varies due to variables such as demography, season, culture and geography making the identification and measurement of solid waste composition a necessary challenge.

Recently, MSW generation has dramatically increased in Iraq, especially in Kerbala city, because of a range of issues such as population growth, economic and social developments and the massive influx of pilgrims during major religious events [6-8]. Every year, Kerbala city hosts numerous religious events, attended by a minimum of 18 million pilgrims from several counties across the world [9]. Large quantities of MSW are generated during these events which have negative impacts on the local environment and human health in addition to stretching Kerbala's landfill capacity to its maximum. The issue of mounting solid waste disposal and treatment costs, in addition to the need to avoid further deterioration of Kerbala and the surrounding environment, have made it even more pressing that city authorities manage generated waste.

A variety of research on solid waste composition has been conducted in Kerbala during the last decade [6, 7] but there is no research or records involving solid waste composition during major religious events. Therefore, it is important to study the characteristics and composition of MSW to allow for a reliable estimation of waste recycling potential and for the development of an active management plan [10]. The goal of the current study is to define MSW composition in Kerbala city during major religious events, based on a site investigation conducted in Kerbala during the AL-Arba'een event (the largest event in the city) in 2016.

1.1. Overview on solid waste management in Kerbala.

According to Ali [7], around 0.1 million tons of MSW was generated by a population of 0.5 million residents in Kerbala city in 2008. In comparison, the annual generated MSW was about 0.3 million tons by about 0.9 million inhabitants in Kerbala in 2012 [6]. These numbers show considerable growth of MSW generation in Kerbala. Current estimates put the growth rate at 4% annually [6]. In addition, the influx of pilgrims during major events have added an extra 15% to the annual amount of MSW. The same study detailed that solid waste in Kerbala comprised 61.5% organic, 10% plastic, 7% paper, the reminder including metal, glass and other miscellaneous waste.

Solid waste streams are normally collected on a daily basis and taken to disposal sites without sorting or recycling by the collection authorities (holy shrine and Kerbala municipalities). Waste is disposed of in open sites with no lining and treatment, there being several dumpsites and landfill areas (Fig.1) in and around the city [6]. Informal, unofficial MSW recycling occurs, something which has grown over the last decade, as scavengers sift through and recover recyclable material from transfer stations or landfill sites. MSW recycling is apparently only carried out on this informal basis by scavengers.

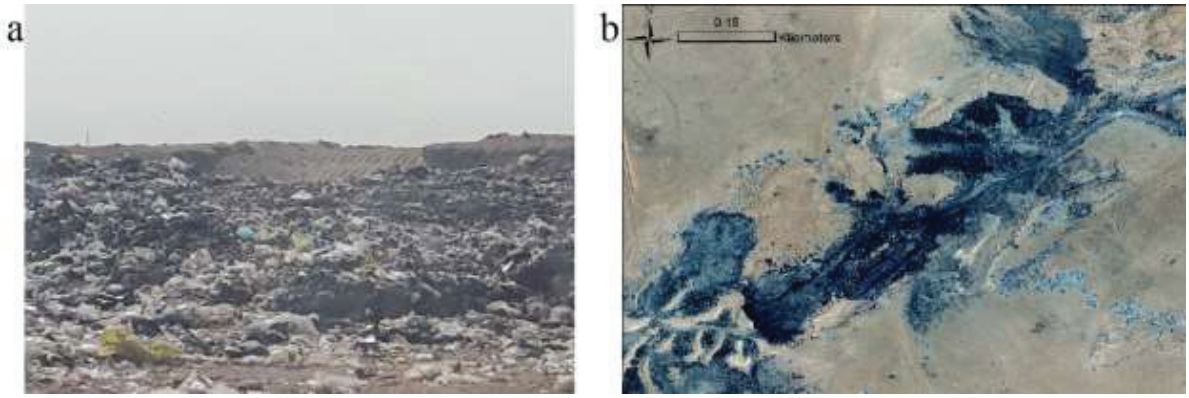

Fig. 1. Kerbala landfill site. (a) Site image; (b) Aerial image.

2. Methodology

2.1. Study area

Kerbala is a holy city for Muslims as it contains Hussein Bin Ali's shrine. It is situated in the middle of Iraq, about 100 km southwest of Bagdad. It has an estimated population of 1,003,516 with an area of 5023 km^2 [11]. Many events take place in the city on an annual basis, involving millions of pilgrims. The largest event which lasts 15 to 20-days (Al-Arba'een), is one of the biggest in Iraq attended by about 20 million pilgrims [9]. In order to serve this huge number of participants, there are about 8000 camps distributed across the city providing free meals and drinks over the duration of the event. In consequence, large amounts of MSW are generated, posing a serious and complex problem for city authorities (holy shrines management and Kerbala municipality). The waste management system applied in the city during the event is very basic in that all the waste is simply collected and transferred to a number of temporary transfer stations, close to the event area, then transported to landfill with no application of recycling or treatment processes.

2.2. Characteristics and composition of event waste

The ASTM D5231-92 test method for calculating the composition of unprocessed MSW was used for the composition analysis of the solid waste. Samples of untreated waste were selected and manually sorted into different categories [12].

2.3. Number of samples

The number of sorting samples used in the current research was calculated according to Eq. (1) identified in the ASTM D5231-92 (2003) standard method. Several parameters, namely level of confidence, standard deviation, level of precision and the mean are used to estimate the number of samples. The governing component was selected as corrugated. The estimated mean and standard deviation were 0.14 and 0.06, respectively, a precision of 10% and confidence level 90% required. Consequently, 52 samples were required to be sorted during the event.

2.4. Waste sampling and sorting procedure

The MSW sorting method was based on the collection of a number of samples of waste over a period of ten days (November 5th to November 15th, 2016) during the event. A ten-day period was chosen to ensure that fluctuations in the composition of the waste stream during the event were considered. A total of 60 samples were collected from three temporary transfer stations around the event area, two samples per day from two randomly selected trucks. The locations of these stations are shown in Fig. 2.

The selection and sorting procedure has been carried out according to ASTM D5231-92 (2003). On selection of the collection vehicle, the driver was directed to discharge the truckload in a secured area. From each MSW vehicle load, a sample weighting approximately 100 kg was prepared, according to the standards set, this sample then manually sorted on a secure sorting platform into the waste groups shown in Table 1.

Table 1. Descriptions of the sorting groups.

Groups	Items
Organic waste	Food waste (cooked and uncooked) including bones, garden waste, yard waste and other plant parts.
Paper and cardboard waste	All paper such as office paper, magazines, newspaper, brown paper, high-grade paper, packing board, carton boxes and corrugated paper.
Plastic waste	All plastics, for example, bags, packaging, solid plastic items, pens, bottles and toys.
Glass waste	All glass, for instance, glass pieces and glass bottles (without metal or plastic lids).
Metal and aluminum waste	All kinds including tin cans, aluminum cans, bi-metal cans, lids and aluminum foil.
miscellaneous waste	Textile, wood, rubber, shoes and batteries (anything which does not fit into the categories above).

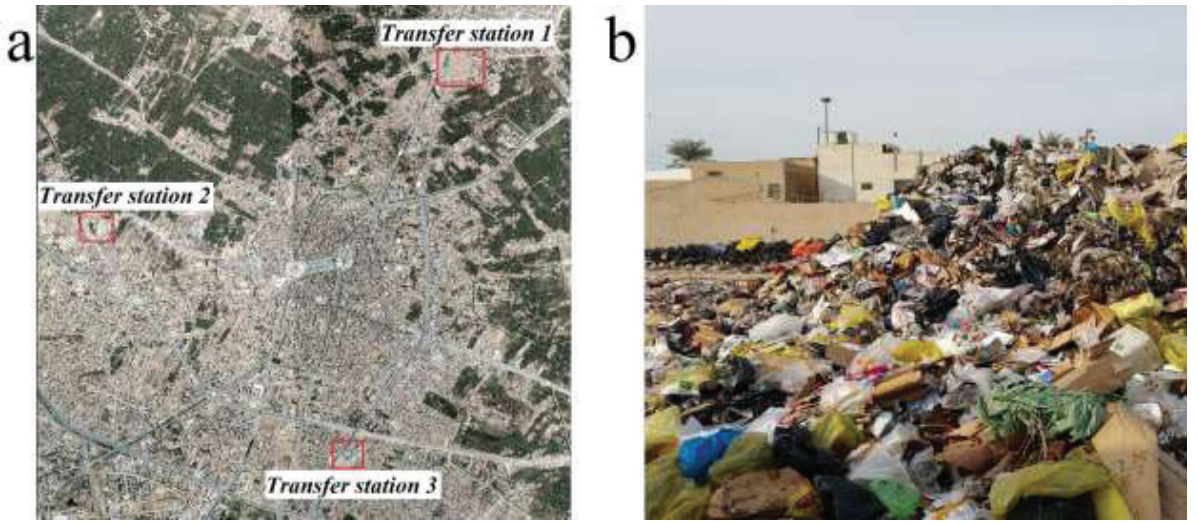

Fig. 2. (a) Aerial image of transfer stations sites; (b) Site image for transfer station 1

3. Results and discussion

3.1. MSW composition

Vital information required for the management of solid waste is data about the composition of the MSW as this affects decisions on solid waste management planning, treatment and disposal. A sampling program based on weight or volume can determine MSW composition.

Fluctuations in the composition of solid waste is not significant for the categorization of waste but some categories of waste may increase or decrease owing to certain situations or consequences during the event. The composition of MSW produced at Kerbala during Al Arba'een event is as variable as any waste generated in similar events [13].

The MSW composition analysis for the Al-Arba'een event resulted in three main categories of waste: organic, paper and plastic made up 86% of the total waste. Organic waste was the highest at 57%, while plastics and papers were 14% and 15%, respectively. Figure 3 shows the composition of said MSW. This analysis indicates that MSW in Kerbala city during the event has an average compostable and recyclable content of 93%. This recyclable waste contains organic, metal and plastic materials which occur in different percentages in comparison to non-event days in Kerbala and in other neighboring cities [6, 8]. There is therefore, considerable potential for MSW recycling and recovery programs [3].

The principal component of the refuse generated at Kerbala city during major events was organic waste, mainly food residual mixed with paper and plastic packaging. Pure organics such as food residual (cooked and uncooked) were also found in the waste stream. The average organic refuse generated during the event (57.8%) was found to be less than that generated in Kerbala over the year (61.5%) [6]. It is worth noting here that there are around 8000 camps in Kerbala, which provide free food and drinks for all pilgrims over the total period of the event. Consequently, pilgrims have many free options to choose from, this choice possible responsible for the amount of organic waste generated during the event. However, the decrease in organic waste might be due to the controls practiced by the camp managers. The majority of camp mangers estimate demand and provide meals according to this. The size of the meal (the portion) is also controlled so that the pilgrim consumes all of it.

Two waste categories, paper and plastic, share 29.5% of the event refuse. Due to the extensive use of packaging materials by camps, paper (15%) and plastic waste (14.6%), it was expected that these would constitute a high percentage of event refuse. Almost all the camps provide plastic or paper packaged takeaway meals for the pilgrims during the event period meaning that the paper and cardboard waste found during the sorting process were mostly cardboards, paper plates and mixed paper while plastic waste was mainly plates and plastic films. The average

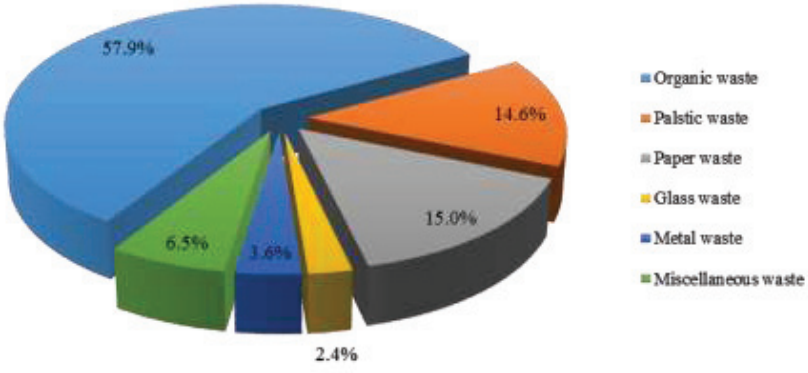

Fig. 3. Solid waste composition in Kerbala during major pilgrimage events.

percentage of both paper waste (15%) and plastic waste (14.6) in the event waste were more than that in the normal paper (7%) and plastic (10%) waste in Kerbala [6].

Metal and glass waste made up 6% of the total refuse. These low percentages of metal (3.6%) and glass (2.4%) can be attributed to a minimal use of canned drinks and glass materials. This percentage is similar to the amount of waste normally generated in Kerbala city [6, 8]. The percentage of miscellaneous waste generated during the event was less than that normally generated in Karbala and other Iraqi cities.

4. Conclusion

This study was conducted with the aim of establishing up to date waste composition data from major events for local waste management authorities (holy shrine and Kerbala municipalities). The solid waste stream produced by pilgrims during the event, was analyzed to identify categories of waste, and their percentages by weight basis.

The analysis of the waste revealed a high percentage of recyclable materials which may be separated and returned to the market. About 35.5% of the total solid waste are pure recyclable products such as paper (15%), plastic (14.6%), metal (3.6%) and glass (2.4%). These materials can be separated from the waste stream during the generation stage (by the pilgrims in camps) or at the treatment stage (by the management authority in the treatment facilities). 57.8% of the total waste was organic which can be converted to compost by use of a composting plant. Altogether, 93.5% of the solid waste has the potential to be reused and recycled effectively. These results provide evidence for the potential to successfully separate and recycle event waste in Kerbala and from similar events across the country, thus tackling issues around pollution of the environment.

Limitations and Future Research

Kerbala city hosts several events across the year. This study was conducted at one major event (Al-Arba'een) and so may not be generalizable to all events over the year. Research should be carried out to define the seasonal fluctuation of solid waste composition during major events.

Acknowledgements

The authors would like to express their appreciation to The Higher Committee for Education Development in Iraq for financial support and to the Karbala Center for Studies and Research, Kerbala municipality and other establishments for making the data collection possible.

References

[1] A. El Hanandeh, Quantifying the carbon footprint of religious tourism: the case of Hajj. Journal of Cleaner Production, 2013. 52: p. 53-60.
[2] I. Arbulu, J. Lozano, and J. Rey-Maquieira, Tourism and solid waste generation in Europe: A panel data assessment of the Environmental Kuznets Curve. Waste Manag, 2015. 46: p. 628-36.
[3] I.A. Al-Khatib, M. Monou, A.S. Abu Zahra, H.Q. Shaheen, and D. Kassinos, Solid waste characterization, quantification and management practices in developing countries. a case study: Nablus district - Palestine. J Environ Manage, 2010. 91(5): p. 1131-8.
[4] E. Gidarakos, G. Havas, and P. Ntzamilis, Municipal solid waste composition determination supporting the integrated solid waste management system in the island of Crete. Waste Manag, 2006. 26(6): p. 668-79.
[5] M.E. Edjabou, M.B. Jensen, R. Gotze, K. Pivnenko, C. Petersen, C. Scheutz, and T.F. Astrup, Municipal solid waste composition: sampling methodology, statistical analyses, and case study evaluation. Waste Manag, 2015. 36: p. 12-23.
[6] M.A. Abdulredha, Landfill Site Selection for Kerbala Municipal Solid Wastes by Using Geographical Information System Techniques Building and construction department 2012. M.Sc.
[7] M.F. Ali, The study of solid waste collection to the city of Karbala. Journal of Engineering and Development, 2009. 12(3): p. 1-20.
[8] A.N. Alnakeeb, Baghdad Solid Was te Study And Landfill Site Selection Using GIS Technique. Building and Construction Engineering Department, 2007. PhD.
[9] O. Ha, Modeling Sewer Overflow of a City with a Large Floating Population. Journal of Waste Water Treatment & Analysis, 2014. 05(02).
[10] S. Mor, K. Ravindra, A. De Visscher, R.P. Dahiya, and A. Chandra, Municipal solid waste characterization and its assessment for potential methane generation: a case study. Sci Total Environ, 2006. 371(1-3): p. 1-10.
[11] Republic of Iraq Ministry of Planning Central Statistical Organization. Demographic Statistics report of population state. 2010 10.10 2015; Available from: http://cosit.gov.iq/en/joomla-templates.
[12] ASTM D5231-92, Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste. 2003: p. 6.
[13] A.F. Alsebaei, Solid Waste Management and Recycling During Hajj Pilgrimage in Mina. School of Civil Engineering, 2014. PhD.