ORIGINAL PAPER

Municipal solid waste characterization and household waste behaviors in a megacity in the northwest of Iran

Kh. Zoroufchi Benis[1] · A. Safaiyan[2] · D. Farajzadeh[3] · F. Khalili Nadji[4] · M. Shakerkhatibi[5] · H. Harati[6] · G. H. Safari[5] · M. H. Sarbazan[6]

Abstract

Improper solid waste management poses adverse health effects and pollution challenges in both developed and developing countries. The present study is aimed to evaluate the fate of municipal solid waste (MSW) and household waste behaviors in Tabriz megacity. A questionnaire survey was performed to evaluate the knowledge, attitudes and practices of residents toward MSW reduction, source separation, recycling and collection. The results indicated that food wastes make up the highest portion of MSW, and high moisture content of waste leads to low heating value which is below than average heating value for applicability of incineration. Potentially recyclable wastes such as paper and cardboard, plastics, metals, textiles, glass, wood and others make up a total of 33% of the household solid wastes. Investigation of the fate of MSW revealed that about 55.5% of generated waste ends up in landfill sites, 20.5% is separated by itinerant buyers and separation facility just before landfilling, and 24% is converted into compost. The evaluation of resident's behaviors toward MSW demonstrated the low knowledge of respondents and their high willingness to segregate solid wastes.

Keywords Municipal solid waste management · Source separation · Waste characterization · KAP

✉ M. Shakerkhatibi
shakerkhatibim@tbzmed.ac.ir

1 Faculty of Chemical Engineering, Environmental Engineering Research Center, Sahand University of Technology, Tabriz, Iran

2 Department of Statistics and Epidemiology, School of Health, Tabriz University of Medical Sciences, Tabriz, Iran

3 Department of Cellular and Molecular Biology, Faculty of Biological Sciences, Azarbaijan Shahid Madani University, Tabriz, Iran

4 Student Research Committee, Tabriz University of Medical Sciences, Tabriz, Iran

5 Health and Environment Research Center, Tabriz University of Medical Sciences, 5166614711 Tabriz, Iran

6 Waste Management Organization, Tabriz Municipality, Tabriz, Iran

Introduction

Municipal solid waste management (MSWM) is one of the major challenges that world faces today. The rapid urbanization along with the population growth, rising in living standards and economic development has been indicated as the main causes for the increase in municipal solid waste (MSW) generation (Cavdar et al. 2016; Pakpour et al. 2014; Sessa et al. 2010). Based on the available data, MSW generation in Asia in 1998 was 0.76 million tons per day with an annual growth rate of 2–3% in developing and 3.2–4.5% in developed countries. This figure is predicted to increase to 1.8 million tons per day by 2025 (Damghani et al. 2008).

Improper management of the increasing amount of MSW poses a serious environmental problems in both developed and developing countries (Malmir and Tojo 2016; Mosaferi et al. 2014; Kumar and Baskar 2015). These problems are more serious in developing world, where waste collection operations do not occur at all or not enough (Pakpour et al. 2014; Song et al. 2015).

In developed countries such as the USA, Germany and Japan, significant successes in waste management have been achieved due to the establishment of various laws and

regulations in MSWM in recent decades (Potdar et al. 2016; Yakubu and Zhou 2018). There is a move from a landfill-based waste management system to a more integrated one. As a critical component of a successful integrated waste management system, source sorting and separation increases the quality of produced compost and fractions, reduces the cost of waste management, optimizes incineration and provides data on waste generation (Chi et al. 2015; Miezah et al. 2015; Taghipour et al. 2016).

The most important cost-effective way to achieve success in MSWM is through making changes in attitudes and behaviors and also public participation and empowerment in waste management programs (Babaei et al. 2015; Barr et al. 2001; Desmond 2006; Mongkolnchaiarunya 2005). Given the importance of citizen participation in the waste management programs, knowledge, attitudes and practices (KAP) has been assessed extensively in the literature as the most influencing factors (Babaei et al. 2015; Momoh and Oladebeye 2010; Otoma et al. 2013; Pakpour et al. 2014; Sukholthaman et al. 2017; Zhang et al. 2012).

As defined, the knowledge is a familiarity, awareness or understanding of someone or something, such as information, facts and skills that can be obtained through observation, experiment and education. The attitude is a way of thinking or feeling about something and a tendency to whether to like or dislike it. The attitudes of people show how they study their surroundings and respect environmental issues. The knowledge and attitude of people both together determine the behavior of the society. In other words, the knowledge and attitudes are the factors that make the practice of people in a society (Afroz et al. 2017; Babaei et al. 2015; Chauhan and Raksha 2016).

As a developing country, Iran is faced with serious environmental and administrative challenges caused by MSWM. The total amount of MSW generated in the country is about 50,000 tons annually (Babaei et al. 2015). Despite the fact that the significant portion of MSW in Iran are recyclable and more than 60% have a good composting potential (Moghadam et al. 2009; Hassanvand et al. 2008), unfortunately only 8% of the municipal waste is recycled and the remaining is buried mainly with unsanitary methods (Jamshidi et al. 2011).

In Iran, the national waste management laws and regulations have been established in 2004. Since then, some success has been achieved in implementing integrated waste management in metropolitans. Based on the reports of waste management organization of Tabriz, as the fourth largest city in the country, some practices have been made to implement the integrated management of solid waste in recent years. In the last 2 years, educational programs with respect to source separation and encouraging a culture of waste separation at home have been done by means of supplying special bags to temporary storage of separated dry wastes and planning for collection based on the time table. The success of this project requires comprehensive studies evaluating the effectiveness of both implemented and running programs. Therefore, this study aimed to comprehensively assess the KAP of residents, the current status of the source separation and also the characterization of MSW in Tabriz.

Materials and methods

Study area

Tabriz is located in the northwest of Iran lying at 46.13 east and 38.8 north with an altitude of 1351 m above the sea level. It has a semiarid climate with the annual precipitation of around 380 mm. The mean, maximum and minimum annual temperatures are 13, 38 and -15 °C, respectively. Its 324 km^2 area comprises 10 urban regions (Fig. 1). According to the latest census conducted in 2016, it has a population over 1.5 million with 388,000 households.

Data collection

A questionnaire survey was conducted to assess the present status of MSW source separation in the city. Questionnaire was designed in a way that enables the evaluation of the KAP of residents toward the source separation program consisted of two groups of questions; the first part was related to demographic information such as gender, education level and occupation, and the second part was related to household waste behaviors. The face-to-face household survey method, due to its reliability and more substantial response rate, was employed to assess the KAP in this study. The following formula which is widely used in previous studies (Afroz et al. 2017; Liu et al. 2015; Song et al. 2015) was taken to select sample size randomly from the population:

$$ss = \frac{z^2(p(1-p))}{d^2} \tag{1}$$

where z is 1.96 for 95% confidence level, p is the percentage of respondents, expressed as a decimal (0.5 used for the sample size needed), and d is the confidence interval, expressed as a decimal (5% was selected in the study).

Based on Eq. 1, a total of 384 households as sample size were selected randomly from all over the city with regard to the population density of 10 municipality regions. Moreover, the observation method was used to fully evaluate the practice of residents. The basic information was collected from Tabriz municipality and waste management organization.
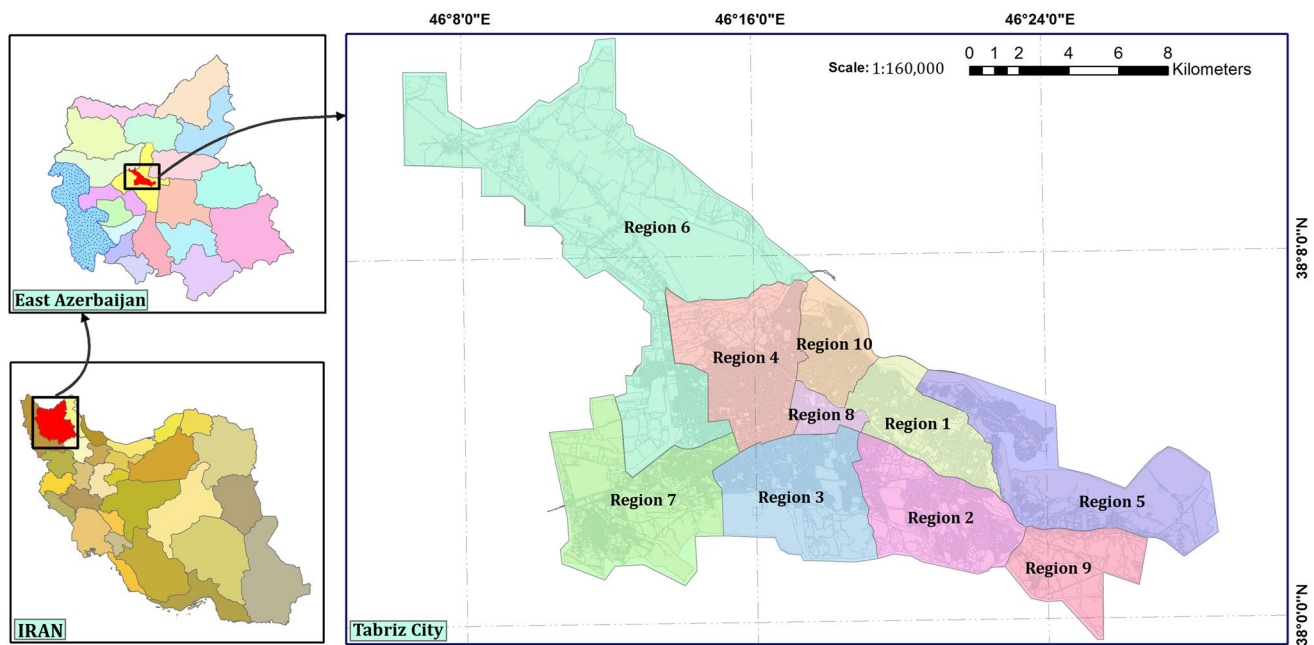
Fig. 1 Urban regions of Tabriz

Characterization of solid wastes

Characterization of solid wastes and acquiring reliable data on waste composition and quantities is an essential step to formulate an integrated MSWM program and provide basic data on the utility of the material for composting and assessing the suitability of the waste as a fuel (Pichtel 2005). In this study, direct sampling by employing manual sorting at the centralized collection point (i.e., unloading area) according to the procedure described by Pichtel (2005) and ASTM (2003), was used to measure the composition of unprocessed MSW. The moisture content was also determined by heating the waste at 105 °C for 1 h (Pichtel 2005). The energy content and chemical composition of the MSW were determined according to the procedures described by ASTM (2007) and Pichtel (2005), respectively.

Statistical analysis

To assess the relations of the knowledge, attitude and practice as the response variables with gender, education (illiterate, diploma, upper diploma, bachelor and more) and occupation (governmental, self-employed and unemployed) as the predictors, each indicator of the response variables was coded as 1 and 0 for yes or no responses, respectively. In the univariate analysis, Chi-squared tests were used to assess the relations (Jafarabadi and Mohammadi 2013; Jafarabadi et al. 2014). All analyses were performed using SPSS 13 (SPSS Inc. IL, Chicago, USA) statistical software. Statistical

significance level was set as 0.05 ($P < 0.05$ considered as significant).

Results and discussion

MSW generation and characterization

According to the collected data, about 383,000 tons of MSW is generated in Tabriz each year, so the waste generation rate is estimated to be 732 g per capita per day (GPCD) which is comparable to some Iranian metropolitans such as Rasht (800 GPCD) (Moghadam et al. 2009) and Tehran (880 GPCD) (Damghani et al. 2008) as well as other countries such as Serbia (870 GPCD) (Vujic et al. 2015) and Turkey (1300 GPCD) (Turan et al. 2009). Taking into account the factors that can influence MSW generation rates in different countries, such as gross domestic product (GDP) and developmental stage, the MSW generation rates in this study are of no surprise (Bandara et al. 2007; Chandrappa and Das 2012; Phillips and Gholamalifard 2016). There is positive correlation between high GDPs and MSW generation per capita. The waste generated in large cities of low-income countries ranges between 0.4 and 0.6 kg/person/day which is lower than the generated waste of 1.1–5.0 kg/person/day in high-income countries.

The physicochemical analysis and physical composition of the MSW in Tabriz are presented in Table 1 and Fig. 2, respectively. Deriving formula for physicochemical composition of wastes will help in calculating requirement data for

Table 1 Physicochemical properties of MSW in Tabriz

Parameter	Value
Chemical formula	$C_{400}H_{4550}O_{2210}N_{20}S$
C/N ratio	18.4
pH	6.2
Moisture content (%)	72.0
Density (kg/m^3)	252.0
Heat value (dry) (MJ/kg)	14.2
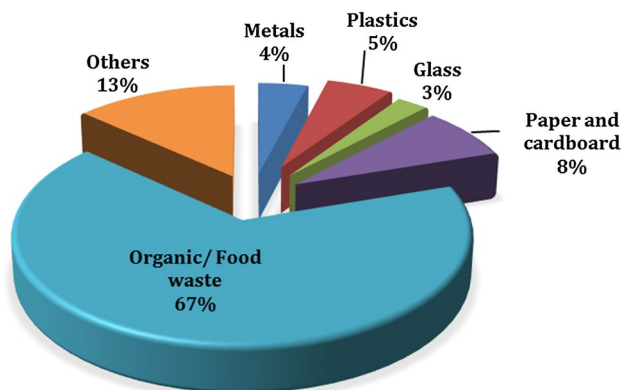
Fig. 2 Composition of MSW generated in Tabriz

making decisions about disposal options, energy production and also probable emission during natural degradation or waste treatment (Carboo and Fobil 2005; Chandrappa and Das 2012; Zhou et al. 2014).

According to the presented data, organic/food wastes make up the highest proportion (66.8%), mainly due to the use of unprocessed foods in daily people diets and high dependency on agricultural products (Moghadam et al. 2009; Miezah et al. 2015). The C/N ratio of municipal wastes ranges from 4.6, for the wastes containing higher proportion of food waste components (i.e., meat), to above 1000 for the wastes consist of plastics due to their high C and low N contents (Komilis et al. 2012). Nitrogen in the chemical formula is due to the food wastes which particularly include meat, fruits and vegetables. However, high hydrogen fraction of wastes is especially due to the high content of H in plastics. Oxygen is one of the dominant elements in waste components, except plastics. According to the study conducted by Komilis et al. (2012), due to the presence of inorganics or low oxygen content organic molecules in magazines, newsprints and tetra pack, their oxygen content is lower than office, toilet and kitchen papers.

Generally, the physical composition of MSW varies by economic status, lifestyle, climate; in the regions with high living standards, the MSW contains more plastics, paper, textiles and less moisture content and organic

wastes (Chandrappa and Brown 2012; Kourkoumpas et al. 2015; Zhou et al. 2014). The high portion of biodegradable (organics and papers) materials revealed in our study (75%) could serve as a guide for bioconversion programs such as composting and biofuel production (Miezah et al. 2015). Energy recovery from waste, as an integral part of solid waste management system, is a good option for utilization of waste and minimization of environmental impacts of MSW (Di Lonardo et al. 2015; Scarlat et al. 2015b; Vounatsos et al. 2016). However, the application of this option has not been studied in Tabriz. It is essential to determine waste heating value in order to evaluate the feasibility of energy recovery from waste (Zhou et al. 2014). According to Table 1, the dry basis higher heating value (HHV_{db}) of MSW is 14.2 MJ/kg. In practical applications, moisture content must be taken into account, so wet basis lower heating value (LHV_{wb}) is calculated using the following equations (Hla and Roberts 2015; EN, U 2010):

$$LHV_{db} = HHV_{db} - 0.2122 \times H - 0.0008 \times (O + N) \tag{2}$$

$$LHV_{wb} = LHV_{db}(1 - W \times 0.01) - 2.443 \times W \times 0.01 \tag{3}$$

where N, O and H are mass percentages for nitrogen, oxygen and hydrogen, respectively, and W is moisture content. Units of heating values are in MJ/kg. The parameters of N, O and H were calculated using the chemical properties presented in Table 1.

According to Eqs. 2 and 3, when the energy content of waste is presented in wet basis LHV (LHV_{wb}), it is reduced from 10.2 to 1.1 MJ/kg. These results indicate the significant role of moisture content on the heating value of wastes. Increasing the moisture content decreases the heating value of waste, or in other words, the heat content of the waste is used up to evaporate its moisture (Komilis et al. 2014). This value is significantly less than 7 MJ/kg, which is suggested by World Bank (Rand et al. 2000) as an average heating value for applicability of incineration. However, it is below engineering experience value (4.1 MJ/kg) to ensure complete combustion (Zhou et al. 2014). Also, this value is not comparable with LHV_{wb} of MSW in other countries such as 4.3 MJ/kg of Algeria (Guermoud et al. 2009), 7.9 MJ/kg of Australia (Hla and Roberts 2015) or 3.3–4.1 MJ/kg of India (Sessa et al. 2010).

Considering that thermochemical treatment technologies require an input feed with a sufficiently high heating value to obtain high process efficiencies, a pretreatment is needed before using MSW as a feed for waste-to-energy systems. In general, these pretreatment processes consist of shredding, screening, sorting, drying and/or pelletization (Bosmans et al. 2013), among which drying is crucial for Tabriz MSW.

According to Fig. 2, potentially recyclables such as paper and cardboard, plastics, metals, textiles and leather, glass, wood and others make up a total of 33% of the MSW. The composition of MSW in Tabriz is similar to those reported for some other Iranian metropolitans. However, the quantity of organic waste in our study is considerably higher and potentially recyclables are significantly lower than those reported from some of the Iran's neighbor countries (Table 2).

The fate of MSW

About 33% of the total MSW generated in Tabriz city are recyclables (Fig. 2), from which around 14% is collected by itinerants right away after generation, 2.5% is collected by municipal workers, and 4% is separated in a facility operated upstream of the local landfill. The collection of recyclables by itinerants is always done using unhealthy methods. Approximately 400 tons per day (40% of the total daily MSW) is sent to composting plant, of which about 160 tons per day (16%) is rejected to the landfill. The recycling chance of remainder portion of dry MSW is lost due to the mixing with other materials such as food wastes at the source. Figure 3 shows the summary of the fate of MSW in Tabriz city.

Despite all efforts to reduce, recycle and reuse, about 550 tons per day (55%) of total generated waste is disposed in the landfill. Although landfilling is the simplest and normally cheapest method for disposing of solid wastes, it is declining in developed countries due to the advanced regulations encouraging waste reduction and recycling (Aljaradin and Persson 2012; Intharathirat and Abdul Salam 2016; Scarlat et al. 2015a). Increasing of waste landfilling as a result of the increase in waste generation can be expected for developing countries. So, improvement of

MSWM strategy aiming to reduction of waste disposal with focus on waste prevention and 3R (reduce, reuse and recycle) can be considered in developing countries. In consequence, Tabriz municipality has undertaken feasibility study of some projects including garbage burning, electricity generating from biogas, medical waste management (disinfection and elimination), production of refuse-derived fuel (RDF), recycling old rubber tires and recycling construction and demolition debris aimed at achieving less adverse environmental impacts and energy production.

KAP of residents toward MSW

Sample distribution

Based on demographic characteristics (Table 3), the respondents were 59% males and 41% females, and most of them were employed with university degrees (higher than diploma) by 47%.

During the last years, Tabriz municipality has undertaken the following activities in order to increase public KAP regarding waste reduction and separation:

- Holding meetings and giving lectures in public places such as schools.
- Preparation and distributing brochures and posters about solid wastes recycling.
- Establishment of solid waste collection centers in the study area.
- Preparation and installation of containers for solid waste collection in the city.
- Spreading the awareness on waste management by television programs on local channels.

Table 2 MSW composition in Iran and some neighbor countries

City/country	Organic/ food waste	Paper and cardboard	Rubber and plastics	Glass	Metals	Textiles and others	References
Ahvaz	76.9	11.4	6.3	1.2	1.2	3.0	Monavari et al. (2012)
Tehran	74.5	5.0	7.4	2.0	2.5	8.6	Damghani et al. (2008)
Rasht	80.2	8.7	9.0	0.2	0.7	1.2	Moghadam et al. (2009)
Isfahan	69.0	4.1	17.8	1.2	1.4	6.5	Abdoli et al. (2013)
Abadan	66.9	11.2	14.4	2.8	1.4	3.4	Babaei et al. (2015)
Iran (average)	72.0	6.4.0	7.8	2.0	2.5	9.3	Hassanvand et al. (2008)
Turkey	53.9	14.3	10.1	4.0	2.9	14.9	Karak et al. (2012)
Oman	53.0	13.0	12.5	6.5	6.0	9.0	Karak et al. (2012)
Qatar	53.3	17.7	15.0	3.1	4.3	6.6	Karak et al. (2012)
Kuwait	50.0	20.7	12.6	3.3	2.6	10.8	Karak et al. (2012)
Armenia	61.5	18.0	2.0	4.0	0.3	14.2	Karak et al. (2012)

Data are expressed as %

Fig. 3 The fate of MSW in Tabriz city
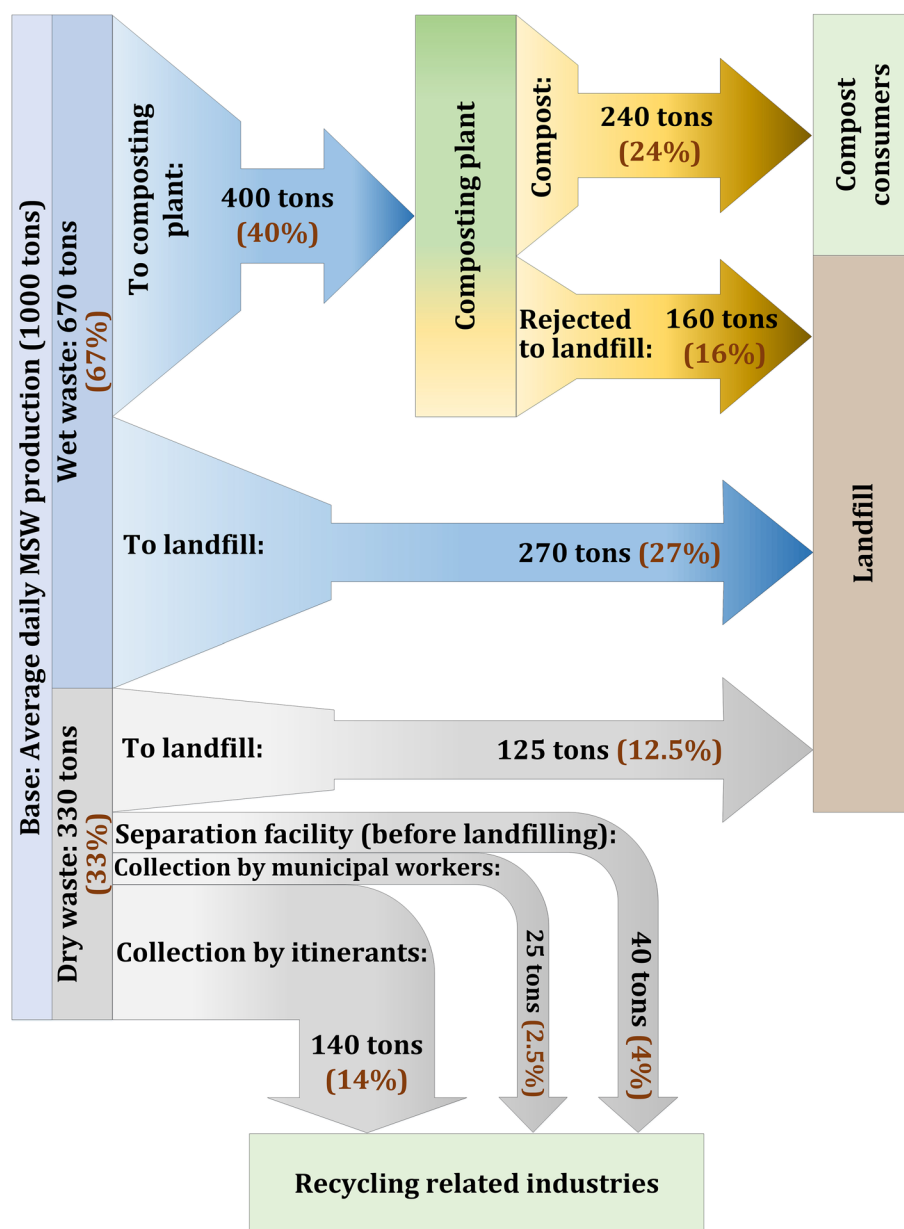
Considering the above-mentioned activities, following results revealed from the questionnaire survey. As indicated earlier, knowledge, information and accessibility of citizens to recycling opportunities can play an important role to amplification of their participation in separation and recycling programs (Babaei et al. 2015; Keramitsoglou and Tsagarakis 2013). Results of this study demonstrated the low knowledge of respondents toward solid wastes and ways of reducing waste generation (14.6 and 25.8%, respectively). Nevertheless, participants had significant knowledge about the value of MSW, recyclable wastes and benefits of recycling.

The results also indicate that participants have high willingness to segregate of solid wastes (87.7%), so 43.3% of them segregate solid wastes at home, 27.9% sell segregated wastes to itinerant waste buyers, and most of them (90.1%) are eager to deliver segregated wastes to the waste collection agents. When respondents were asked about the best way for reducing waste generation, the majority (74.3%) indicated the production of high-quality goods as the best way for reducing waste generation. Also, changing the products packaging and waste separation at source were stated as the preferred ways.

Based on the results, 82.9% of the households were not satisfied with the current waste collection service provided by municipality and 19.8% referred their waste problems to the municipality. About 70% of respondents indicated that municipality has not specified certain time for delivering

Table 3 Demographic characteristics of the respondents

In depended group	Respondent's no. (%)	Total
Gender		346 (100%)
Male	204 (59%)	
Female	146 (41%)	
Level of education		346 (100%)
Illiterate	36 (10%)	
Diploma	149 (43%)	
Upper diploma	51 (15%)	
Bachelor and more	110 (32%)	
Occupation		346 (100%)
Governmental	99 (28.6%)	
Self-employed	125 (36.1%)	
Unemployed	122 (35.3%)	

their waste bags to a neighborhood collection point. However, 37% of them preferred to leave out their MSW in the morning, 29.3% in the evening, 25.4% in the midnight and 7.4% during night. Based on Chi-square test, the correlation between demographic characteristics of the citizens (education level, gender and occupation) and KAP about MSWM was investigated in this study ("Appendix" section).

Level of education

The results indicated that knowledge of participants was slightly improved with their education level, so the people with a relatively high level of education had more MSW knowledge than those who had primary level of education. Also, a higher education level had positive influences on the willingness to separate wastes. These results corroborate the findings of previous studies, indicating that education level plays a major role in the MSWM-related behavior of citizens (Al-Khateeb et al. 2017; Babaei et al. 2015; Jin et al. 2006; Saphores et al. 2006). Generally, it can be said that the people with high education levels have more general knowledge which consequently enhances their sensitivity to environmental issues (Babaei et al. 2015; Saphores et al. 2006).

Occupation

Investigation of the impact of respondents' occupation over KAP of MSWM revealed that people with governmental occupation were more aware than unemployed or self-employed ones and also they had more tendencies to refer to the municipality for waste problems. It should be noted that the knowledge and awareness of government employees toward recycling programs and waste management system are more than the self-employed and unemployed people that is due to the direct notifications and education by the Iran's government to employees.

Gender

The results of Chi-square test indicated that the association of gender with waste separation behavior was statistically significant (25.6% of females and 5.9% of males know the solid wastes). In the case of waste segregation practices, women's participation (50%) was higher than men (37.6%) in source separation. Also, females had more willing to segregate solid wastes. This observation is in agreement with the results obtained in the cities of Abadan (Babaei et al. 2015) and California (Saphores et al. 2006).

Based on the results, the women's participation has been found to be reasonably effective in source separation activities, and in general, women are more likely to recycle (Nixon and Saphores 2009). The higher responsibility of females in recycling tasks is due to the fact that women traditionally have more authority of decision and execution in the domestic area (Meneses and Palacio 2005). Therefore, females can be the main audience group in participation and training programs.

Conclusion

Tabriz, a city sited in a developing country, has started the implementation of an integrated waste management system. One of the main reasons of increasing the worldwide waste generation is inadequate participation of households in waste reduction behaviors (Bortoleto et al. 2012), which should be taken into account when designing the waste management systems. In this regard, educational programs regarding source separation and encouraging a culture of waste separation at home are the main principles of a waste management system. So, various educational programs in mentioned fields were conducted to promote waste management system during the last years. Also, several measures have been carried out to optimize the collection, recycling and disposal systems of the city. Although, the influence of knowledge of citizen's toward source separation and recycling on their attitudes and practice has been indicated in previous studies (Abeliotis et al. 2014; Afroz et al. 2017; Keramitsoglou and Tsagarakis 2013), it is essential to understand the community's level of related knowledge before conduction of MSWM programs. So, in this study for the first time, waste behaviors of Tabriz's citizens were investigated using a questionnaire survey.

The analysis of survey revealed a significant role of the knowledge of respondents regarding the value of MSW, recyclable wastes and benefits of recycling, and also a high portion of households have high willingness to segregate solid wastes. Based on the results, high majority of respondents were not satisfied with the current waste collection service provided by municipality, which indicates the lack of

coordination of services and households demands. So, it is crucial for municipality to entice people by providing proper facilities in order to improve the waste management system. Analysis of the composition of MSW showed that because of high moisture content of waste, pretreatment technologies are needed to establish waste-to-energy systems. It can be concluded that, despite the implementation of waste management program in Tabriz urban areas, investigation of the fate of MSW in the city showed that there is a big gap between current status of waste management and the goal of considered waste management system.

Compliance with ethical standards

Ethical approval and informed consent The present research was approved by the Research Ethics Committee of Tabriz University of Medical Sciences (IR.TBZMED.REC.1390.108). We fully explained the objectives and methods of the study to the participants and obtained written informed consent.

Conflict of interest The authors declare that they have no conflict of interest.

Appendix

KAP of the respondents toward MSW

Question	No (%)	Yes (%)	Chi-square	P value
Knowledge				
Do you know solid wastes?	85.4	14.6		
Occupation				
Governmental	87.5	12.5	32.8	<0.001
Self-employed	89.6	10.4		
Unemployed	95.6	4.4		
Gender				
Male	94.1	5.9	24.9	<0.001
Female	74.4	25.6		
Do you know ways of reducing waste production at home?	74.2	25.8		
Do you know MSW is valuable (is dirty gold)?	18.8	81.3		
Education				
Illiterate	40.0	60.0	18.4	<0.001
Diploma	24.3	75.7		
Upper diploma	12.5	87.5		
Bachelor and more	9.5	90.5		
Occupation				
Governmental	7.3	92.7	19.8	0.001

Question	No (%)	Yes (%)	Chi-square	P value
Self-employed	25.4	74.6		
Unemployed	27.4	72.6		
Do you know glass, paper, metals and plastics are recyclable?	4.4	95.6		
Education				
Illiterate	19.4	80.6	21.2	<0.001
Diploma	5.6	94.4		
Upper diploma	4.6	95.4		
Bachelor and more	0.0	100.0		
Do you know economical and environmental benefits of recycling?	15.9	84.1		
Education				
Illiterate	40.6	59.4	22.6	0.001
Diploma	17.0	83.0		
Upper diploma	12.5	87.5		
Bachelor and more	6.6	93.4		
Attitude				
Would you like to segregate waste at home (wet and dry)?	12.3	87.7		
Education				
Illiterate	21.9	75.0	12.8	0.045
Diploma	12.0	88.0		
Upper diploma	10.2	89.8		
Bachelor and more	8.3	91.7		
Gender				
Male	64.3	35.7		
Female	50.6	49.4		
Would you like to deliver segregated waste to the collection agents?	9.9	90.1		
Is the waste collection service of municipality satisfactory?	82.9	17.1		
Practice				
Do you segregate solid waste at home?	56.7	43.3		
Gender				
Male	62.4	37.6	6.2	0.004
Female	50.0	50.0		
Do you sell any segregated waste to itinerant waste buyers?	72.1	27.9		
Occupation				
Governmental	68.1	31.9	12.3	0.030
Self-employed	60.0	40.0		
Unemployed	51.5	48.5		
Education				
Illiterate	45.5	54.5	8.6	0.035
Diploma	54.0	46.0		
Upper diploma	65.0	35.0		

Question	No (%)	Yes (%)	Chi-square	P value
Bachelor and more	71.7	28.3		
Do you refer to the municipality for waste problems?	80.2	19.8		
Occupation				
Governmental	74.0	26.0	12.5	0.028
Self-employed	83.1	17.9		
Unemployed	88.3	11.7		
Education				
Illiterate	90.9	9.1	7.8	0.049
Diploma	76.8	23.2		
Upper diploma	85.4	14.6		
Bachelor and more	70.8	29.2		

References

Abdoli MA, Tavakolli H, Azari A (2013) Alternatives for solid waste management in Isfahan, Iran: a case study. Waste Manag Res 31(5):532–537. https://doi.org/10.1177/0734242X13477718

Abeliotis K, Lasaridi K, Chroni C (2014) Attitudes and behaviour of Greek households regarding food waste prevention. Waste Manag Res 32:237–240. https://doi.org/10.1177/0734242x14521681

Afroz R, Rahman A, Masud MM, Akhtar R (2017) The knowledge, awareness, attitude and motivational analysis of plastic waste and household perspective in Malaysia. Environ Sci Pollut Res 24:2304–2315. https://doi.org/10.1007/s11356-016-7942-0

Aljaradin M, Persson KM (2012) Environmental impact of municipal solid waste landfills in semi-arid climates-case study-Jordan. Open Waste Manag J 5:28–39

Al-Khateeb AJ, Al-Sari MI, Al-Khatib IA, Anayah F (2017) Factors affecting the sustainability of solid waste management system-the case of Palestine. Environ Monit Assess 189:93. https://doi.org/10.1007/s10661-017-5810-0

Jafarabadi MA, Mohammadi S (2013) Statistical series: summarizing and displaying data. J Diabetes Lipid Disord 12:83–100

Jafarabadi MA, Soltani A, Mohammadi M (2014) Statistical series: the analysis of contingency tables 1 (Chisquare tests). Iran J Diabetes Metab 13:83–101

ASTM (2003) Standard test method for determination of composition of unprocessed municipal solid waste. ASTM International, West Conshohocken, pp 5231–5292

ASTM (2007) Standard test method for gross calorific and ash value of waste materials. ASTM D 5468-02

Babaei AA, Alavi N, Goudarzi G, Teymouri P, Ahmadi K, Rafiee M (2015) Household recycling knowledge, attitudes and practices towards solid waste management. Resour Conserv Recycl 102:94–100. https://doi.org/10.1016/j.resconrec.2015.06.014

Bandara NJGJ, Hettiaratchi JPA, Wirasinghe SC, Pilapiiya S (2007) Relation of waste generation and composition to socio-economic factors: a case study. Environ Monit Assess 135:31–39. https://doi.org/10.1007/s10661-007-9705-3

Barr S, Gilg AW, Ford NJ (2001) A conceptual framework for understanding and analysing attitudes towards household-waste management. Environ Plan A 33:2025–2048

Bortoleto AP, Kurisu KH, Hanaki K (2012) Model development for household waste prevention behaviour. Waste Manag 32:2195–2207. https://doi.org/10.1016/j.wasman.2012.05.037

Bosmans A, Vanderreydt I, Geysen D, Helsen L (2013) The crucial role of waste-to-energy technologies in enhanced landfill mining: a technology review. J Clean Prod 55:10–23

Carboo D, Fobil J (2005) Physico-chemical analysis of municipal solid waste (MSW) in the Accra metropolis. West Afr J Appl Ecol 7(1):31–39. https://doi.org/10.4314/wajae.v7i1.45644

Cavdar K, Koroglu M, Akyildiz B (2016) Design and implementation of a smart solid waste collection system. Int J Environ Sci Technol 13:1553–1562. https://doi.org/10.1007/s13762-016-0993-4

Chandrappa R, Brown J (2012) Solid waste management: principles and practice. Springer

Chandrappa R, Das DB (2012) Waste quantities and characteristics. In: Solid waste management. Environmental science and engineering (Environmental engineering). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-28681-0_2

Chauhan J, Raksha KP (2016) Refocusing the concept and application of knowledge management. Indian Res J Ext Educ 15:118–127

Chi Y, Dong J, Tang Y, Huang Q, Ni M (2015) Life cycle assessment of municipal solid waste source-separated collection and integrated waste management systems in Hangzhou, China. J Mater Cycles Waste Manag 17:695–706. https://doi.org/10.1007/s10163-014-0300-8

Damghani AM, Savarypour G, Zand E, Deihimfard R (2008) Municipal solid waste management in Tehran: current practices, opportunities and challenges. Waste Manag 28:929–934. https://doi.org/10.1016/j.wasman.2007.06.010

Desmond M (2006) Municipal solid waste management in Ireland: assessing for sustainability Irish. Geography 39:22–33. https://doi.org/10.1080/00750770609555864

Di Lonardo MC, Lombardi F, Gavasci R (2015) Quality evaluation and improvement of mechanically–biologically treated municipal solid waste in view of a possible recovery. Int J Environ Sci Technol 12:3243–3254. https://doi.org/10.1007/s13762-014-0735-4

EN, UNI (2010) Solid biofuels, determination of calorific value. Austrian Institute for Standardization, Vienna

Guermoud N, Ouadjnia F, Abdelmalek F, Taleb F, Addou A (2009) Municipal solid waste in Mostaganem city (Western Algeria). Waste Manag 29:896–902. https://doi.org/10.1016/j.wasman.2008.03.027

Hassanvand M, Nabizadeh R, Heidari M (2008) Municipal solid waste analysis in Iran. Iran J Health Environ 1:9–18

Hla SS, Roberts D (2015) Characterisation of chemical composition and energy content of green waste and municipal solid waste from Greater Brisbane, Australia. Waste Manag 41:12–19. https://doi.org/10.1016/j.wasman.2015.03.039

Intharathirat R, Salam PA (2016) Valorization of MSW-to-energy in Thailand: status, challenges and prospects. Waste Biomass Valor 7:31–57. https://doi.org/10.1007/s12649-015-9422-z

Jamshidi A, Taghizadeh F, Ata D (2011) Sustainable municipal solid waste management (Case study: Sarab County, Iran). Ann Environ Sci 5:55–59

Jin J, Wang Z, Ran S (2006) Comparison of contingent valuation and choice experiment in solid waste management programs in Macao. Ecol Econ 57:430–441. https://doi.org/10.1016/j.ecolecon.2005.04.020

Karak T, Bhagat RM, Bhattacharyya P (2012) Municipal solid waste generation, composition, and management: the World Scenario. Crit Rev Environ Sci Technol 42:1509–1630. https://doi.org/10.1080/10643389.2011.569871

Keramitsoglou KM, Tsagarakis KP (2013) Public participation in designing a recycling scheme towards maximum public acceptance. Resour Conserv Recycl 70:55–67. https://doi.org/10.1016/j.resconrec.2012.09.015

Komilis D, Evangelou A, Giannakis G, Lymperis C (2012) Revisiting the elemental composition and the calorific value of the organic

fraction of municipal solid wastes. Waste Manag 32:372–381. https://doi.org/10.1016/j.wasman.2011.10.034

Komilis D, Kissas K, Symeonidis A (2014) Effect of organic matter and moisture on the calorific value of solid wastes: an update of the Tanner diagram. Waste Manag 34:249–255. https://doi.org/10.1016/j.wasman.2013.09.023

Kourkoumpas D-S, Karellas S, Kouloumoundras S, Koufodimos G, Grammelis P, Kakaras E (2015) Comparison of waste-to-energy processes by means of life cycle analysis principles regarding the global warming potential impact: applied case studies in Greece, France and Germany. Waste Biomass Valor 6:605–621. https://doi.org/10.1007/s12649-015-9367-2

Kumar KS, Baskar K (2015) Recycling of E-plastic waste as a construction material in developing countries. J Mater Cycles Waste Manage 17(4):718–724

Liu T, Wu Y, Tian X, Gong Y (2015) Urban household solid waste generation and collection in Beijing, China. Resour Conserv Recycl 104(Part A):31–37. https://doi.org/10.1016/j.resconrec.2015.09.004

Malmir T, Tojo Y (2016) Municipal solid waste management in Tehran: changes during the last 5 years. Waste Manag Res 34:449–456. https://doi.org/10.1177/0734242x16632056

Meneses GD, Palacio AB (2005) Recycling behavior a multidimensional approach. Environ Behav 37:837–860

Miezah K, Obiri-Danso K, Kádár Z, Fei-Baffoe B, Mensah MY (2015) Municipal solid waste characterization and quantification as a measure towards effective waste management in Ghana. Waste Manag 46:15–27. https://doi.org/10.1016/j.wasman.2015.09.009

Moghadam MRA, Mokhtarani N, Mokhtarani B (2009) Municipal solid waste management in Rasht City, Iran. Waste Manag 29:485–489. https://doi.org/10.1016/j.wasman.2008.02.029

Momoh J, Oladebeye D (2010) Assessment of awareness, attitude and willingness of people to participate in household solid waste recycling programme in Ado-Ekiti, Nigeria. J Appl Sci Environ Sanit 5:93–105

Monavari S, Omrani G, Karbassi A, Raof F (2012) The effects of socioeconomic parameters on household solid-waste generation and composition in developing countries (a case study: Ahvaz, Iran). Environ Monit Assess 184:1841–1846. https://doi.org/10.1007/s10661-011-2082-y

Mongkolnchaiarunya J (2005) Promoting a community-based solid-waste management initiative in local government: Yala municipality, Thailand. Habitat Int 29:27–40. https://doi.org/10.1016/S0197-3975(03)00060-2

Mosaferi M, Dianat I, Shakerkhatibi M, Mansour SN, Fahiminia M, Hashemi AA (2014) Review of environmental aspects and waste management of stone cutting and fabrication industries. J Mater Cycles Waste Manag 16:721–730. https://doi.org/10.1007/s10163-013-0193-y

Nixon H, Saphores J-DM (2009) Information and the decision to recycle: results from a survey of US households. J Environ Plan Manage 52:257–277. https://doi.org/10.1080/09640560802666610

Otoma S, Hoang H, Hong H, Miyazaki I, Diaz R (2013) A survey on municipal solid waste and residents' awareness in Da Nang city, Vietnam. J Mater Cycles Waste Manag 15:187–194. https://doi.org/10.1007/s10163-012-0109-2

Pakpour AH, Zeidi IM, Emamjomeh MM, Asefzadeh S, Pearson H (2014) Household waste behaviours among a community sample in Iran: an application of the theory of planned behaviour. Waste Manag 34:980–986. https://doi.org/10.1016/j.wasman.2013.10.028

Phillips J, Gholamalifard M (2016) Quantitative evaluation of the sustainability or unsustainability of municipal solid waste options in Tabriz, Iran. Int J Environ Sci Technol 13:1615–1624. https://doi.org/10.1007/s13762-016-0997-0

Pichtel J (2005) Waste management practices: municipal, hazardous, and industrial. CRC Press, Boca Raton

Potdar A, Singh A, Unnnikrishnan S, Naik N, Naik M, Nimkar I (2016) Innovation in solid waste management through clean development mechanism in India and other countries. Process Saf Environ Prot 101:160–169. https://doi.org/10.1016/j.psep.2015.07.009

Rand T, Haukohl J, Marxen U (2000) Municipal solid waste incineration: a decision maker's guide. The World Bank, Washington DC

Saphores J-DM, Nixon H, Ogunseitan OA, Shapiro AA (2006) Household willingness to recycle electronic waste an application to California. Environ Behav 38:183–208

Scarlat N, Motola V, Dallemand J, Monforti-Ferrario F, Mofor L (2015a) Evaluation of energy potential of municipal solid waste from African urban areas. Renew Sustain Energy Rev 50:1269–1286

Scarlat N, Motola V, Dallemand JF, Monforti-Ferrario F, Mofor L (2015b) Evaluation of energy potential of municipal solid waste from African urban areas. Renew Sustain Energy Rev 50:1269–1286. https://doi.org/10.1016/j.rser.2015.05.067

Sessa A, Di Giuseppe G, Marinelli P, Angelillo IF (2010) Public concerns and behaviours towards solid waste management in Italy. Eur J Public Health 20:631–633. https://doi.org/10.1093/eurpub/ckp204

Song Q, Li J, Zeng X (2015) Minimizing the increasing solid waste through zero waste strategy. J Clean Prod 104:199–210. https://doi.org/10.1016/j.jclepro.2014.08.027

Sukholthaman P, Chanvarasuth P, Sharp A (2017) Analysis of waste generation variables and people's attitudes towards waste management system: a case of Bangkok, Thailand. J Mater Cycles Waste Manag 19(2):645–656. https://doi.org/10.1007/s10163-015-0456-x

Taghipour H, Alizadeh M, Dehghanzadeh R, Farshchian MR, Ganbari M, Shakerkhatibi M (2016) Performance of on-site medical waste disinfection equipment in hospitals of Tabriz, Iran. Health Promot Perspect 6:202–206. https://doi.org/10.15171/hpp.2016.33

Turan NG, Çoruh S, Akdemir A, Ergun ON (2009) Municipal solid waste management strategies in Turkey. Waste Manag 29:465–469. https://doi.org/10.1016/j.wasman.2008.06.004

Vounatsos P, Atsonios K, Itskos G, Agraniotis M, Grammelis P, Kakaras E (2016) Classification of refuse derived fuel (RDF) and model development of a novel thermal utilization concept through air-gasification. Waste Biomass Valor 7:1297–1308. https://doi.org/10.1007/s12649-016-9520-6

Vujic G, Stanisavljevic N, Batinic B, Jurakic Z, Ubavin D (2015) Barriers for implementation of "waste to energy" in developing and transition countries: a case study of Serbia. J Mater Cycles Waste Manag. https://doi.org/10.1007/s10163-015-0377-8

Yakubu Y, Zhou J (2018) Novel approach to quantify municipal solid waste management hierarchy based on analytical hierarchy process. Int J Environ Sci Technol. https://doi.org/10.1007/s13762-018-1768-x

Zhang W, Che Y, Yang K, Ren X, Tai J (2012) Public opinion about the source separation of municipal solid waste in Shanghai, China. Waste Manag Res 30(12):1261–1271. https://doi.org/10.1177/0734242X12462277

Zhou H, Meng A, Long Y, Li Q, Zhang Y (2014) An overview of characteristics of municipal solid waste fuel in China: physical, chemical composition and heating value. Renew Sustain Energy Rev 36:107–122. https://doi.org/10.1016/j.rser.2014.04.024