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Original Research Paper

The effect of source separation training on municipal waste reduction: A case study

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Abstract

Waste disposal problems are still serious and fundamental challenges in today's world. Khalkhal city in the south of Ardabil province of Iran, like other cities in the country, faces many environmental problems, including waste disposal. The current research aimed to provide solutions for waste reduction at the source. Systematic random sampling was conducted by available information and maps from three districts of this city. The sample size was estimated to be 380 household heads (100 households) based on the population of the city using Cochran's formula, covering household heads with the scope of residential houses. Total generated municipal solid waste was collected, weighed and separated during a week before and after training through face-to-face interaction and brochures regarding the economic, social, cultural and environmental importance of source separation. Data were analyzed by SPSS software using independent t-test and correlation test. The results confirmed the effectiveness of training on the waste reduction so that education could promote people's knowledge about waste, recycling, harms of waste, definition of separation, benefits of separation, source separation and level of household education (P=0.000). The waste reduction had no significant correlation with the age (P=0.89), occupation (P=0.16), income (P=0.95) and educational level (P=0.36) of the heads of each household. The findings of this research revealed that education, regardless of basic and demographic characteristics of the research units, is an effective method to change specific behavior and create motivation to reduce the amount of waste at source, underlining the importance of training to improve waste recycling management.

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1. Introduction

Waste management prefers the two methods of waste reduction (minimization) and waste separation (segregation) over other methods (Masoumi et al., 2020; Safavian et al. 2015). Waste segregation means separation of waste into dry and wet (Farsani et al., 2021; Hemmati et al., 2019). Source separation is considered one of the most important and least expensive methods of separating waste materials (Fataei et al., 2006). Therefore, source separation of waste is among the duties of citizens in the advanced cities of the world, with the aim of preserving the environment on which the health of humans and other living beings depend (Farsani et al., 2022; Arjaqy and Fataei, 2015).

Education occupies a special place in municipal solid waste (MSW) management, so that every country and every region should tackle the issue of education using appropriate tools and special socio-cultural conditions. These trainings aim to reduce the waste generated by different sectors and finally to cooperate in the source separation program (Fataei et al., 2004; Ojaghi et al., 2021). Hence, training in waste management is of particular importance, so that no success should be expected for the implementation of plans and programs without knowledge (Fataei, et al., 2011). The purpose of solid waste management training is to minimize the cost of environmental effects and maximize the recycling and conservation of energy and materials (Seiiedsafavian et al., 2014; Amirfazli et al., 2019). Failure to pay attention to education in this field can stagnate the role of citizens in the urban management system and prevent the development of a sustainable urban plan (Fataei and Seiiedsafavian, 2017). The sustainability of MSW management requires the comprehensive participation of the government, private sector and residents (Samadi Khadem et al., 2020; Seiiedsafavian and Fataei, 2012). The participation of all stakeholders can play a vital role in supporting policymakers in defining an effective and long-term waste management plan at the local level (Safavian et al., 2015; Fataei and Alesheikh, 2009).

The increase in population and the variety of different products produce all kinds of waste in the environment, which must be disposed of properly (Abbaspour et al., 2013; Mirzade Ahari et al., 2019; Nikpour et al., 2020) . The total amount of waste in Iran is estimated to be between 500 and 1000 grams per capita on average, and this figure is increasing. Household waste can be considered as one of the most important wastes, because decomposable organic materials in wet household waste can be composted into organic fertilizer (Fataei and Hashemimajd, 2012). Household waste includes food waste, paper, glass, metal, plastic, textile, etc. (Majlesi, 2004). The quantity and quality of generated waste vary greatly in different places, depending on environmental conditions, season, geographical location, economic, social and cultural factors and others (Russell, 1987).

Waste not only incurs huge costs in the processes of collection, transportation and disposal, but also poses serious environmental hazards (Moore, 1997). Therefore, the waste-mediated damage has made it necessary to conduct research on proper disposal of waste and its proper management. People are willing to separate and reduce waste at the source (Metin, 2003). In a research by Khudaverdyan and Farajollah Hosseini (2010), the results revealed that public participation is one of the most important strategies for community development and management, and promotion plays a role in improving people's knowledge and skills through professional training. Considering the risks posed by waste to human life, the participation of citizens in waste management can play a significant role as a key factor in its acceptance (Guerrero et al., 2013).

The increase in waste generation rate is a serious issue and thus proper waste management should be prioritized (Fataei et al., 2011). Since waste management in developed countries is based on three technologies of source reduction, waste recycling and waste recovery, and source reduction is the most important one; this research has investigated ways of source reduction that can play an important role in reducing economic and environmental burden.

Khalkhal is one of the cities that faces many environmental issues like other cities in Iran. The purpose of this research was to provide solutions for source separation and waste reduction in this city.

2. Materials and Methods

This was an intervention study in which the independent variable regarding the source separation of household waste and the amount of waste reduction in the city of Khalkhal was used as an intervening factor among the people. All the households of this city with a population of about 36,000 people live in this area and they were the statistical population of this research project. In the present study, the samples were selected by systematic random sampling method after estimating the sample size. The sample size was determined to be 380 people and about 100 households based on the population of the city using Cochran's formula. The selected samples included the head of the household and the research area covered residential houses in this city. Therefore, other places such as hospitals, government offices, etc. were not considered in this research.

In order to evaluate the research units and measure their information about the research topic, we used a researcher-made questionnaire that was designed and prepared in two sheets consisting of questions about the household, the occupation of the head of the household, educational level, income level and age. Subsequently, 20 five-choice questions were presented with responses categorized from very little to very much regarding the level of household knowledge about waste, recycling, harms of waste, definition of waste separation, benefits of waste separation, waste separation and source separation. At the bottom of the form, the weight of the waste was measured and written before and after training.

The difference in the composition and amount of waste generated before and after training was compared by independent t-test. The effect of the basic and demographic characteristics of the head of the household on reducing the amount of generated waste was determined by correlation test. Data were analyzed by SPSS software using appropriate statistical methods at the level of 99% probability.

3. Results

Figure 1 shows the pie chart of waste composition in the studied households before the training. The findings indicated that the most type of waste generated in households was paper and the least type was wood and textiles.

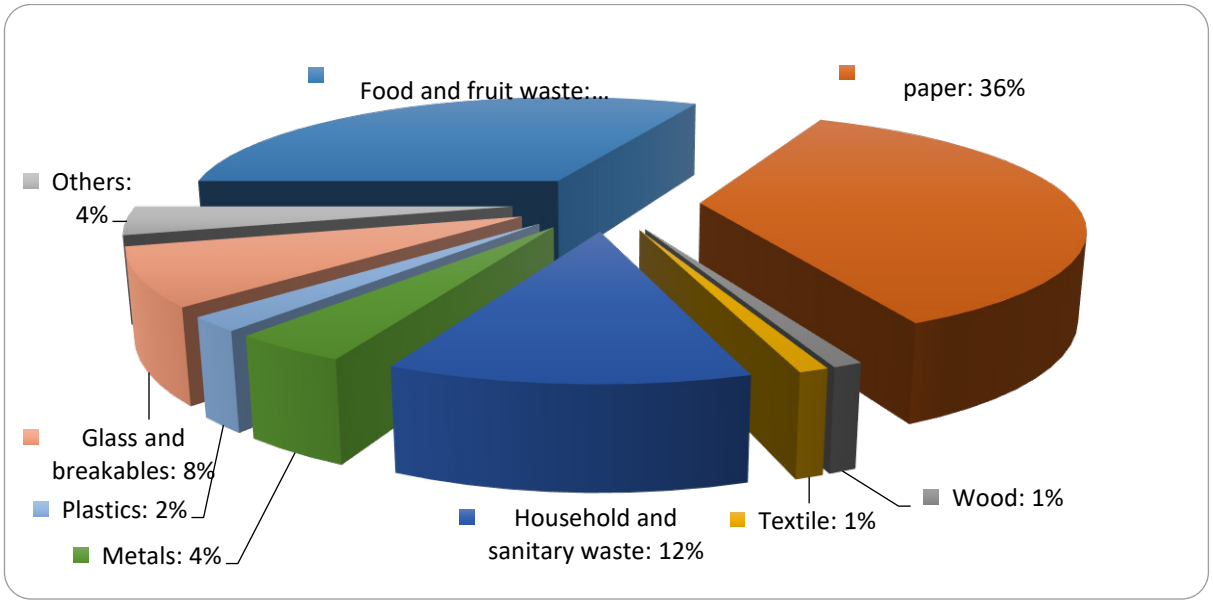

Figure 1. Pie chart of waste composition in Khalkhal city (Iran) **before training**

The basic characteristics of the research subjects were the occupation of the head of the household, the income level of the head of the household, the age and educational level of the head of the household, the level of information of the families regarding waste in the first and second stages of waste collection, and the weight of the waste in the first and second stages of waste collection.

The results showed that the occupation of household heads included 12% (n=12) as employees, 4% (n=4) as teachers, 75% (n=75) as self-employed and 9% (n=9) as others. The income level of households included 1% below 500 thousand Tomans, 5% between 500 thousand Tomans and 1 million Tomans, 54% between 1 million Tomans and 2 million Tomans, and 40% above 2 million Tomans. The age range of household heads included 15% (n=15) less than 30 years old, 33% (n=33) between 30 and 40 years old, 27% (n=27) between 40 and 50 years old, and 25% (n=25) over 50 years old. The educational level of household heads included 55% (n=55) high school and lower, 34% (n=34) associate and bachelor's degree, 10% (n=10) master's degree and 1% (n=1) PhD.

After evaluating the questionnaires and the responses of the household heads to the questions, the results were as follows:

The highest response of household heads to the questionnaire regarding their information on waste was "somewhat" (49%) before training and "somewhat" (37%) after training, with the difference that the response rate to the option "much" was 10% in the first stage, but 35% in the second stage, indicating the increase of household heads' information about waste. The most responses of household heads in the questionnaire about their information about recycling in the first stage was "very little" (45%) and in the second stage and after training "somewhat" (30%). The most response of household heads in the questionnaire regarding their knowledge about the harms of waste in the first stage was "very much" (85%) and in the second stage and after training, "very much" (90%). The most response of household heads in the questionnaire regarding their information about the definition of waste separation in the first stage was "very much" (48%) and in the second stage and after the training, "very much" (50%).

The most response of household heads in the questionnaire about their information about the benefits of waste separation in the first stage was "somewhat" (68%) and in the second stage and after training, "much" (59%). The most response of household heads in the questionnaire about their information about source separation in the first stage was "somewhat" (40%) and in the second stage and after the training, "much" (32%). Table 1 shows the responses of household heads to the questions of the questionnaire in the first stage (before training) and the second stage (after training).

The normality of research variables was determined using Kolmogorov-Smirnov (K-S) test, see Table 2.

Table 1. Responses of household heads to the questions of the questionnaire in the first (before training) and the second (after training) stages

Information of household heads	First stage (before training), Second stage (after training)	Very little	Little	Somewhat	Much	Very much
Waste	First	7	13	49	10	11
	Second	3	10	37	35	15
Recycling	First	45	20	15	11	9
	Second	19	10	30	21	20
Harms of waste	First	1	2	4	8	85
	Second	0	0	2	8	90
Definition of waste separation	First	2	8	12	30	48
	Second	2	6	10	32	50
Benefits of waste separation	First	8	10	68	7	7
	Second	2	4	25	59	10
Waste separation	First	10	28	40	12	10
	Second	8	8	27	32	25
Source separation	First	10	28	40	12	10
	Second	8	8	27	32	25

Table 2. Kolmogorov-Smirnov test results to determine the normality of research variables

Variables	Z value	Sig.
Age	2.078	0.000
Occupation	4.387	0.000
Income level	3.026	0.000
Educational level	2.078	0.000
Waste weight in the first stage	1.984	0.001
Waste weight in the second stage	1.964	0.001
Waste weight reduction rate	2.177	0.000

The significance level of K-S test was less than 0.05, thus the null hypothesis was rejected and the research hypothesis was confirmed. Therefore, it can be claimed that the first hypothesis indicated the data normality, and so appropriate parametric tests were used to test the hypotheses.

The average weight of waste for each household was 3.2 kg before training and 1.2 kg after training, which shows a decrease compared to before training. Independent t-test is used to check the effect of an intervention. In the current research about the effect of training on the waste reduction, the intervening factor was training. In this case, pre- and post-training data were collected to check their effectiveness. Considering that in this case the P value was equal to 0.000 and so was less than 0.05, therefore, source separation training has had a significant effect on the amount of waste generated before and after it at the level of 99% probability.

Correlation test was used to investigate the relationship between the basic characteristics of households and the weight reduction of generated waste. There was no significant correlation between the waste reduction and the age of household heads (P=0.89), the occupation of household heads (P=0.16), the education level of household heads (P=0.36) and the income level of household heads (P=0.95), see Table 3.

Table 3. Correlation between the basic characteristics of the head of the household and the waste reduction rate

Variables	P value	Correlation
Age	0.89	No
Occupation	0.16	No
Income level	0.95	No
Educational level	0.36	No

4. Discussion

The most effective way to change certain behavior and create motivation is to train people. At the same time, providing educational information alone does not result in changing the opinions or behaviors of a person. A firm belief is a knowledge that has taken root and can lead to action. People who have the firm belief believe that what they do is useful, and regarding waste management, they consider everything they do as a service to reduce the problem and thus benefit themselves and society as a general principle. Therefore, understanding what society includes and what it needs is important for all organizations involved in the design and implementation of these policies.

This research tried to investigate the effect of training on the amount of waste generation in 100 randomly selected households of Khalkhal city. We also examined the effect of factors such as age, educational level, occupation and income level of household heads on the amount of waste reduction.

According to the results, the scope of household knowledge about waste before training was in the "somewhat" range; after training, we saw an increase in response to the options "much" and "very much", which may somehow indicate an increase in household knowledge about waste. By examining the impact of training on household information levels on waste using independent t-test, P value was equal to 0.000, which shows the role of education on the level of household information on waste. Regarding the information level of household heads about recycling in the pre-training stage, most of the responses were related to the "very little" option, and that most of the responses after training were related to the "somewhat" option, which means increased post-training knowledge about recycling. Examining the effect of education on household information about recycling showed a significant correlation (P=0.000). On the other hand, when the effect of training on the level of household knowledge about the harms of waste (P= 0.000), definition of separation (P= 0.001), benefits of separation (P= 0.004), source separation (P= 0.000) and education about waste (P = 0.000) through independent t-test, we found the effect of training on household information about these items.

In addition, this research investigated the effect of training as an intervening factor on the weight of generated waste before and after training and determined the effect of training on the amount of generated waste (P=0.000).

However, the age, occupation, educational level and income level of household heads had no effect on the amount of waste reduction.

The results of the present study showed that most people had the desire to separate waste at home, but source separation was impossible in principle due to insufficient knowledge in this field and the lack of a plan and lack of sustainable support for this issue from different municipal districts. Shams Khoramabadi (2007) stated that there was no possibility of source separation due to low education in Lorestan province (Iran), and therefore the share of people's participation in solid waste management was very low. This research also showed the importance of education in waste management.

Abedi et al. (2012) demonstrated that the training provided by the waste management organization was effective for source separation, which somehow confirms the findings of this study. Asghari et al. (2013) found that a small percentage of people were aware of the ability to recycle most of the generated household waste, and concluded that this issue requires thinking of measures to increase people's knowledge. On the other hand, there was no significant relationship between the level of education and the amount of this knowledge.

In the present study, there was a significant correlation between the level of education and the amount of information about waste recycling before and after training (P=0.000), which does not confirm the results of Asghari et al. (2013). The reason for this difference might be attributed to the difference in the statistical population and the cultural characteristics of the two societies. Khodadadi et al. (2013) reported that most people had relatively good knowledge and attitude regarding waste recycling. However, they suggested that achieving successful recycling programs in the future requires the improvement of this level of knowledge and attitude in all sections of society using various educational and promotional methods.

5.Conclusion

The findings of this research revealed that education, regardless of basic and demographic characteristics of the research units, is an effective method to change specific behavior and create motivation to reduce the amount of waste at source, underlining the importance of training to improve waste recycling management.

Education is one of the important elements of raising the knowledge level of the society. Environmental training is significant and difficult to reduce waste generation and beyond that, waste separation and proper recycling. Planners and managers should believe that the fruits of environmental education will be visible in the long term and this issue will be very important. The main point is the continuous follow-up and supervision of the trustees. It is suggested to conduct a study on motivational factors in each region according to the cultural context and the existing attitude in the region, and then the subsequent consequences should be compared with other regions, the most important common motivational factors should be selected and applied in all regions. By increasing information through public media, the authorities should continuously provide the grounds for increasing people's participation in the source separation of municipal waste.

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