Estimating municipal solid waste generation from service processions during the Ashura religious event

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Abstract. Multiple religious events attended by millions of pilgrims take place across the world every year. Large quantities of municipal solid waste are therefore produced which pose serious threats to the management systems of the host cities and negatively affect their attractiveness. Accurate and reliable information about municipal solid waste generation during such events is thus valuable in terms of management planning and resource recovery applications. The current investigation thus aims to estimate waste generation from the service processions, which are temporary tents set up by Iraqis to provide accommodation and services to pilgrims, during such events. To achieve this goal, a pilot questionnaire survey and an on-site municipal solid waste audit were conducted over 20 processions during Ashura, which is one of the largest religious events in the city, being attended by up to 3.5 million pilgrims. The outcomes of this investigation indicated that municipal solid waste generation from processions broadly varied from 22 to 944 kg per day, with an average of 284 kg per day. This variation can be attributed to the number of meals provided by each procession and similar expenditures. These results can thus be taken as a starting point for introducing a proper management system to be used in Kerbala during religious events.

Keywords: data collection; Kerbala; large religious events; municipal solid waste generation; service processions.

1. Introduction
Tourism is now one of the main industries globally [1]. In 2015, for example, the number of international tourists grew by 4.4% to reach 1,184 million tourists, accounting for 10% of the world’s domestic product, one in every ten jobs, and 7% of the worldwide exports [2]. The number of tourists entering Iraq in 2016 reached 7.7 million, providing about 10 thousand jobs in tourism and resort activities [3]. Such growth also has its negative side, however, and tourism is blamed for being a primary pollution source, in particular generating huge quantities of Municipal Solid Waste (MSW) [1]. Religious events, where people of a particular belief travel to participate in events of spiritual significance to their faith, is a particular tourism practice [4], and every year, around 300 million individuals from around the world take part in religious events according to estimates by the World Religious Tourism Association [5]. Such religious events draw around 20 million visitors each year to the city of Kerbala, Iraq [6, 7]. The city thus faces regular increased pressure on its Municipal Solid Waste Management (MSWM) system due to the large floating populations during religious gatherings. MSWM in Kerbala is still in its infancy.
and the MSW generated are directly disposed of in landfill without treatment and recovery, which has significant negative impacts on both the environment and human health [9]. The increasing costs of MSW treatment and disposal have compounded the difficulties faced by MSWM in Kerbala, and pilgrimage arrivals generate extra quantities of MSW, which may affect the attractiveness of Kerbala more generally [6].

MSW generation is one of the most tangible impacts that hospitality establishments, including service processions, have on the environment [10, 11]. There is wide variation between hospitality establishments when it comes to how much waste is produced on a daily basis, however. Previous research has attributed this variation to a range of parameters including MSWM practices, establishment type, size and staff activities, guest attributes, and purchasing practices [10-16]. Ball and Abou Taleb [13] studied MSWG rates from 24 five-star hotels in Cairo, Egypt, of various sizes and occupancy rates, over two months and noted such variations, for example.

To develop an integrated MSWM system, a reliable forecast of the quantity of MSW created by hospitality establishments is required [17]. A common approach to estimating MSW generation is considering the trend of MSW production variation over a long period in a target area [18]. However, records regarding MSW generation in developing countries do not exist, particularly for large religious events, owing to improper MSWM systems and insufficient resources [18, 19]. Thus, it is quite challenging to use such methods to forecast MSW generation based on this lack of historical records. Various forecasting methods have thus been proposed by researchers to predict MSW generation, including Multiple Linear Regression [20, 21] and artificial neural networks [19]. Among these, Multiple Linear Regression is most commonly applied to predict MSW generation due to its relative simplicity[22].

To further develop the MSWM system currently used in Kerbala, it is vital to study MSW generation from processions during large religious events. This research is thus devoted to studying MSW generation by processions during Ashura, one of the biggest religious events in Kerbala and worldwide. During a recent event, 20 processions were approached and information gathered about variables such as size, number of meals provided, and expenditure; an on-site MSW audit was also conducted for each to estimate the quantity of MSW produced by each participating procession. Due to the lack of such data in the literature, especially from processions, the data collected in this study should be very useful for MSWM prediction during religious events and future scientific studies in this area.

2. **Methodology**

2.1. **Case study.**

Kerbala city is situated in the middle of Iraq, 62 miles from the Iraqi capital (Bagdad) at 32° 44’ 00” and 32° 06’ 00”N and 43° 10’ 00” and 44° 18’ 00”E (see Figure 1) [23]. It has an area of 5,034 km², almost 1.2% of Iraq’s total area. It has a population of 1,151,152, about 3.2% of the Iraqi population, and a density of 223 persons per square kilometre [24]. The city hosts many religious ceremonies on a yearly basis, drawing in millions of travellers from many nations across the world [25]. Ashura, one of the main religious events in Iraq and globally, lasts for up to 8 days during which the city hosts up to 5 million pilgrims [26], who produce large amounts of MSW. The management authority (Holy Shrines) has stated that the city has more than 600 service-processions providing meals to these pilgrims, and these processions, therefore, should be considered one of the main sources of the MSW created in the city during the event. MSWM in Kerbala has been insufficient in the past, with little control applied for many years; the city is thus bereft of a proper MSWM strategy [27].
Figure 1. Geographical location of Kerbala city.

2.2. Data collection

The data used in this study were drawn from a field survey conducted in Kerbala, Iraq, during the Ashura event and an on-site MSW audit in several stages. In the first stage, a data collection instrument (questionnaire) was developed to collect data about procession features such as area, expenditure, staff size, location, and MSW generation. Previous researchers [28, 29] have stated that the questionnaire is a useful technique to collect predefined information from a large number of participants and that outcomes can be generalised to a target population. Based on a comprehensive literature review [12, 19, 20, 30-33], the questionnaire was thus designed and its items formulated in a single section. The questionnaire was then revised and corrected by a panel of MSWM and survey experts to allow proper construct validity.

In the second stage, the Holy Shrine authorities, which are the main organisers of religious events in the city, were contacted for permission to start the survey during the Ashura event. These supported the research team by offering four assistants to carry out the survey due to the short event duration (8 days). Thus, a comprehensive workshop was held over two days regarding survey ethics, survey methodology, contacting participants, reading the questions, and recording participant responses accurately for these assistants. During the Ashura event in 2016, 20 randomly selected processions were then approached in person and, after being asked for informed consent, were required to complete the questionnaire and complete the procession MSW audit. The MSW audit was conducted to estimate the quantity of MSW generated by each procession, based on the Waste and Resources Action Programme (WRAP) [16] methodology. The audit included defining waste container numbers on-site, their sizes, collection frequency, and average filling level. The waste mass of the MSW produced was then estimated by multiplying the onsite density of the MSW by the total MSW volume.

2.3. Data analysis

SPSS software (version 23; SPSS Inc., Chicago, IL) was used to complete a statistical analysis of the acquired data. The processions’ features, including area, expenses, location, number of staff, number of served meals, and MSW generation, were examined using descriptive statistics. For the continuous variables, mean and standard deviation were employed to express the quantitative variables [29], while for categorical variables, counts and percentiles were used [34]. In addition, the Pearson Correlation Coefficient was used to evaluate the associations between processions’ variables and solid waste generation [35].

3. Results and discussion
3.1 Respondents’ Demographic
Citizen demographics such as gender, age, and education level play an important role in their MSW generation activities as well as in their attitudes toward MSWM operations [19]. All of the participating procession owners (100%) were male, which was expected due to the cultural norms of Kerbala. Opoku and Abdul-Muhmin [36] stated that it is not easy to recruit females for questionnaire surveys in some cases because of cultural issues. Figure 2 shows the variety of ages among the participants. The majority of the procession owners were from older or middle age groups. None of the respondents was in the 18 to 25 age group, and only 15% of the respondents were from the 26 to 35 age group, while 45% of the owners were from the 36 to 45 age group and 40% were from the 46 and over age group. This was again as expected due to the cultural norms in Iraq.

![Figure 2. Age profile of the participants.](image)
The responses to the level of education question are presented in Figure 3. The proportion of university graduates among procession owners was 30%, while the proportion of secondary school graduates was 25%. The majority of procession owners had thus only completed primary education.

![Figure 3. Respondents’ education levels](image)

3.2 Waste generation from service processions
To estimate the mass of MSW produced, the methodology developed by WRAP [16] was followed. According to this, the volume of MSW produced by each procession over a specified duration was first identified. Then, the on-site density of MSW was calculated according based on a random sample extracted from the total quantity of MSW. Finally, the total mass of the MSW produced by each procession was calculated by multiplying the total volume by the onsite density.

Two methods were included with the aim of estimating the volume of the MSW generated by processions. Procession owners were asked to estimate the volume of the MSW produced in their procession over a one-day period, and an on-site audit was also conducted at the 20 participating processions. This involved visual inspection to establish volume-to-weight conversion factors (densities) and a general overview regarding composition. Two bins were randomly selected in each
case for the calculation of weight and volume. The density was estimated for each procession by dividing the average MSW weight in the selected bins by their average volume. The latter factor was used to convert the daily volume of the procession’s MSW into a weight.

The results showed that there were significant variations among processions in terms of MSW generation. The masses of MSW generated from processions were in the range of 22.72 to 944.26 kg.day⁻¹ (Table 1). The mean quantity of MSW produced by processions was thus 284.46 kg.day⁻¹ with a 239.41 standard deviation. The per-meal procession MSW generation was calculated by dividing the total MSW produced by the number of meals that the procession provided that day. Based on this, the rate of MSW generation from processions in kg per meal was 0.095 (SD=0.045, n=20) during the event. The majority of processions’ MSW was organic, being mainly food residue mixed with plastic and paper. Pure organics such as food residues were also found. High percentages of plastic and paper refuse were also detected due to the extensive use of packaging materials. Metal and glass wastes were very low due to the minimal use of canned drinks and glass materials.

| Units     | Waste generation | Waste generation per meal |
|-----------|------------------|---------------------------|
|           | kg.day⁻¹         | kg.meal⁻¹                 |
| Mean      | 284.46           | 0.095                     |
| Median    | 168.97           | 0.090                     |
| Maximum   | 944.26           | 0.240                     |
| Minimum   | 22.72            | 0.040                     |
| Std. Dev. | 239.41           | 0.045                     |
| Skewness  | 1.295            | 1.942                     |
| Kurtosis  | 1.492            | 4.528                     |

3.3. The influence of expenditure and food services on waste generation

MSW production is often related to expenditure and services [18]. Thus, three questions were designed to provide descriptive information regarding the expenditures and services of each procession over Ashura. The first was designed to identify the expenditure during the whole event, as it is very hard to identify this per guest, while the second aimed to identify which camps provided free food services and how many times such food was offered over the course of a day. The third was designed to investigate the number of servings (meals) provided over the day.

All processions offered free food to pilgrims. The number of servings (meals) provided by each procession is thus shown in Table 2. The average number of servings provided by processions was more than 4,000 per day. The smallest procession offered 250 servings per day, while some owners claimed to deliver 35,000 servings to pilgrims each day over the entire event period. Based on this, pilgrims have many free options to choose from and this activity might increase the amount of MSW produced during the event. The statistical analysis also showed that waste generation from processions is significantly influenced by the number of served meals, with a Pearson Correlation Coefficients of 0.889 (Sig. 0.000). This agrees with Snarr and Pezza [37], who stated that the number of meals served is an important factor influencing waste generation.

In terms of expenditure, the average expenditure per procession is more than 34 million Iraqi Dinar (ID). The maximum observed expenditure per procession was 350 million ID, while the minimum was 500 thousand ID (Table 2). This variation in expenditure can be attributed to varying services provided by processions. For example, some processions provided one meal per day while others offered more than three meals per day in addition to beverages, leading to an increase in expenditure. The analysis showed
that processions’ expenditure was positively correlated to solid waste generation, with a Pearson Correlation Coefficient of 0.770 (Sig. 0.000). Processions that spend more on purchasing produce larger quantities of MSW. This seems to support previous findings, as many researchers have suggested that waste generation at hospitality establishments is affected by purchasing activities [37].

Table 2. Descriptive statistics of processions’ features.

| Features          | Expenditure | Area | Location | Staff size | No. of meals |
|-------------------|-------------|------|----------|------------|--------------|
| Units             | Iraqi Dinar (millions) | Square meter | meters | - | Times.day-1 |
| Mean              | 34.28       | 149.0 | 461.00   | 34.1       | 4105.00      |
| Median            | 14.50       | 100.0 | 400.00   | 27.50      | 2000.00      |
| Maximum           | 350.00      | 400   | 850.00   | 100.00     | 25000.00     |
| Minimum           | 0.50        | 40    | 320.00   | 8.00       | 250.00       |
| Std. Dev.         | 76.31       | 105.67| 142.71   | 21.51      | 5481.13      |
| Skewness          | 4.112       | 1.026 | 1.406    | 1.567      | 3.167        |
| Kurtosis          | 17.639      | 0.251 | 1.417    | 3.43       | 11.824       |
| PCC               | 0.770       | 0.008 | 0.33     | 0.387      | 0.899        |
| Sig.              | 0.000**     | 0.973 | 0.891    | 0.092      | 0.000**      |

** Notes significant influence on MSW generation.

3.4. *The impacts of procession area, staff, and location on waste generation*

MSW generation has been associated with the service area [38], staff size [12], and location [39] of hospitality accommodations. Thus, three questions were designed to collect information about these features during the event in Kerbala. Table 2 shows the descriptive statistics for area, staff size, and location of the examined processions in Kerbala.

These results (Table 2) reveal that the mean area of the participating processions was 149 square meters with a standard deviation of 105.67 square meters. Many researchers [13, 38] have indicated that MSW generation by hospitality establishments is associated with its size. For instance, Purcell and Magette [40] showed that the areas of hospitality establishments significantly affected waste generation. However, the current study found no significant association found between the processions’ areas and MSW generation, with the Pearson Correlation Coefficient being only 0.008 with a significant value of 0.973. This could be due to the impact of other aspects such as services of processions and attributes of pilgrims. As stated earlier, processions all offer food and beverage services to all pilgrims free of charge, but it is unknown whether these services are similar or different e.g. only breakfast and dinner or complete dining and refreshment services.

The average staff size in the targeted processions was 34.1 members with a standard deviation of 21.51 members (Table 2); these individuals are responsible for preparing and delivering processions’ services to pilgrims. As with area, no significant connection was identified between staff size and quantity of MSW generation; the correlation coefficient with MSW generation was 0.387, with a low significance of 0.092. This may be attributed to the varying activities of staff: for example, many processions provide different services such as massages [41], which require higher numbers of staff and produce little MSW.

The target processions were distributed across the old city of Kerbala, with the nearest procession 320 meters away from the centre of the event. The average distance between the targeted processions and the centre of the event was 461 meters, with a standard deviation of 142.71 meters (Table 2). Boateng, et al [39] stated that MSW generation from an establishment situated in principal streets is influenced by location. Thus, it was expected that processions located closer to the centre of the event would be likely to produce more MSW than those located in outlying areas due to demand. However, the analysis
revealed that location does not have a tangible influence on waste generation by processions. The event size ensures consumption of the full capacity of all processions in the city, regardless of their location, which minimises the impact of location on MSW generation.

4. Conclusion

In this study, the issue of MSW generation from processions during a large religious event in the city of Kerbala, Iraq, was examined. The aim was to estimate the amount of MSW that processions produce during Ashura and to define the variables that influence MSW generation by such processions. The survey revealed substantial variation in MSW generation between processions, though an average of 284.46 kg day \(^{-1}\) of waste was produced. The statistical analysis confirmed that procession features greatly influence their MSW generation. The rate of MSW generation was found to be positively correlated with processions’ expenditure and number of meals served, with number of meals being the most influential variable with regard to MSW generation and expenditure the least. The remaining variables did not affect the quantity of MSW produced by processions. As this city does not have long-term records regarding MSW generation from processions over large religious events, this study helps to begin to provide proper information on MSW generation from processions over event periods in order to develop an integrated MSWM strategy in Kerbala and cities hosting similar events.

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