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Comparison of Rural Solid Waste Management in Two Central Provinces of Iran

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Abstract

Solid waste management has been known to play an important role in public health and the environmental status of developing countries. Waste assessment can help researchers and governors in management programs and devising alternative plans in order to improve public health and economical savings. In the present study, statistical estimations regarding waste generation and type of solid wastes in central provinces of Iran has been provided. Chaharmahal and Bakhtiari and Yazd are located in central regions of Iran, with an average waste production estimated at 0.507 and 0.293 kg/ca/day, respectively. Improper solid waste management continues to be a big concern in the region, with water contamination as its main consequence. High amount of putrescible material ratio showed the capability of bio-fuel generation in rural areas. The results of survey conducted among waste management experts showed that waste separation prior to collection is recommended as the most efficient method for managing waste collection in the area. This study could contribute to the body of knowledge enhancement by proposing a set of practical waste management strategies that would be beneficial in rural areas.

Keywords: Rural waste management, Solid waste, Waste composition, Central regions of Iran, Rural regions

Introduction

In developing countries, in which high population densities reside in rural areas, pollution resulting from inadequate treatment of rural Municipal Solid Waste (MSW) has become a serious threat to the environment. Despite substantial efforts regarding the treatment and control of solid wastes in urban areas, little attention has been paid to the rural areas of such countries (Zarate et al., 2008; Zurbrügg, 2002).

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Wastes are defined as any discarded or abandoned materials that can contribute to bad odor, aesthetic problems and maladies. Also, contamination of water resources and soil can jeopardize the natural environment of villages, which is considered as their biggest advantage compared to cities. The increase in population eventuates in the increase of waste production. Establishment of management systems for the collection and disposal of wastes can reduce the costs of collection, disposal and recycling of solid wastes. Based on the national enumeration in 2006, the population of Iran exceeded 70 million and statistics show that 31.5 percent of the population was located in rural areas. (Population report, 2012) Iran's population has recently been reported at around 77,773,000, 28% of which is currently residing in rural communities. A 2.3% increase in the total population is expected by 2017, most of which contributes to urban population growth (Population report, 2012).

Distribution of population across the rural areas of Iran is not uniform, and depends mainly on geography, topography, climate, soil type, water content, livelihood, and culture. As a result, significant numbers of Iranian's inhibit the western regions of the country. Moreover, moving southwards has significantly decreased population. In other words, increase in temperature climates and humidity has resulted in distant villages with lower population densities (Population report, 2012).

Rural solid wastes mainly originate from four sources; orchard and farmland residues, such as straw, grass, leaves and vines; manure of livestock and poultry; agricultural wastes such as plastic films; and finally, human excrement and municipal solid waste. Most of the solid wastes, generated in rural areas, are agricultural and can easily be degraded (Tian et al., 2012). In developing countries, easily degradable waste, which accounts for nearly 50% of the total amount, can be treated and recycled into agricultural fields by composting or other biological treatments (He, 2012). Considering the changes made in the quality of solid wastes in rural areas, and also the increasing demand for recycled materials, the development of recycling industries and waste management systems seems inevitable.

On June 2004, the Waste Management Law, an environment protection law, was legislated by the Iranian parliament. According to this law, various types of wastes are categorized as municipal solid waste, medical, industrial, agricultural and rural. The responsibility of all agencies and institutions regarding the management of solid wastes has also been specified. For the purpose of this project, the entire country was divided into ten separate districts and an executive consultant was selected for each.

Based on the Waste Management Law, comprehensive waste management reports are required for the initial study of urban and rural wastes. Unfortunately, in most cases, due to the inaccurate report descriptions, various shortcomings are witnessed in the reports.

In Iran, government officials in charge of solid waste collection and disposal in rural areas are known as Dehyari (Abduli et al., 2008). Due to the poor financial funding available for Dehyaries, they are unable to meet the requirements of this law. This is similar to the report made by (Fakayode, 2005) and (Gunattilaka, 2006), in which they believe many developing countries have failed in implementing environmental laws (Rafee et al., 2008).

Extensive research has been done on urban waste management in Iran, e.g., Tehran (Abduli, 1995; Chokouhmand, 1982; Damghani et al, 2008; Abduli, 1996; Taghipour et al., 2014), Qazvin (Pakpour et al., 2014), Rasht (Alavi Moghadam et al, 2009), KhoramAbad(Jafari et al., 2010) Mashhad (Farzadkia et al., 2012), Babolsar (Ghanami et al., 2013), Zanjan (Fathi et al, 2014), Hamadan (Samadiand Morshedi, 2003). However, only few studies can be found on rural waste management (Abduli et al, 2008; Abdoli et al, 2014).

Researchers reported the waste generation in rural regions around the world as follows: 0.4-0.6 kg/ca/day in Palestine (UNEP, 2003), 0.528 kg/ca/day in Brazil (Bernardes and Günther, 2014), 2.14 kg/ca/day in Fiji (Lal et al., 2007), 0.44 kg/ca/day in Nigeria (Abila and Kantola, 2013) and 0,646 kg/ca/day in Bushehr (Abduli et al., 2008), 1.215 , 0.178 and 0.255 kg/ca/day in Noth China, Southwest China and East China, respectively (Ji et al., 2006; Han et al., 2015), and 1.616 and 0.829 kg/ca/day in Italy and Czech as two developed countries (Passarini et al., 2011; Doležalováet al., 2013). The difference between the reported amounts depends of a wide range of factors such as food habit, lifestyle, climate, income, etc. Physical analysis also shows that the highest contribution to waste generation is of putrescible materials. This stated the capability of bio-fuel generation in rural areas as a new energy resource.

This paper presents an overview of the current rural solid waste management programs in the central regions of Iran, with about 9 percent of Iran's area, along with the challenges and some helpful suggestions. Due to the lack of research on rural waste management, this study can help other researchers have a better understanding of the amount of waste production in rural communities and facilitate their studies on the capability of bio-fuel electricity generation.

Materials and methods

Study Area

The study areas for this research were Chaharmahal and Bakhtiari and Yazd provinces, Iran, ranging from 31° 4' to 42° 4' N and from 49° 39' to 51° 21' E, and from 29° 52' to 33° 27' N and from 52° 55' to 56° 37' E, respectively, located in the central plateau of Iran, with a total area of 145,617 km^2. According to the latest population estimates, the population of rural areas was recorded as 1,228,000 people. This study was done during 2012-2013 and the population at that interval was 1,270,000 people (Population report, 2012). The climate of the studied provinces differs from each other. Yazd is located in the driest regions of Iran, and Chaharmahal and Bakhtiari is located at the center of Zagros Mountains experiencing a cold and freezing climate. Figure 1 shows the location of the studied areas.

Fig. 1. Location of studied provinces in Iran

Sampling and sorting operations

In order to investigate the amount of solid waste generated in the studied regions and its physical analysis, sampling was conducted for 24 randomly chosen villages in Chaharmahal and Bakhtiari and 24 villages in Yazd. These villages were selected from the most populated villages of the provinces. Sampling was done three times a week during all 4 seasons, whereas the collecting program was planned to be every other day. For the purpose of convenient analysis, the number of households chosen for the survey was with respect to the need for 100 kg of solid waste each day. In order to obtain this amount of solid waste, a number of 65 households contributed to the project in each village.

First, in order to collect data for the physical analysis of solid wastes, plastic samplers were distributed among 65 different households in each village. Next, the collected plastic samplers were weighed and separated according to the tables provided by consultants.

Moreover, several questionnaires were prepared and distributed among different experts, including municipality engineers, environmental engineering students and consultants for their comments around waste management reports and recommendations on enhancing waste management. The results of these surveys were used in order to find the challenges of rural solid waste management and recommendations for enhancing the waste management situation.

Research Method

Descriptive statistics are used to describe the basic features of the data in this study. They provide simple summaries about the sample and the measures. Descriptive statistics are typically distinguished from inferential statistics and used to present quantitative descriptions in a manageable form (Yuan and Liyin, 2011).

Results and Discussion

In this section, the current state of solid wastes in the Chaharmahal and Bakhtiari and Yazd, together with the existing challenges and recommendations for improving waste management are discussed.

Current state

Solid waste generation, waste handling and separation, storage and processing collection, transfer and transport and final disposal are the fundamental elements of solid waste management (Tchobanoglous et al, 1993). The current state of solid wastes in each region is discussed in this section.

Waste composition

Collected data indicates a solid waste generation ratio of 0.513 kg/ca/day for Chaharmahal and Bakhtiari and 0.293 kg/ca/day for Yazd. Table 1 shows generated waste per capita for autumn, winter, spring and summer seasons of Chaharmahal and Bakhtiari and Yazd. Using normality tests (Kolmogorov-Smirnov and Shapiro-Wilk) indicates that the results follow the normality, as sigma is more than 0.05. In addition, as the Pearson coefficient is more than 0.7, the results of

seasons have direct correlation. In order to have a comprehensive comparison of waste generation, two kinds of comparisons were performed. The first is a descriptive statistics comparison. The second is inferential statistics, which was performed by ANOVA to confirm any significant differences between the average waste generation in seasons and provinces.

- *Multiple comparison waste generation in different seasons*

The results of ANOVA show that there is no meaningful difference between the average waste generations between four seasons in two provinces. Therefore, waste generation and season do not have correlation (or: waste generation does not depend on season).

Moreover, Table 2 presented the mean ratio of total waste in different seasons for the two provinces. In addition, ANOVA were performed to find meaningful differences between four seasons in various types of waste generation. Also, according to Table 1, the waste generation per capita for the Yazd province is much less than the other province. It can be concluded that it is occurred due to two main reasons; First, the climate and second, the culture of its residents. Yazd province is located in the driest regions of Iran near Dasht-e-Lut and Dasht-e-Kavir and as a result, diversity of consumed materials, including food, vegetables, and fruit is less than the two other provinces and consumption of these materials and the generated waste is less than other regions. The second reason, which seems to pose a greater impact, is the residents' culture. Saving-based economy, culture, and reusing the materials without entering the materials to the waste cycle leads to declining the generation of wastes becomes part of Yazd residents' culture.

Table 1. Waste generation rate in villages of Chaharmahal and Bakhtiari and Yazd

Province	Number of studied Villages	Studied villages' population*	Total rural population* Estimation of 2015	Average Waste Generation Kg/Ca/day					Total waste generated each Estimation of 2015 Kg/day
				Autumn	Winter	Spring	Summer	Mean	Mean
Chaharmahal and Bakhtiari	24	82526	370,000	0.568	0.517	0.480	0.489	0.513	189810
Yazd	24	31505	159,000	0.298	0.211	0.252	0.277	0.259	41181

*(Population report, 2012)

Table 2. Waste Generation composition in the studied provinces

Province	Season	Putrescible	Recyclable Materials												Others
			Paper	Cardboard	Plastic	Metals	Aluminum	Tin	Other non-metal[1]	Glass	PET	Textile	Wood	Rubber	
Charmahal and Bakhtiari	Autumn	33.6	6.3	2.8	11.8	12.1	0.6	4.2	0.7	10.1	4.9	3.5	3.0	2.2	4.2
	Winter	42.0	6.3	2.4	7.9	9.8	0.4	3.5	0.5	5.1	10.3	4.3	2.5	2.5	2.6
	Spring	38.1	6.1	2.8	9.3	8.1	0.7	3.8	0.6	4.9	8.8	4.6	2.8	2.3	6.1
	Summer	43.4	6.3	2.1	9.1	5.3	0.3	2.5	0.3	3.3	6.5	4.7	2.8	2.8	10.9
	Mean	39.3	6.3	2.5	9.5	8.8	0.5	3.5	0.5	5.8	7.6	4.3	2.8	2.4	5.9
Yazd	Autumn	41.5	7.0	3.5	10.1	7.7	0.7	2.6	0.2	7.0	3.9	3.7	2.8	2.7	6.8
	Winter	51.3	6.1	2.2	7.9	5.4	0.4	2.5	0.2	5.8	5.1	5.3	2.5	3.1	2.2
	Spring	37.6	7.4	3.1	11.5	9.1	0.7	2.5	0.1	10.2	3.3	4.8	2.4	2.7	4.6
	Summer	33.7	8.2	3.9	10.8	9.9	0.9	2.9	0.2	9.7	5.0	4.0	2.4	2.5	5.8
	Mean	41.0	7.2	3.2	10.1	8.0	0.7	2.6	0.2	8.2	4.3	4.5	2.5	2.8	4.9

[1]Other non-metals= Copper, Brass, etc.

- *Capability of bio-gas generation*

The high ratio of putrescible materials, as shown in Table 2, indicates the capability of bio-compost generation or establishment of bio-gas generating sites in the two provinces. In another research done by Abduli et al in the rural areas of Bushehr province, Iran, the mean percentile of obtained putrescible materials were 40.91% for autumn, 39.97% for winter, 48.57% for spring and 40.51% for summer. (Abduli et al., 2008) These two studies indicated a potential for electricity generation. It is also possible that the amount of potential biogas energy can cover up to 1% of the primary energy demand and by using the "best-practice-scenario" calculation for separately collected bio waste, the coverage of primary energy demand may even be increased above 2% for several countries. (Lorenz et al., 2013)

As these regions comprise of regions with different climate and people with different cultures, it can be concluded that in rural areas, using the waste as a new energy resource for generation of bio-fuel can be an alternative.The highratio of recyclable materials also proves the importance of separation prior to collection by village residents.

Waste separation and Processing at source

As shown in Table 3, waste separation was not implemented in villages and agricultural, medical and domestic wastes were collected in one place. However, if the separation were to be done, the following stages would be performed much easier. According to the information obtained, on average only 4 percent of the wastes were separated by workers in the two provinces and the other 96 percent were left untouched. Unfortunately, despite the high amount of recyclable materials displayed in Table 2, little recycling was performed. Abduli reported waste separations of 26.7 percent in Bushehr villages. (Abduli et al., 2008)

Table 3. Waste Separation in each province

Waste Separation	No (%)	Yes (%)
Chaharmahal and Bakhtiari	96	4
Yazd	96	4

Collection of Solid Wastes

Collection of solid wastes is a difficult and complex task. The organic matter in MSW can easily be degraded, which causes offensive odors and leachate in storage containers (Alavi Moghaddam et al., 2009). Frequency of collection is one of the most important factors in creating a clean and healthy environment. Table 4 presented the frequency of collection in the two provinces. In a similar study in Bushehr, the results of 9.1, 36, 36 and 18.9 percent waste collection performed once, twice, three times and six times a week, respectively, were reported.

In Charmahal and Bakhtiari Dehyaries were responsible for 64 percent of the waste collection, while other partwas undertaken by the village council. In Yazd, Dehyaries were responsible for 75 percent of the waste collection, the village council 12 percent, municipality 9 percent and Home Health 4 percent. Abduli et al. reported 85 percent of waste collection undertaken by Dehyaries, and 15 percent collected by the village council. Furthermore, a collection frequency of

9.1 percent once a week, 36 percent twice a week, 36 percent three times a week and 18.9 percent six times a week was reported (Abduli et al., 2008)

Unfortunately, as shown in Table 5 in many cases medical wastes were disposed along with other household wastes. In 68, and 42 percent of the cases in Chaharmahal and Bakhtiari and Yazd, respectively, medical wastes were disposed along with other household wastes. Due to the severe risk of medical waste contamination, sanitary disposal of such wastes prohibits their transmission in rural areas. Disposal of medical wastes is not the only issue that raises concern; animal wastes must also be disposed in a way that prevents environment contamination. Around 56 and 100 percent of animal wastes are used as compost in Chaharmahal and Bakhtiari and Yazd, respectively. The latter data were gathered by survey conducted among the residents of the villages.

Table 4. Weekly waste collecting frequency

Frequency	One time per week	Two times per week	Three times per week	four times per week	No collection	No answer	percent
Chaharmahal and Bakhtiari	40	24	20	0	0	16	100
Yazd	33	25	4	4	23	21	100

Table 5. Disposal of medical wastes with other household wastes

	Along with other types of wastes	Separated	Medical waste generation Kg/ca/day
Chaharmahal and Bakhtiari	68	32	0.008
Yazd	42	58	0.0083

Transport and transfer

It is noted that due to the lack of a centralized waste management system, the major means for waste transport in rural communities are tractors, cattle and manually. According to Table 6, in Chaharmahal and Bakhtiari, Tractor, and in Yazd, Van is the most used vehicle for collecting wastes.

Final disposal

According to Table 7, the disposal scenarios for the two provinces are presented. Considering the unsanitary dumping and incineration performed by citizens, air and ground water pollution are among the possible consequences of this non-normative disposal method.

Table 6. Type of vehicles used to collect the waste

Type of Vehicle	Chaharmahal and Bakhtiari	Yazd
Rickshaw	4.16	4
Waste transfer vehicle	20	17
Tractor	41.6	13
Van	4.16	50
wheelbarrow، rickshaw،tractor	4.16	0
wheelbarrow	4.16	8
Van & truck, waste transfer vehicle	4.16	0
Wheelbarrow & tractor	4.16	0
Truck	8.33	0
No answer	4.16	8
Total	100	100

Table 7. Waste disposal scenarios in rural areas of the province

status	Chaharmahal and Bakhtiari	Yazd
Dumping outside the village	16.7	13
Entered in the waste collection network of neighbor town	4.1	21
Spread on pastures as fertilizer	4.1	4
Dumping and incinerated	20.8	32
Buried in the ground	4.1	4
Dumping, incinerated and buried in the ground	29.2	13
Dumping, spread and buried in the ground	4.1	0
Dumping and incineration, disposal in river, scattering, feeding animals, buried in ground	4.1	0
Feeding animals, collecting network, dumping and incineration	4.1	13
Dumping, feeding animals, scattering, disposing in river	4.1	0
Dumping, scattering, incineration, disposing in rivers	4.1	0
Total	100	100

Present challenges of solid waste management in the provinces

Based on Table 8, it is observed that the major issue regardingwaste disposal is water pollution which occurs by unsanitary disposal and generated leachate. As most of the generated leachate is due to the putrescible materials, to overcome this problem, composting organic wastes and the establishment of bio-compost and bio-gas units can be considered as an alternative way to help solve the problem. The percentage of each challenge is derived from the survey conducted among the waste management experts.

Several questionnaires were prepared and distributed among different experts, including environmental engineering students, municipality engineers, and consultants for their comments around recommendations for the improvement of solid waste management.

Table 8. Major problems of current waste disposal

Problem	**P**ercent
Scattering light waste	4.16
Fire at disposal	4.16
Bad odor, vicinity to roads, animals, lack of fencing	4.16
Scattering light waste, vicinity to roads and gardens, the animals, separation	4.16
All the above mentioned	4.16
Scattering light waste, lack of fencing, firing, unsanitary separation,	8.33
Bad odors, scattering, vicinity to roads, lack of fencing, firing	12.5
Water contamination, bad odors, scattering, vicinity to roads, animals, lack of fencing	24
Bad odors, scattering, animals, lack of fencing, lack of separation	8.33
Scattering, vicinity to roads, animals, lack of fencing, firing	8.33
Leachate, bad odors, vicinity to gardens, lack of fencing	4.16
Leachate, bad odors, scattering, vicinity to gardens, animals, firing	4.16
Lack of proper roads caused Lack of garbage collection in winter	4.16
Water contamination, lack of fencing	4.16
Others	4.16
Total	100

Recommendations for the improvement of solid wastes management in the province

Based on previous sections, some recommendations are provided in order to overcome the shortcomings and consequences of rural waste management as follows:

- Separation and recycling of waste prior to disposal
- Considering a waste disposal site for each district
- Considering waste incinerators in order to prevent air pollution
- Considering landfills in order to prevent water pollution
- Using buckets instead of open cans along the roads
- Recycling and composting wastes
- Implementing justification programs to inform citizens of the benefits of public participation in separating wastes prior to disposal
- Granting facilities to the NGO's to encourage the participation of rural communities in the process of waste management
- Distribution of free trash bags
- Distribution of recycling bins

Implementing these recommendations can enhance the environmental status of rural communities. However, given the inevitable importance of citizen's role in rural areas, public awareness can prove to be less expensive with more tangible results.

Conclusions

There are several shortcomings in rural waste management around the world. As other parts of the world, lack of considerations on proper implementation of the current laws are the most important problem that if resolves, may results in a better environmental situation. The changes in lifestyle and the need for alternative energy sources makes the necessary steps to be considered

in order to use biogas capability to provide the gas required. The obtained data shows the capability of rural areas for providing alternative energy sources, if proper actions are done.

There are many challenges such as contaminating water sources, scattering the light waste by wind etc. as mentioned before, and by recycling prior to disposal and volunteer actions these challenges can be solved without spending too much money. Public awareness can be another way to inform them their inevitable role in environmental status and health. Efforts should be made by government, public and NGOs in order to achieve the benefits of waste after recycling.

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