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Estimating solid waste generation by hospitality industry during major festivals: a quantification model based on multiple regression

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Abstract

Major-religious festivals hosted in the city of Kerbala, Iraq, annually generate large quantities of Municipal Solid Waste (MSW) which negatively impacts the environment and human health when poorly managed. The hospitality sector, specifically hotels, is one of the major sources of MSW generated during these festivals. Because it is essential to establish a proper waste management system for such festivals, accurate information regarding MSW generation is required. This study therefore investigated the rate of production of MSW from hotels in Kerbala during major festivals. A field questionnaire survey was conducted with 150 hotels during the Arba'een festival, one of the largest festivals in the world, attended by about 18 million participants, to identify how much MSW is produced and what features of hotels impact on this. Hotel managers responded to questions regarding features of the hotel such as size (Hs), expenditure (Hex), area (Ha) and number of staff (Hst). An on-site audit was also carried out with all participating hotels to estimate the mass of MSW generated from these hotels.

The results indicate that MSW produced by hotels varies widely. In general, it was found that each hotel guest produces an estimated 0.89 kg of MSW per day. However, this figure varies according to the hotels' rating. Average rates of MSW production from one and four star hotels were 0.83 and 1.22 kg per guest per day, respectively. Statistically, it was found that the relationship between MSW production and hotel features can be modelled with an R^2 of 0.799, where the influence of hotel feature on MSW production followed the order Hs > Hex > Hst.

Keywords: Major festivals; hotels; solid waste generation; multiple linear regression; Kerbala.

1. Introduction

Today, travel and tourism has grown to be one of the largest industries around the world. In 2015, international tourism numbers grew by 4.4% reaching a total of 1,184 million travellers, accounting for around 10% of the world's Gross Domestic Product, one in every ten jobs and 7% of worldwide exports (WTO, 2016). With such expansion comes responsibility as tourism-related activities are blamed for being one of the leading sources of pollution globally, generating large amounts of Municipal Solid Waste (MSW) (Arbulu *et al.*, 2015). This applies to large festivals and events, considered common tourist destinations in many countries, worldwide (Cierjacks *et al.*, 2012).Religious tourism, where individuals of a particular belief travel to participate in events or festivals of spiritual importance, is one facet of travel and tourism. Every year, around 300 million individuals from around the world take part in religious festivals, according to the World Religious Tourism Association (WRTA, 2011).

To meet the demands of increasingly sophisticated tourists, the hospitality sector is expected to grow significantly in the next few years. For instance, Revenue Per Available Room is expected to increase by 2.3% in 2017 in the United States (Berman *et al.*, 2017) and by more than 6.8% in several European cities in 2018 (Trunkfield and Mayer, 2017). Gulf Cooperation Council countries in the Middle East also expected to see an increase in their revenue in 2016 (MeetMiddleEast, 2013). This growth in hospitality industry operations results in increased quantities of MSW constituting a substantial increase in the environmental footprint and ecosystem damage. Municipal Solid Waste Generation (MSWG) is one of the most tangible impacts that hospitality establishments, including hotels, have on the environment (Bohdanowicz, 2006; Pirani and Arafat, 2014).

The literature reports that in one night stay, 1 kg of MSW is produced by a typical hotel guest (Bohdanowicz, 2005; Losanwe, 2013). Previous work by Axler (1973) found that in general, guest rooms were responsible for around 0.91 kg of MSW per day, while around 0.45 kg of MSW was produced by both dining rooms and kitchens. In contrast, Earle and Townsend (1991) reported MSW generated per room, per day varied from 1.81 to 3.18 kg. The same study included reference to a MSW audit conducted in the Orlando area where MSW generation in guest rooms ranged from 0.23 to 12.93 kg per day. As a rule, there is wide variation between hotels when it comes to how much waste per room is produced on a daily basis. For instance, The Rezidor Hotel Group (2014) reported that Park Inn hotels produced 2.87, 1.77 and 0.76 kg/guest of unsorted MSW per night in the United Kingdom, France and Germany, respectively. Research has attributed this variation to a range of parameters including MSW management practice, hotel type and size, type of food, occupancy rate, guest and staff activities, guest attributes and purchasing practices (Snarr and Pezza, 2000; Bohdanowicz, 2005; Bohdanowicz, 2006; Ball and Abou Taleb, 2010; WRAP, 2011; Pirani and Arafat, 2014; Pirani and Arafat, 2016). For instance, Ball and Abou Taleb (2010) studied MSWG rates from 24, five-star hotels in Cairo, Egypt, of various sizes and occupancy rates, over two months. Their results illustrated that there were strong relationships between both hotel size and occupancy rates with MSWG. Given there is a large fluctuation in the generation rate of MSW from hospitality sector, it is of interest to establish this in the Middle East, specifically during major festivals, to develop proper management systems.

To develop an integrated MSW management system, the literature agrees that a precise prediction of the quantity of MSW generated is required (J. S. Kumar *et al.*, 2011; Intharathirat *et al.*, 2015; Peeters *et al.*, 2015; Azadi and Karimi-Jashni, 2016; Ghinea *et al.*, 2016; Jiang and Liu, 2016). Inaccurate forecasting may result in difficulties such as negative impact on the environment, MSW treatment facilities which do not have the required capacity and inappropriate policies (Beigl *et al.*, 2008; Intharathirat *et al.*, 2015). Researchers have developed various modelling techniques of differing complexity, to predict the rate of MSW generation. These models have been used to investigate the influence of many explanatory variables related to economic conditions including, waste management measures, waste management policies, public habits, weather conditions and population growth (Edjabou *et al.*, 2015; Fu *et al.*, 2015; Intharathirat *et al.*, 2015; Suthar and Singh, 2015; Azadi and Karimi-Jashni, 2016; Grazhdani, 2016). One of the most common approaches to forecasting MSWG is by considering varying trends in MSW production, over a long period, in the targeted area or event (Intharathirat *et al.*, 2015). Unfortunately, such historical records in developing countries do not exist owing to improper management systems and inadequate funds (Intharathirat *et al.*, 2015; Azadi and Karimi-Jashni, 2016). To tackle this problem therefore, new approaches need to be adopted where historical MSWG rates are not required (Azadi and Karimi-Jashni, 2016).

Various complex forecasting techniques have been proposed by researches to predict MSWG including Multiple Linear Regression (MLR) (Parisi Kern *et al.*, 2015; Grazhdani, 2016), artificial neural networks (Azadi and Karimi-Jashni, 2016) and grey models (Intharathirat *et al.*, 2015). Parisi Kern *et al.* (2015), for example, suggested an equation using MLR to determine the mass of waste generated in the construction phase of high-rise structures by examining the influence of building design and production systems, concluding that the suggested equation was useful for prediction purposes. Intharathirat *et al.* (2015) used a multivariate, grey modelling technique to predict the quantity of MSW production from residential and commercial sectors in Thailand, consequently suggesting that grey models can be used to forecast MSWG rates when a complete historical record is not available. Jahandideh *et al.* (2009) also used MLR to forecast the generation rate of medical MSW from 50 hospitals in Fars Province, Iran, their results also suggesting that MLR can be used to forecast the generation rate of medical waste from medical establishments. Among these previously mentioned models, MLR, which models the relationship between one or more Independent Variables (IVs) and a Dependent Variable (DV), is commonly applied to predict MSWG rates due to its simple algorithms and theory.

Based on the literature review above, there appears to be limited, if any, research analysing waste production from the hospitality sector during multi–million participant festivals, making this study the first. This research was carried out by conducting a comprehensive field survey of the hospitality sector during AL-Arba'een, one of the largest festivals in Iraq and worldwide. A prediction model was developed using the MLR technique that employs the collected data from the field survey to estimate the quantity of MSW produced from the hospitality sector. This research may be a platform for future studies concerning the development of MSWM systems for major festivals. It is also suggested that the results can be used by local authorities in order to develop integrated waste management systems.

2. Events and festivals tourism

Recently, there has been a surge in research in tourism related events and festivals (Getz, 2010). Although all planned events have the potential to be of interest to tourists, the literature focuses on four broad categories: business, entertainment, sport and festivals and other cultural celebrations (Getz and Page, 2016).

Business events such as exhibitions and conventions have received quite a lot of attention, as the majority of major cities hold a substantial number of these events (Boo et al., 2008). Topics such as constraints which influence exhibition attendance (Lee and Palakurthi, 2013), loyalty and satisfaction (Tanford *et al.*, 2012), economic impact (Dwyer, 2002) and the impact on public sectors (Andersson and Samuelson, 2000) have already been examined. However, Mair (2012) has acknowledged the need for research focusing on the environmental impacts of business events.

Entertainment events including recorded music, film, museums and theme parks, have also been studied by various researchers around the world (Getz and Page, 2016). Easto and Truzzi (1973) surveyed the nature of various carnivals in the USA, estimating that they attract 85 million visitors every year. The motivation for music tourism in South Africa (Kruger and Saayman, 2012) and the environmental consequences of several music festivals in Germany (Cierjacks et al., 2012) have also been investigated.

A growing amount of research on sport events now exists in the literature (Getz and Page, 2016). Researchers have explored many sport tourism related topics such as motivation, satisfaction and behaviour (Prayag and Grivel, 2014), the relationship with urban development (Rozin, 2000) and their economic impact (Lee and Krohn, 2013). For instance, Kennelly and Toohey (2014) studied how the co-operation between sport tour operators and sport events' organizers could enhance the financial outcomes of sport tourism while Wicker and Hallmann (2013) investigated willingness to pay to travel to, and participate, in marathon events.

Festivals and cultural events have occupied an important place in tourism-related studies (Getz and Page, 2016). A comprehensive review, conducted by Getz (2010), identified several facets of festivals and cultural events including pilgrimage, celebrations and carnivals. Matheson *et al.* (2014) investigated the impact of spiritual attitudes on visitor attendance to the Beltane Fire Festival in Edinburgh, UK. Buzinde *et al.* (2014) investigated the experiences, activities and motivations of pilgrims on the Kumbh Mela pilgrimage, Allahabad, India. Giovanardi *et al.* (2014) investigated encounters between residents and visitors during the 'Pink Night' festival in Italy while Panfiluk (2015) analysed the effects of tourist events in Poland on levels of employment and the income of the population.

However, the above research aside, Getz and Page (2016) state that academic research has largely neglected the environmental impacts of tourism events. For example, Arbulú *et al.* (2017) looked at the impact of variations in tourism on the performance of waste-to-energy facilities. Zeng *et al.* (2014) investigated greenhouse gas emissions from solid waste generated at the Shanghai Expo, 2010. Barber *et al.* (2014) measured the recycling behaviour, altitudes and intentions of visitors to festivals in the USA, while Alsebaei (2014) developed an econometric model to predict future recycling behaviour of the Hajj pilgrims in Saudi Arabia, based on their stated intentions. Collins *et al.* (2012) have examined two methods of evaluating the environmental sustainability of mega sporting events in the UK and Ahmed *et al.* (2008) studied the environmental impact of beach sport events in South Africa. Other topics such as litter management at festivals (Cierjacks *et al.*, 2012) and the carbon footprint of mega events (El Hanandeh, 2013) have also been investigated.

3. Methodology

Apart from the study area selection, the methodology consists of three main stages. The first stage involves developing a data collection instrument (structured questionnaire), conducting a field survey (questionnaire survey and on-site MSW audit) during one major event, and checking the reliability and validity of the collected data. The second stage compromises defining explanatory variables that affect MSW generated from the hospitality sector. The final stage deals with data preparation, treatment and development of an MLR model which is then tested using a cross-validation method.

3.1. Study area and event.

The governorate of Kerbala is located in the middle of Iraq, 62 miles from the Iraqi capital, Bagdad, from 32° 44′ 00″ and 32° 06′ 00″N and 43° 10′ 00″ and 44° 18′ 00″E (see Fig.1). The governorate has an area of approximately 5034 km^2, covering nearly 1.2% of the total area of Iraq (Abdulredha *et al.*, 2017a). According to the latest statistics provided by the Ministry of Planning of Iraq, it has a population of 1,151,152, constituting about 3.2% of the total population of Iraq with a population density of 223 persons per square kilometre (CSOI, 2015). It has smooth topographical features with a general elevation ranging between 30m-95m above sea level (Khalaf and Hassan, 2013). The city experiences hot weather conditions in summers and cool in winter, with an average annual rainfall of approximately 85 mm (CSOI, 2015). It contains one lake (Razzaza Lake) (see Fig.1) and several ground water reservoirs.

Kerbala city, which is in the centre of Kerbala governorate, was selected as the case study area, as it is one of the main tourism centres in Iraq. The city hosts many religious festivals on an annual basis, attracting millions of tourists from many countries across the world. AL-Arba'een, one of the biggest festivals in Iraq, and in the world (Cockburn, 2017), takes place in Kerbala. It lasts up to 15 days and attracts approximately 18 million tourists annually (Abdulredha *et al.*, 2017b; Cockburn, 2017). Ashura, another festival in the same city, lasts up to 8 days attracting approximately 5 million visitors (AFP, 2016). Due to the large numbers of tourists attending these festivals, enormous quantities of MSW are generated in the city, severely impacting local solid waste management systems. Hotels are considered one of the main solid waste producers in the city during festivals. According to the latest statistics provided by the Ministry of Planning of Iraq, the Central Statistical Organization (CSOI, 2016), Kerbala city has 667 hotels open during these events (Fig.2 shows hotel rankings), the majority of these fully occupied, providing meals and services, as well as addressing the basic needs of their guests.

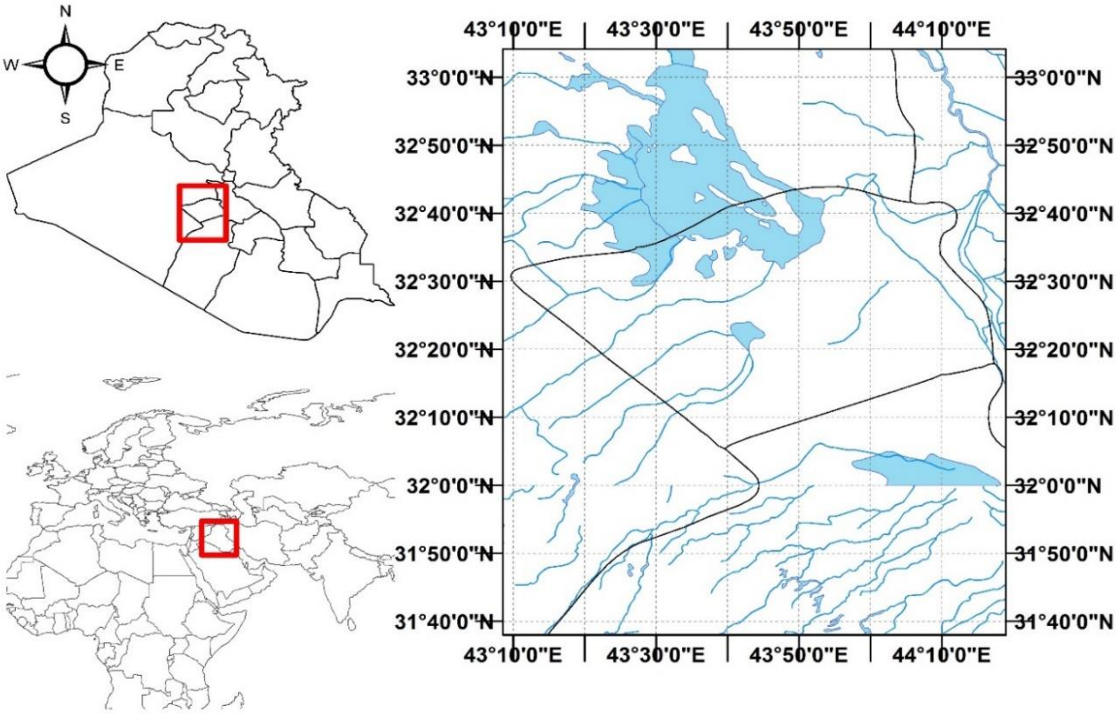

Fig. 1. The geographical location of Kerbala city.

Kerbala does not have an efficient solid waste management system. People from many neighbourhoods throw garbage on illegal dump sites situated close to residential areas (Abdulredha, 2012; Abdulredha *et al.*, 2017c). Three institutions, namely Kerbala Municipality (city centre based), Kerbala Municipalities (outskirt districts based) and the Holy Shrines Authorities, were identified as directly responsible for the provision of waste management services in the city and during festivals; there is no private sector involvement in the delivery of these services. Despite that these institutions have 223 collection vehicles in total, they were only able to cover about 80% of the festival area. None of them practices MSW management activities, except to dump all MSW into nearby landfill. Large amounts of MSW generated during major festivals, are treated in the same manner. Estimating the amount of solid waste generated by the hospitality industry will help improve the current solid waste management system applied in the city, particularly during festivals.

It should be noted here that exact and reliable figures about waste management issues are not available and have had to be estimated by the event management. The interview with the MSW management authority revealed that an estimated 53 kt of MSW was generated during the Arba'een festival in 2016 while up to 11 kt of MSW was generated during the Ashura event in the same year (Abdulredha *et al.*, 2017c). These amounts account for around 11% of the total waste generated in the city each year (560 kt) (ESD, 2014), but there is no separate estimate available for the quantity and composition of solid waste generated by the hospitality industry. These estimates must be considered unreliable, as the city lacks any reliable solid waste information system that accurately captures the quantity of waste generated in the city let alone during festivals. Management authorities stated that they used an estimated density of 400 kg/m^3 for collection trucks to calculate the amount of solid waste delivered to landfill, this calculation according to the volume of the trucks and number of trips to the landfill. The management authorities do not have any information about the quantity of waste generate from the city or festivals which is not delivered to the designated landfill.

In summary, the MSW management system in Kerbala is inefficient and has not really been properly managed for many years, the city lacking an appropriate MSW management strategy for separating and recycling waste (Abdulredha, 2012; Abdulredha *et al.*, 2017c). Therefore, an efficient and functional solid waste infrastructure is required, as the current situation has the potential to have a severe impact on the environment and on human health. This study can enable waste management authorities to develop integrated measures for solid waste management in Kerbala and other cites hosting similar festivals by estimating the quantity of solid waste generated by the hospitality sector.

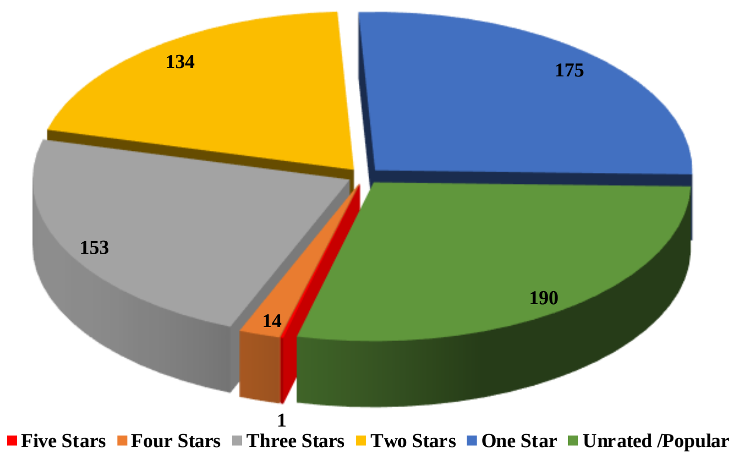

Fig. 2. Hotel ratings in Kerbala city.

3.2. Data collection

The data used in this study are drawn from a field questionnaire survey conducted in Kerbala during the Arba'een event and an on-site MSW audit. The questionnaire was developed to test the hypothesis that a relationship exists between the features of hotels (Hs, Hex, etc.) and the rate of MSW generated by hotels during such events.

A structured questionnaire was developed in stages, to collect data about some of the characteristics of the hotels including size (number of beds), area, number of floors, location and expenditure. Firstly, the questionnaire items were formulated after carrying out an extensive literature review on MSW management (Beigl *et al.*, 2008; De Feo and De Gisi, 2010; De Feo *et al.*, 2013; Edjabou *et al.*, 2015; Azadi and Karimi-Jashni, 2016; Grazhdani, 2016; Pirani and Arafat, 2016). In the second stage, the questionnaire was reviewed by a panel of MSW management and survey research experts to check its construct validity. It was then revised and corrected, according to the suggestions and feedback from the experts in the third stage. In the fourth stage, a pilot study was conducted during one major event (Ashura) to check the content validity of the questionnaire, possible areas of ambiguity and comprehensiveness. A total of 29 hotel managers, within the city centre, were asked to complete the questionnaire and comment on its clarity or areas of ambiguity. Finally, based on expert recommendations and the results of the pilot study, the questionnaire was amended and used in the main survey during the Arba'een event.

After developing the questionnaire and contacting the holy shrine authorities (main festival organizers) for permission to carry out the main survey, the authorities supplied 4 research assistants to conduct the field survey, because of the short duration of the festival (15 days) and the amount of data required. An intensive 2-day course covering survey ethics, survey methodology, contacting the participant, reading the questions and recording the participant responses accurately, was provided for and completed by the assistants.

Rea and Parker's (2014) method was used to determine the sample size (see supplementary materials). 123 hotels were required to achieve a 95% confidence level with confidence intervals of 8% in the study area, this from a total population of 667 hotels (see Fig 2). Based on the variety of sampling approaches presented in the literature such as purposive and probability sampling (Bryman, 2012; Rea and Parker, 2014), and guided by the goals of this study, simple random sampling was selected as the sampling approach (Bryman, 2012). Based on this approach, the festival area was divided into four zones (Table 2). The survey took place over a period of 10 successive days during the Arba'een event in November 2016. The research assistants visited three to five hotels, in each zone, on each survey day. Therefore, 15 to 20 hotels were visited in all zones per day and given an information sheet describing the research objectives, the interview outline, the audit process and details about confidentiality. In total, the research assistants approached 180 randomly selected hotels, in person, to obtain their permission to participate in the survey. Of these, 150 hotel managers consented to participate in the survey, which represents 22.4% from the total population of 667 hotels. Following this, the assistant read the questionnaire items to the participant and recorded his/her responses. The research assistants made sure that all of the questionnaire items were properly addressed. Using this method, every hotel from the whole hospitality sector, has an equal chance of being included as part of the sample. In this way, a representative sample is more likely to be targeted, the findings from the sample then generalized to the total population from which it was selected (Bryman, 2012).

After completing the questionnaire, an on-site audit was conducted to estimate the quantity of day-to-day MSW generated by the 150 participating hotels, according to the methodology used by the Waste and Resources Action Programme WRAP (2011). First, the hotel manager, or the member of staff responsible for hotel waste management, took the investigator to the area where the waste was kept prior to removal. At this point, a short interview was conducted to determine when the hotel waste was last collected and whether the waste in situ was typical for one day. The investigator also asked for information about the number of times per day the waste was collected by the collection service and average level of bins fill during the festival. The reminder of the time on-site involved a visual inspection to establish a volume-to-weight conversion factor (density) and general over view regarding solid waste composition at the targeted hotels. This inspection included noting how many containers/bins the hotel has on-site, the volume of the bins and the average fill level for each bin when collected. Using this data, the volume of MSW generated from the hotel can be calculated by multiplying the number of bins they have on-site, their volume, times of collection and average fill level when collected.

To convert volume of waste to weight, bulk density factors have been used for many years in industrial and commercial sectors (WRAP, 2011). For the current study, two bins from each participating hotel were randomly selected to calculate the waste weight and bin volume. The weight of the waste in the selected bins was calculated on site using a Suaoki digital scale which has a maximum capacity of 50kg, accurate to 5g. The waste density conversion factor was estimated for each hotel by dividing waste weight in the selected bin, by the volume of the bin. The latter factor was used to convert the daily volume of the hotel waste into weight. To validate this estimation, the actual amount of MSW generated from ten differently ranked hotels randomly selected from the total sample, was recorded and compared with the estimated amounts.

Before the collected data were entered into the database for analysis and modelling, the reliability and validity of the collected data were examined. Reliability refers to the consistency of a measure of a concept (Bryman, 2012). It is assumed that different questions targeting the same underlying concept are correlated (Aday and Cornelius, 2006). The coefficient of internal consistency, Cronbach's alpha (α), one of the most commonly used tests among researchers, was used to assess the reliability of the questionnaire (Bryman, 2012; Malik *et al.*, 2015). Using a scale from 0-1, the closer the coefficient (α) is to 1.0, the more credible it is (Babaei *et al.*, 2015). In this study, Cronbach's alpha (α) was calculated as 0.77, according to the method described by Aday and Cornelius (2006) (see supplementary martials), confirming the questionnaire as reliable.

In addition, and as stated above, the questionnaire was developed according to an extensive literature review, revised by a panel of experts and assessed by a random set of hotels managers for clarity. This process confirmed that the questionnaire had acquired proper construct and content validity (Aday and Cornelius, 2006; Bryman, 2012).

3.3. Predictor variable

The broad objective of this research is to define the features of a hotel that influence MSW generation during major events. The literature states that the amount of MSW generated is highly influenced by several features/parameters such as number of beds, expenditure, waste collection frequency, geographical location, food habits and economic conditions (Intharathirat *et al.*, 2015; Azadi and Karimi-Jashni, 2016; Pirani and Arafat, 2016). Pearson's Product Moment Correlation was performed to rate the contribution of each single feature/parameter. Any parameter with a Pearson's Correlation Coefficient (PCC) of less than 0.3 was dismissed as it does not exert a significant influence on the rate of production of MSWG.

The parameters identified as influencing MSWG rates are firstly hotel size (Hs), measured by the number of beds; the rate of MSWG increases with an increase in both hotel size and occupancy rate (Ball and Abou Taleb, 2010; WRAP, 2011; Pirani and Arafat, 2016). Likewise, the rate of MSW production is influenced by hotel expenditure (Hex), there being a relationship between the rate of MSWG production and expenditure over different activities (Thanh *et al.*, 2010; Intharathirat *et al.*, 2015). MSW collection frequency (Freq) was also considered since collected MSW will increase with an increase in the need to collect more frequently (Keser *et al.*, 2012; Azadi and Karimi-Jashni, 2016). The fourth parameter was the area of the hotel in square meters (Ha) because there is evidence to suggest that the quantity of MSW generated from a hotel varies according to its total size (Trung and

Kumar, 2005). The last parameter included in this study was the number of employees or staff (Hst). Purcell and Magette (2009) estimated the quantity of waste generated from hotels in Dublin, United Kingdom according to the number of staff and the number of beds.

3.4. Data analysis and statistical modelling

In MLR, a family of techniques first introduced by Francis Galton in the 19th century, the interrelationship among several explanatory IVs and a response DV are modelled by fitting a linear equation to the training dataset as shown in Eq. (1) (Tabachnick and Fidell, 2013; Azadi and Karimi-Jashni, 2016):

$$Y = B_0 + \sum_{i=1}^{n} B_i \, x_i \tag{1}$$

where Y is the predicted value of the response DV, B_i (1, 2, …, n) are the regression coefficients and x_i (1, 2, …, n) are the explanatory IVs. To enhance the performance of the predicting equation, a random residual error coefficient (ε) was added (Azadi and Karimi-Jashni, 2016; Hashim *et al.*, 2017c):

$$Y = B_0 + \sum_{i=1}^{n} B_i \, x_i + \varepsilon \tag{2}$$

MSW generation is a function of several parameters including geographical location, season, collection frequency, characteristics of the service area, economic conditions, existing management laws, local culture and beliefs, and population (Tchobanoglous *et al.*, 1993; Beigl *et al.*, 2008; Purcell and Magette, 2009; Li *et al.*, 2011; Pirani and Arafat, 2014; Intharathirat *et al.*, 2015), which can be expressed as follows:

$$MSWG = f(population, income, laws, charachteristics, \dots etc) \tag{3}$$

In the current study, the influence of Hs, Hst, Hex, Ha and Freq in terms of MSW generation was investigated. Therefore, hotel MSWG is expressed by the following equation:

$$Hotel\ MSWG = f(Hs, \mathrm{He}x, Freq, Ha, \mathrm{Hst}) \tag{4}$$

Based on the assumptions stated above, to develop an MLR model, it is essential to define the regression coefficients in such a way that they are statistically significant (Azadi and Karimi-Jashni, 2016). Several methods including standard, hierarchical and stepwise can be used to determine these. In the current study, a stepwise MLR was used. In this method, explanatory IVs which have weaker correlations with the response DV, will be excluded (Pires *et al.*, 2008; Tabachnick and Fidell, 2013).

To develop a stepwise MLR, two stages must be followed (Pallant, 2007). The first is to check the assumptions of the technique and data treatment, the second to evaluate the performance of the developed model and the contribution of explanatory variables.

3.4.1. Assumption of the MLR and data treatment

I. Sample size

The generalisability of the model built by MLR is influenced by the size of the dataset, as the results cannot be generalized if using a small dataset (Pallant, 2007; Hashim *et al.*, 2017b). The minimum required sample size to develop a generalizable model, taking in to account the number of explanatory IVs, can be calculated by the following equation (Tabachnick and Fidell, 2013):

$$N \geq 50 + 8 * IVs \tag{5}$$

in which N is the sample size and IVs is the number of explanatory IVs used in the MLR.

II. Normality of variables: IVs and DV

Variable screening for normality is an important primary stage in MLR. Although normality of variables is not always required for data analysis, the result is more robust if all the variables are normally distributed (Pallant, 2011; Tabachnick and Fidell, 2013). Expected normal probability plots, P-P plots, are effective graphical devices for assessing normality (Parisi Kern *et al.*, 2015). In these plots, expected normal values are compared with actual normal values for each case. The closer the actual values are to the expected values, the closer to a normal distribution (Tabachnick and Fidell, 2013). The literature provides many data transformation methods depending on direction of skewness and extent from normal distribution, such as logarithmic transformations, to enhance the distribution of variables (Tabachnick and Fidell, 2013).

III. Absence of outliers

An outlier is a case with an extreme value or one which is incompatible with other cases in the same variable (Tabachnick and Fidell, 2013). Outliers impact negatively on the conclusions drawn from the MLR, as they skew the results and make the regression outcome invalid, therefore both explanatory IVs and response DVs must be analysed to remove such extreme values in the initial screening runs (Hashim *et al.*, 2017c). Statistically, the presence of outliers within the variables can be checked using the Mahalanobis distances (Pallant, 2011). The latter values must be less than the critical values shown in Table 1 (Tabachnick and Fidell, 2013).

Table 1: Mahalanobis distances critical values

No. of IVs	critical value	No. of IVs	critical value	No. of IVs	critical value
2	13.82	4	18.47	6	22.46
3	16.27	5	20.52	7	24.32

Key: IVs = independent/explanatory variables

IV. Multicollinearity

A correlation among the explanatory IVs within the data set is the phenomena of multicollinearity, which negatively influences the outcome of the MLR (Pallant, 2011). Multicollinearity must be addressed by excluding one of the correlating IVs, or by producing a new IV representing the correlated IVs (Hashim *et al.*, 2017c). The presence of multicollinearity can be detected by calculating the Variance Inflation Factor (VIF) values (Eq. (6)) by which each explanatory IV, represented by X, becomes the response DV, while the other IVs are preserved as independent variables. Accordingly, the VIF is determined for each IV (VIF_X) as in Tabachnick and Fidell (2013). The current literature provides a wide range of threshold values for VIFs, a value of more than 10, a common cut-off-point in the literature, used to confirm the existence of multicollinearity in this dataset.

$$VIF_X = \frac{1}{1-R^2} \tag{6}$$

where R^2 is the regression coefficient of determination for X the explanatory variable.

V. Normality of residuals

This term refers to the distribution of the residuals of the prediction model around the predicted DV. The assumptions of MLR are that standardised residuals are normally distributed around the predicted DV values (Tabachnick and Fidell, 2013). Residual scatterplots provide the information required to test this assumption where less than 1% of the standardised residual scores may exceed the range -3.3 to 3.3, according to Mahalanobis distances (Pallant, 2011).

3.4.2. IVs contribution and Model performance.

I. The contribution of explanatory IVs.

The contribution of IVs to the results of the built model varies from tangible to negligible according to their statistical significance (p) (Tabachnick and Fidell, 2013). An IV with a p value of less than 0.05, significantly impacts on the results of the proposed model; stepwise MLR excludes any IV with a $p \geq 0.05$ owing to its low contribution to the model (Pallant, 2011).

II. Model performance

Prediction accuracy, an essential performance measure of the MLR model, refers its ability to explain variations in the DV (Hashim *et al.*, 2017a). The coefficient of determination (R^2) is a tool used to evaluate the performance of the applied model, as it measures the differences between observed DV scores and predicted DV scores via the regression model. It ranges on a scale between 0 to1, a coefficient of 1, or close to 1, suggesting that the model can produce a reliable outcome. R^2 can be calculated by the following equation (Tabachnick and Fidell, 2013; Azadi and Karimi-Jashni, 2016):

$$R^2 = \frac{Y\prime}{Y} \tag{7}$$

where Y' is the sum of the total squared difference between the mean and predicted scores and Y the sum of the total squared difference between the mean and observed scores.

In the current study, IBM SPSS 23 was used to analyse the data and build the proposed prediction model.

4. Results and discussion

4.1. Field Work

As mentioned earlier, the required number of hotels was calculated according to Rea and Parker (2014) formula. A minimum of 123 hotels were required to generalize the outcomes of the current study: 150 hotels of different ranks, have been studied. 10 hotels were unrated, 29 were one star, 70 were two star, 37 were three star and four ranked as four star hotels (Table 2). The area studied has been divided into four circular zones: zone A covers the centre of the event (250 m in radius), zone B from 251 to 400 m, zone C from 401 to 600 m and zone D from 601 to 850 m. Table 2 shows the rank distribution according to zone.

Table 2: Hotel rankings zonal distribution

Zone	Number of the studied hotels according their rank					Total
	Unrated	One stars	Two stars	Three stars	Four stars	
A	5	9	23	11	3	51
B	3	11	13	8	0	35
C	1	5	18	11	0	35
D	1	4	16	7	1	39
Total	10	29	70	37	4	150

The amount of MSW generated by these hotels was estimated according to the methodology used by WRAP (2011). To validate this estimation, ten differently ranked hotels were randomly selected from the total number of hotels, the actual amount of MSW generated from each over one day, recorded and compared with the estimated amounts. There was good agreement between the actual and estimated quantities of MSW. This indicates that the method used to estimate the quantity of MSW in this research yields acceptable results.

4.2. The correlation between IVs and DV

Based on the parameters defined in the literature, five explanatory IVs; Hs, Hex per guest, Hst, Ha and Freq, were examined to evaluate the influence of each on the total MSW produced by hotels. PCCs between the explanatory IVs and the response DV were examined to give an indication of the strength of the linear relationship between variables in both directions (negative and positive). Table 3 reports the descriptive statistics and the correlation coefficients between the explanatory IVs and the mass of MSW.

Table 3: Descriptive statistics and correlations between IVs and DV.

Variable	MSWG	Hs	Hex	Hst	Ha	Freq
Units	kg.day^{-1}	No. of beds	Iraqi Dinar per guest	No. of staff	m^2	Times.day^{-1}
Mean	112.342	130.68	13.19	8.38	292.55	3.15
Median	97.558	100.00	10.00	6.00	205.00	3.00
Maximum	375.25	450	70	28	1200	8
Minimum	7.65	14	1	1	50	1
Std. Dev.	78.317	84.215	9.964	6.125	215.493	1.778
Skewness	0.65	1.178	1.884	1.232	1.722	0.858
Kurtosis	-0.089	1.354	6.399	0.804	3.320	0.187

PCC	1	0.7211	0.6292	0.6182	0.5415	0.2440
Sig.	-	0.0000	0.0000	0.0000	0.0000	0.0013

Key: Sig (*p*) = statistical significance; PCC = Pearson's correlation coefficient, and Std. Dev = Standard Deviation

As seen in Table 3, the PCC's between each of the explanatory factors and the amount of MSW generated is positive; the amount of waste produced by any hotel will increase if any of the explanatory IVs increases in its value. Hs and Ha have the highest and lowest correlations with MSW produced by a hotel, while frequency of MSW collection has been omitted from the study as its coefficient was less than 0.3 meaning that it has a negligible influence on the quantity of MSW produced by hotels (Pallant, 2011). The explanatory IVs seen in Table 3 were those used to develop the production model using multiple linear regression.

4.3. Hotel waste generation

The survey results revealed significant variations between different categories of hotel regarding total MSW generation rate, ranging from 7.65 to 375.25 kg.day$^{-1.}$ (Table 4). The mean quantity of MSW produced by hotels was 112.34 kg.day^{-1} (Std. Dev. 78.317). The principal component of the hotels' refuse was organic waste, mainly food residue mixed with plastic and paper. Pure organics such as food residues were also observed in the waste stream. As was expected, high percentages of plastic and paper refuse were detected because of the extensive use of packaging materials. The percentage of metal and glass waste was low because of a minimal use of canned drinks and glass materials. MSW generation per guest per day was calculated by dividing the total MSW produced by the number of guests occupying that hotel that day (Losanwe, 2013).

The average rate of MSW generation in kg.guest^{-1}.day^{-1} was 0.89 (Std. Dev. 0.52; n=150) in the city during the event. However, there was significant variation in the MSW generation per guest according to category of hotel. Four-star rated hotels produced the most MSW with a mean of 1.22 (Std. Dev. 0.52; n=4). Unrated hotels were next with an average of 1.08 (Std. Dev. 0.95; n=10). Two stars' hotels came third with a mean of 0.9 (Std. Dev. 0.52; n=70), the lowest MSW produced by one and three stars' hotels with an average of 0.83 (Std. Dev.'s 0.60 and 0.26, respectively).

Table 4: Descriptive statistics results of waste generation rate according to hotel rating.

Parameter	**Mean**	**Median**	**Max.**	**Min.**	**Std. Dev.**	**Skew.**	**Kurtosis**
Hotels MSWG (kg.day^{-1})	112.34	97.558	375.25	7.65	78.317	0.65	-0.089
Average MSWG rate (kg.guest^{-1}.day^{-1})	0.89	0.77	3.51	0.12	0.52	1.620	4.029
Unrated hotels MSWG rate (kg.guest^{-1}.day^{-1})	1.08	0.88	3.51	0.26	0.95	2.138	5.269
One stars' hotels MSWG rate (kg.guest^{-1}.day^{-1})	0.83	0.60	2.32	0.21	0.6	1.074	-0.035
Two stars' hotels MSWG rate (kg.guest^{-1}.day^{-1})	0.90	0.79	2.68	0.12	0.52	1.185	1.397
Three stars' hotels MSWG rate (kg.guest^{-1}.day^{-1})	0.83	0.81	1.82	0.33	0.29	1.037	2.157
Four stars' hotels MSWG rate (kg.guest^{-1}.day^{-1})	1.22	1.13	1.88	0.75	0.52	0.618	-2.204

Key: Max = Maximum; Min = Minimum; Std. Dev.= Standard Deviation; and Skew = Skewness.

There is considerable variation between hotels when it comes to how much MSW per hotel, or even per guest, are generated on a daily basis. This variation can be attributed to hotel size, hotel type or category, guest and staff activates and guest attributes (Snarr and Pezza, 2000; Pirani and Arafat, 2014). For example, four-star hotel guests produce much more waste than the waste produced by one and three-star hotel guests. This can be attributed to expenditure of the hotel per guest or to the attributes of the guest. The average expenditure per guest four star hotels was 33,750 Iraqi Dinar (ID), this figure dramatically declining to 9,950 and 14,250 ID for one and three star hotels, respectively. This variation in hotel expenditure relates to substantial differences in the services provided by the hotel. Hoteliers claimed that the same services are provided in their hotel along the year and their orders of consumable products is related to the number of guests in the hotel over a specific period (normally one week). Thus, as the hotels normally fully occupied during festivals, the quantities of consumables products increase with the increase in the occupancy rate which influence the amounts of MSW produced by hotels.

Waste generation rates ranged between 0.12 and 3.51 $kg.guest^{-1}.day^{-1}$ with an average of 0.89, which is generally lower the global average figures reported by Losanwe (2013), approximately 1 kg of MSW per day. However, Dangi *et al.* (2011), reported that the average MSW generated by 271 hotels in Kathmandu Metropolitan City, Nepal was 113.3 $kg.day^{-1}$, which is closer to the average mass of MSW produced by the hotels targeted in this study (112.34 $kg.hotel^{-1}.day^{-1}$).

4.4. Modelling MSW generation

Variations in MSW production from hotels (DV) according to variations in hotel characteristics (IVs) has been modelled using the MLR technique using IBM SPSS-23 over two stages, stage 1 being to check assumptions of the technique and data treatment, stage 2 to evaluate model performance and the contribution of the explanatory IVs.

4.4.1. Testing the assumption of MLR and data treatment

I. Sample size

The minimum number of observations required to construct a generalizable prediction model was calculated according to Equation (5). Four hotel characteristics (IVs), Hs, Hex, Hst and Ha, were used to build the prediction model meaning that 82 observations were the minimum required. The first assumption has therefore been met since 150 field observations made, more than the necessary dataset size for Stepwise MLR modelling.

To perform this technique and avoid problems of overfitting (Azadi and Karimi-Jashni, 2016), a test dataset was derived by separating the total dataset into two random samples. The training dataset, comprising 75% of the total datasets (112 observations), was used to build the production model while, the remaining 25% of the dataset (38 observations), were used to check the performance of the model.

II. Normality of variables IVs and DV

Variable distribution should be checked as this guides analyses decision making and enhances the results of the model. Expected normal probability plots (P-P plots) were employed, these plots providing a graphical comparison between the expected normal values and the actual normal values for each observation (Tabachnick and Fidell, 2013). Expected normal values are represented by a diagonal line running from lower left to upper right, normal distribution seen when the points for the observations fall along the diagonal line with limited minor deviations owing to random processes (Pallant, 2011). Fig. 3 illustrates the distribution of all variables (IVs and DV).

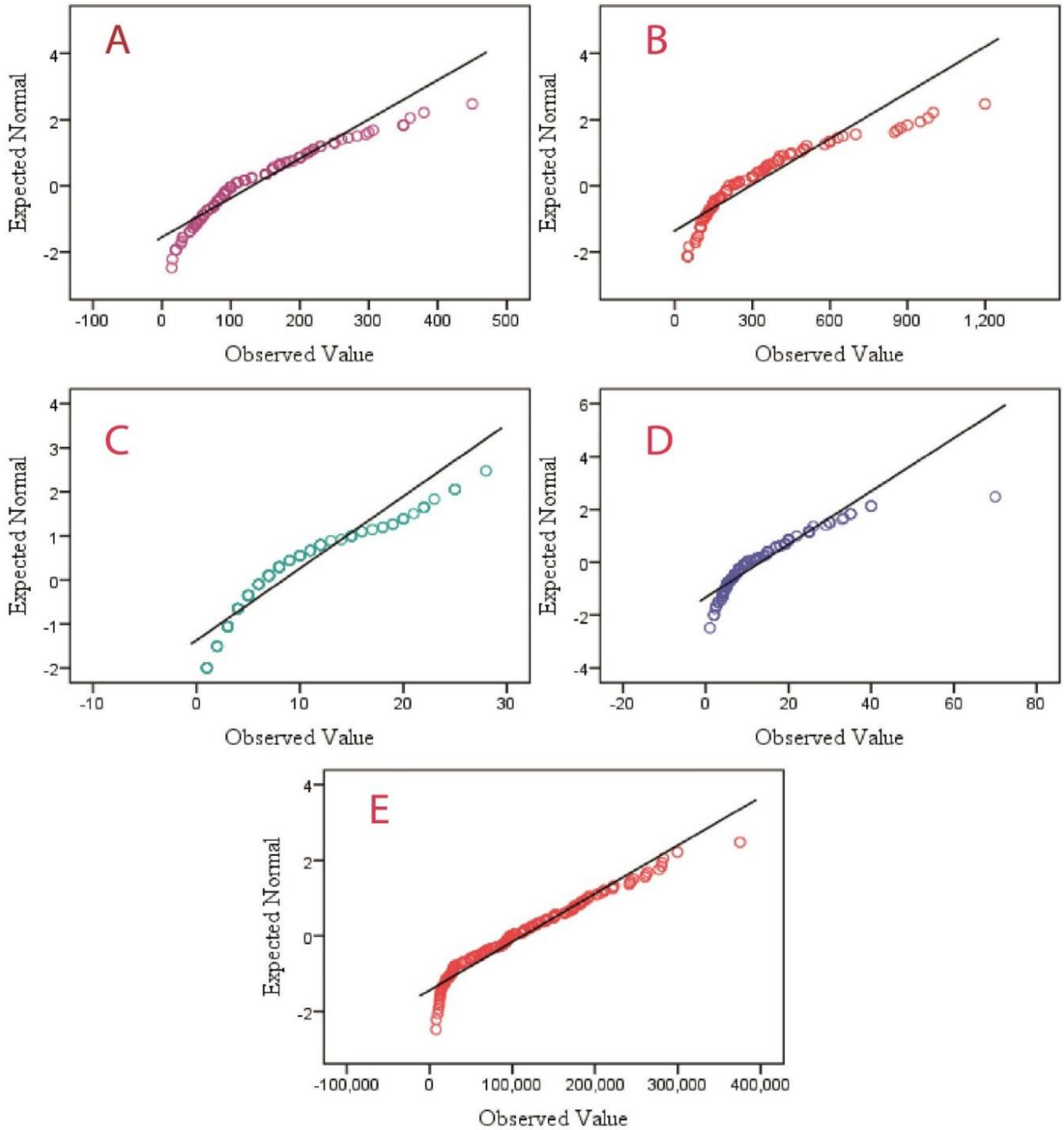

Fig. 3. Expected normal probability plots for the original IVs and DV: (A) Hs, (B) Ha, (C) Hst, (D) Hex, (E) MSWG

As seen in the above graphs, the data do not adhere to the diagonal line which means that they are not normally distributed, violating assumptions of normality. There are many methods available such as Box-Cox, Johnson, logarithmic, and square root transformations (Tabachnick and Fidell, 2013) to transform data to a normal distribution. The selection of an appropriate method for a variable depends on skew and direction. Two transformation methods have been used here; logarithmic and cubic root transformations. Logarithmic transformation was applied to the explanatory variables (IVs) (Eq. (8)), cubic root transformations applied to the DV (Eq. (9)).

$$X' = Ln(X) \tag{8}$$

$$X' = \sqrt[3]{X} \tag{9}$$

where X' is the transferred score and X is the actual score.

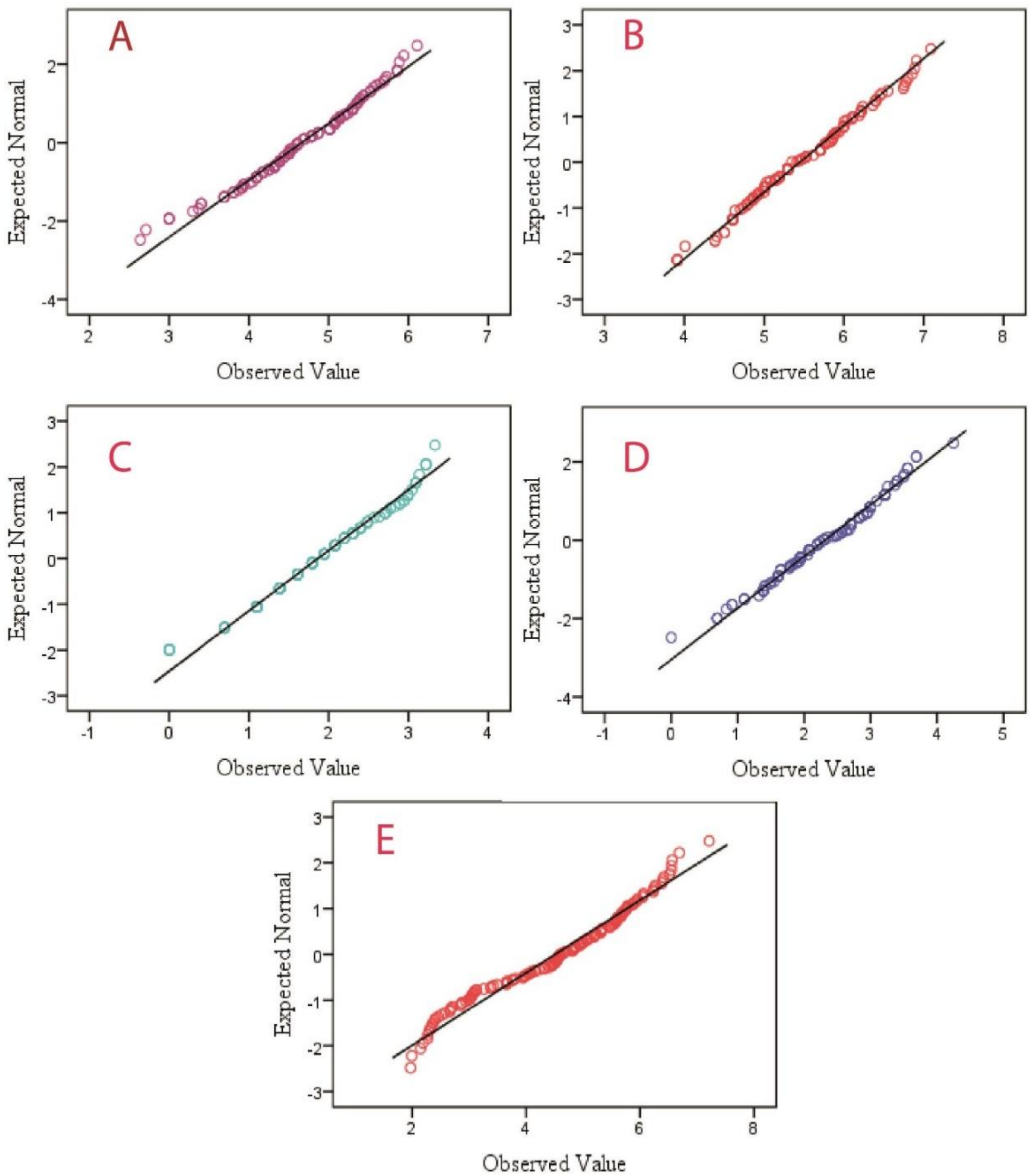

Fig. 4. Expected normal probability plots for the treated IVs and DV: (A) Hs, (B) Ha, (C) Hst, (D) Hex, (E) MSWG

Fig. 4 illustrates the distributions for the treated IVs and DV. Observation points for each variable fall along the diagonal line with limited deviation because of process randomness, meaning that the distributions of the IVs and the DV are normal.

III. Absence of outliers

The initial screening MLR run was conducted on both the IVs and DV to detect the presence of outliers. Mahalanobis distances were calculated and compared with the critical values shown in Table 1. The maximum acceptable Mahalanobis distance for the 4 explanatory variables is 18.47. This critical value was compared with the maximum calculated Mahalanobis distance for the field observations (12.20) confirming the absence of extreme outliers (Table 5).

IV. Multicollinearity

Multicollinearity among explanatory variables, another assumption of MLR that measures a linear relationship between two explanatory variables, has been examined by calculating VIF values for the hotel characteristics (Eq. (6)). Table 5 confirms the absence of multicollinearity as the highest calculated VIF was 1.908 which is considerably less than the critical value of 10.

Table 5: Summary of multicollinearity statistics and model coefficients.

DV	IVs	VIF	Tolerance	Max. Mahalanobis distance	Std. residual outside the acceptable range (3.3 to -3.3)		Max. Cook's Distance	Sig.	Beta
					No. of cases	Values			
MSWG	Hs	1.746	0.573	12.20	1	-3.65	0.108	0.000	0.573
	Hex	1.221	0.819					0.000	0.407
	Hst	1.908	0.524					0.033	0.129
	Ha	-	-					0.408	-

Key: DV = Dependent or response variable; VIF = Variance inflation factor; Sig = statistical significance, and Std. residual = standardized residual.

V. Normality of residuals

The final assumption, the normality of residuals within the investigated samples, was examined using a residual scatterplot. If the assumption is met, the standardised residual scores are expected to be normally distributed around the predicted values, with less than 1% of the standardised residual values lying outside the range -3.3 to 3.3. Fig. 5 illustrates the distribution of the standardised residual scores around the predicted values. One score (out of 150) is located outside the stated range meaning that the normality of residual assumption has been met. However, to check whether this point may have an influence on the results of the MLR model, Pallant (2011) recommends to calculated the Cook's distance of this point, where any point with a Cook's distance of more than 1.0 presents a possible problem.

The maximum Cook's distances for all observations have been determined, the results shown in Table 5 indicating that this case exerts a negligible influence on the model, as the maximum Cook's distance value was below 1.0.

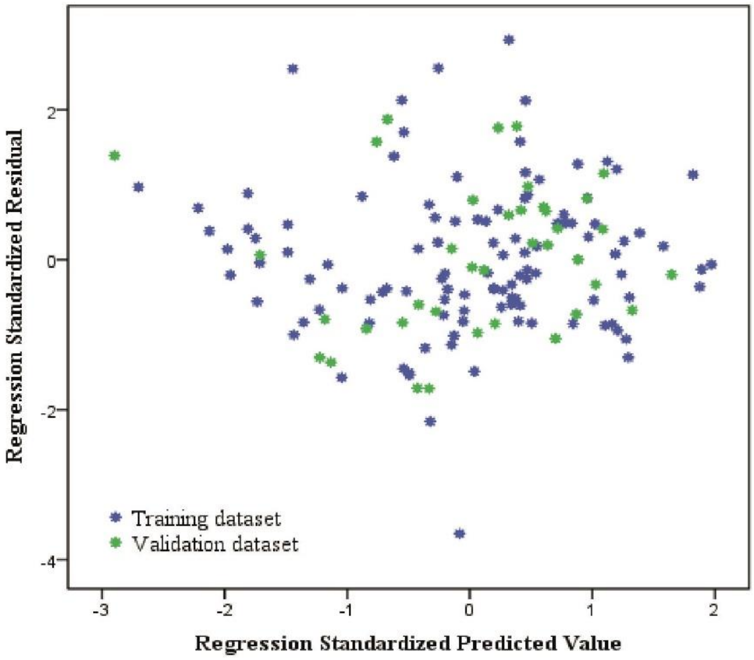

Fig. 5. Scatter plot of the standardised residual scores distribution around the predicted values.

4.4.2. Evaluating the contribution of IVs and the performance of the model

I. Contribution of IVs to the built model

The statistical significance of the hotel characteristics defines whether they apply a tangible or negligible influence on the results of the proposed MLR model. Any feature that has a statistical significance of more than 0.05, can be excluded owing to its negligible contribution.

Based on the results of the statistical analysis (Table 5) all hotel features significantly contribute to the outcome of the suggested model except hotel area (in meters^2). This feature has therefore been omitted from the developed model.

The beta values for parameters Hs, Hex and Hst, have been determined to measure the strength of influence of each on the model. The results obtained in Table 5 illustrate that the hotel size exerts the greatest influence on the suggested model followed by hotel expenditure.

II. Model performance

After confirming that the assumptions for MLR have been satisfied, a cross-validation MLR model was developed to predict the quantity of MSW produced by hotels (Eq. (10)). It is essential to check the ability of this model to explain changes in the quantity of MSW produced by hotels, the best way to do this by calculating the coefficient of determination (R^2), where R^2 represents the degree of concordance between the actual observations for the amount of waste produced and the amounts estimated by the suggested model. R^2 was 0.799 which means that the proposed model is able to explain 79.9% of the variation in the quantity of MSW produced by hotels according to their features. This value is comparable with those obtained by others including Azadi and Karimi-Jashni (2016) and Parisi Kern *et al.* (2015) who obtained R^2 values of 0.78 and 0.69, respectively.

$$MSWG = (-22.41 + 10.40 \ln Hs + 6.49 \ln Hex + 2.13 \ln Hst)^3 \tag{10}$$

The statistical significance of the suggested model is an essential parameter that has to be checked at this stage. According to Tabachnick and Fidell (2013), the significance of a proposed model must be less than 0.05 to accept it. The significance of this study model was 0.033 meaning it can be accepted.

In order to investigate the agreement between the observed and predicted amounts of waste produced by hotels, the model was applied to the randomly selected validation dataset (25% of the total dataset).

Fig. 6 illustrates the relationships between the predicted and observed quantities of MSW for both training datasets (Fig. 6A) and the validation dataset (Fig.6B). The R^2 value for the validation dataset was 0.788, which is comparable to the R^2 of the proposed model (0.799). The outcomes obtained show a meaningful agreement between these values.

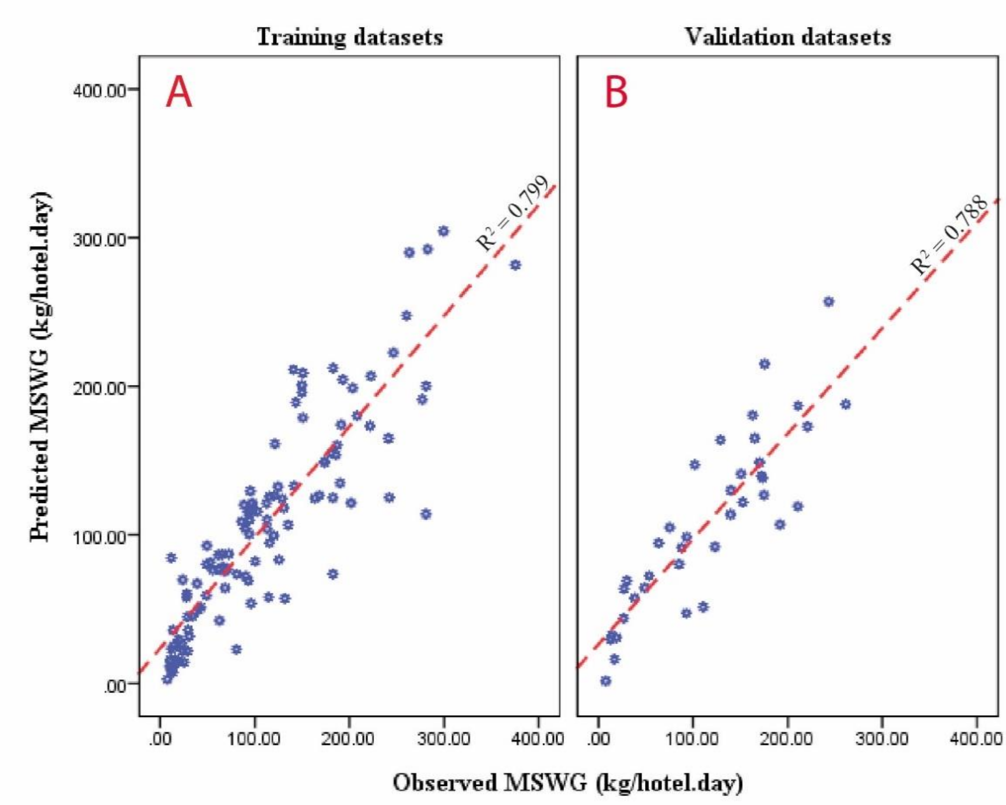

Fig. 6. Relationships between the predicted and experimental MSWG: (A) training dataset, (B) validation dataset

5. Conclusion

The variation in MSW generated from the hospitality sector (hotels) during the Arba'een festival, was examined in this study. The use of MLR as a prediction model that includes a variety of features of hotels to estimate variations in MSW generation, was also investigated. This new study could be used to quantify hotel MSW and contributes to the development of the current unsuitable management system for MSW in Kerbala, resulting in a reduction in the negative environmental impact created by the hospitality sector.

The field survey conducted as the first stage of this study helped establish a foundation regarding the status of this sector during major festivals; this information has not been gathered before. The results obtained show that the rate of MSWG during major events is comparable with those produced by hotels in different countries. However, full occupancy of the hotels during major festivals, significantly increased the amount of MSW produced. The results also revealed that higher ranked hotels have higher MSWG rates than lower rated hotels, something attributed to the expenditure of the hotel and guests' economic attributes and activities.

Through the MLR analysis conducted in the second stage of this research, it was confirmed that hotel features influence rates of waste generation. The rates of MSWG generation were found to be positively correlated with hotel size, expenditure and number of staff; the size of the hotel was the most influential factor on rate of MSW generation, while staff size was the lowest. Waste collection frequency does not affect the quantity of MSW produced and no statistically significant association was found between the rate of MSW generation and hotel area (meters^2).

Based on these results, it can be stated that MLR is a powerful tool to predict variations in the amounts of MSW produced by hotels during AL-Arba'een festival. There is a strong association between some features of hotels and solid waste generation, indicating that this association could be used to estimate the quantity of MSW generated from the hospitality sector. This city does not have any previous records regarding MSWG rates during major festivals; the success of this research implies that there is no need to spend a great deal of time and money on collecting such data. The developed model can provide accurate information on waste generation, assisting decision makers to develop integrated measures for waste management over festival periods.

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